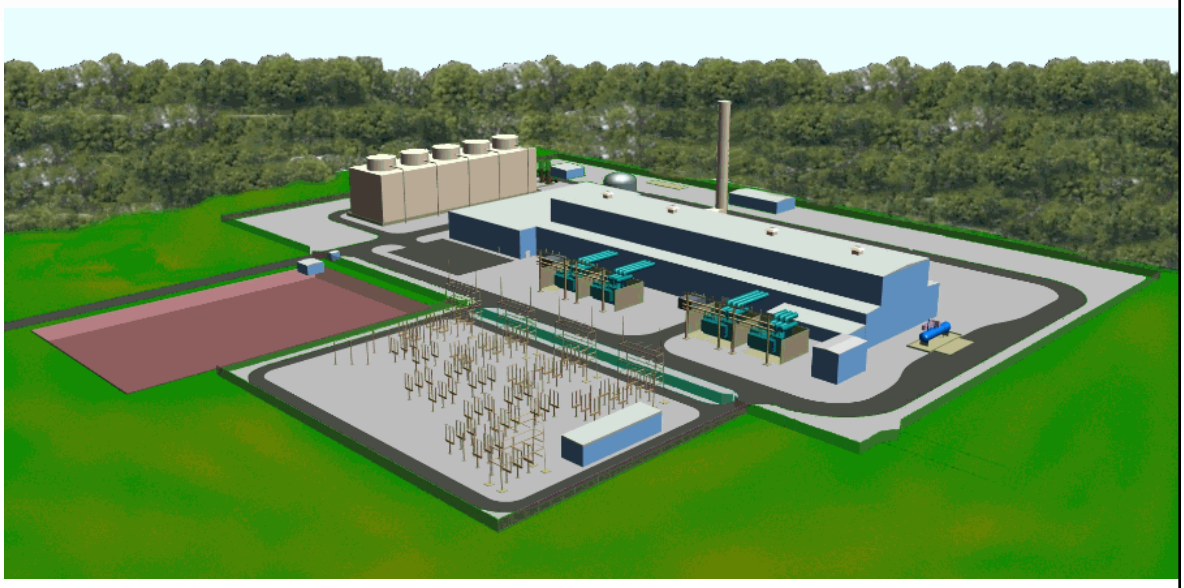
NATIONAL ENERGY TECHNOLOGY LABORATORY



Seneca Compressed Air Energy Storage (CAES) Project

September 2012

Final Phase 1 Technical Report

DOE Award No. DE-OE0000196 and NYSERDA 11052

NYSEG

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NYSEG SENECA COMPRESSED AIR ENERGY STORAGE (CAES) DEMONSTRATION PROJECT

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Final Phase 1 Technical Report

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Abstract and Key Words

Compressed Air Energy Storage (CAES) is a hybrid energy storage and generation concept that has many potential benefits especially in a location with increasing percentages of intermittent wind energy generation. The objectives of the NYSEG Seneca CAES Project included: for Phase 1, development of a Front End Engineering Design for a 130MW to 210 MW utility-owned facility including capital costs; project financials based on the engineering design and forecasts of energy market revenues; design of the salt cavern to be used for air storage; draft environmental permit filings; and draft NYISO interconnection filing; for Phase 2, objectives included plant construction with a target in-service date of mid-2016; and for Phase 3, objectives included commercial demonstration, testing, and two-years of performance reporting. This Final Report is presented now at the end of Phase 1 because NYSEG has concluded that the economics of the project are not favorable for development in the current economic environment in New York State.

The proposed site is located in NYSEG's service territory in the Town of Reading, New York, at the southern end of Seneca Lake, in New York State's Finger Lakes region. The landowner of the proposed site is Inergy, a company that owns the salt solution mining facility at this property. Inergy would have developed a new air storage cavern facility to be designed for NYSEG specifically for the Seneca CAES project. A large volume, natural gas storage facility owned and operated by Inergy is also located near this site and would have provided a source of high pressure pipeline quality natural gas for use in the CAES plant. The site has an electrical take-away capability of 210 MW via two NYSEG 115 kV circuits located approximately one half mile from the plant site. Cooling tower make-up water would have been supplied from Seneca Lake.

NYSEG's engineering consultant WorleyParsons Group thoroughly evaluated three CAES designs and concluded that any of the designs would perform acceptably. Their general scope of work included development of detailed project construction schedules, capital cost and cash flow estimates for both CAES cycles, and development of detailed operational data, including fuel and compression energy requirements, to support dispatch modeling for the CAES cycles.

The Dispatch Modeling Consultant selected for this project was Customized Energy Solutions (CES). Their general scope of work included development of wholesale electric and gas market price forecasts and development of a dispatch model specific to CAES technologies.

Parsons Brinkerhoff Energy Storage Services (PBESS) was retained to develop an air storage cavern and well system design for the CAES project. Their general scope of work included development of a cavern design, solution mining plan, and air production well design, cost, and schedule estimates for the project.

Detailed Front End Engineering Design (FEED) during Phase 1 of the project determined that CAES plant capital equipment costs were much greater than the $125.6-million originally estimated by EPRI for the project.

The initial air storage cavern Design Basis was increased from a single five million cubic foot capacity cavern to three, five million cubic foot caverns with associated air production wells and piping. The result of this change in storage cavern Design Basis increased project capital costs significantly. In addition, the development time required to complete the three cavern system was estimated at approximately six years. This meant that the CAES plant would initially go into service with only one third of the required storage capacity and would not achieve full capability until after approximately five years of commercial operation.

The market price forecasting and dispatch modeling completed by CES indicated that the CAES technologies would operate at only 10 to 20% capacity factors and the resulting overall project economics were not favorable for further development.

As a result of all of these factors, the Phase 1 FEED developed an installed CAES plant cost estimate of approximately $2,300/KW for the 210MW CAES 1A and 2 cycles. The capital cost for the 136 MW CAES 1 cycle was even higher due to the lower generating capacity of the cycle. Notably, the large equipment could have generated additional capacity (up to 270MW) which would have improved the cost per KW; however, the output was limited by the night time transmission system capability. The research herein, therefore, is particular to the site-specific factors that influenced the design and the current and forecasted generation mix and energy prices in Upstate New York and may not necessarily indicate that CAES plants cannot be economically constructed in other places in New York State or the world.

Keywords: energy storage; compressed air energy storage; CAES; bedded salt caverns; turbomachinery; CAES generation siting; New York State; ARRA funded Smart Grid Development Program; CAES project.

List of Acronyms and Abbreviations

A/E	Architect/engineer
AFBC	Atmospheric fluidized bed combustor
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	ASTM International (originally known as the American Society for Testing and Materials)
BACT	Best available control technology
Bbl	Barrel
BEC	Bare erected cost
BOP	Balance of plant
Btu	British thermal unit
ºC	Degrees Celsius
CAA	Clean Air Act
CAES	Compressed Air Storage
CFR	Code of Federal Regulations
CO	Carbon monoxide
CO_2	Carbon dioxide
CTG	Combustion Turbine Generator
DCS	Distributed control system
DI	De-ionized
DOE	United States Department of Energy
EDI	Electro-deionization
EPA	United States Environmental Protection Agency
EPC	Engineer, procurement, and construction
EPCM	Engineering, procurement, and construction management
EPRI	Electric Power Research Institute
ER	Energy Ratio
ºF	Degrees Fahrenheit
HAP	Hazardous air pollutants
HEI	Heat Exchange Institute Standards
Hg	Mercury
HHV	Higher heating value
hp	Horsepower
HRSG	Heat Recovery Steam Generator
H_2S	Hydrogen sulfide
kW	Kilowatt
kWh	Kilowatt hour
LAER	Lowest achievable emissions rate
lb	Pound
lb/hr	Pounds per hour
LHV	Lower heating value
MCR	Maximum continuous rating
MMBtu	10^6 Btu, (U.S. million Btu)
MW	Megawatt
MWh	Megawatt hour
NA, N/A	Not applicable
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NETL	DOE's National Energy Technology Laboratory
NFPA	National Fire Protection Association
NH_3	Ammonia
NSPS	New Source Performance Standards
NO_2	Nitrogen dioxide
NO_X	Oxides of nitrogen
NSR	New source review
NYISO	New York Independent System Operator

NYSEG New York State Electric & Gas Corporation

O&M Operating and maintenance
O_2 Oxygen
OEM Original equipment manufacturer
OSHA Occupational Safety and Health Administration

P&ID Piping and instrumentation diagram
PCD Particulate control device (filter)
PM Particulate matter
POTW Publicly owned treatment works
ppmv Parts per million by volume
ppmvd ppmv (dry basis)
PSD Prevention of significant deterioration
psia pounds per square inch, absolute (14.696 psia = 1 atm)
psig pounds per square inch, gauge

Q Heat

RO Reverse osmosis

S Sulfur or sulfur content of fuel
scf Standard cubic foot
SO_2 Sulfur dioxide
SO_X Oxides of sulfur
ST Steam turbine

t Short ton (2,000 lbs)
t/h, tph Short tons per hour (2000 lb/h)
t/y, tpy Short tons per year (2000 lb/y)
TBD To be determined
TEMA Tubular Exchanger Manufacturers Association
TEQ Toxicity equivalent
Ton Short ton (2,000 lb)
Tonne Metric ton (1,000 kg or 2,205 lb)
TPC Total plant cost

UL Underwriters Laboratory
US, U.S. United States
USD, US$ United States Dollar

y, yr Year

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1. Executive Summary

1.1 Overview of Phase 1 Study Results

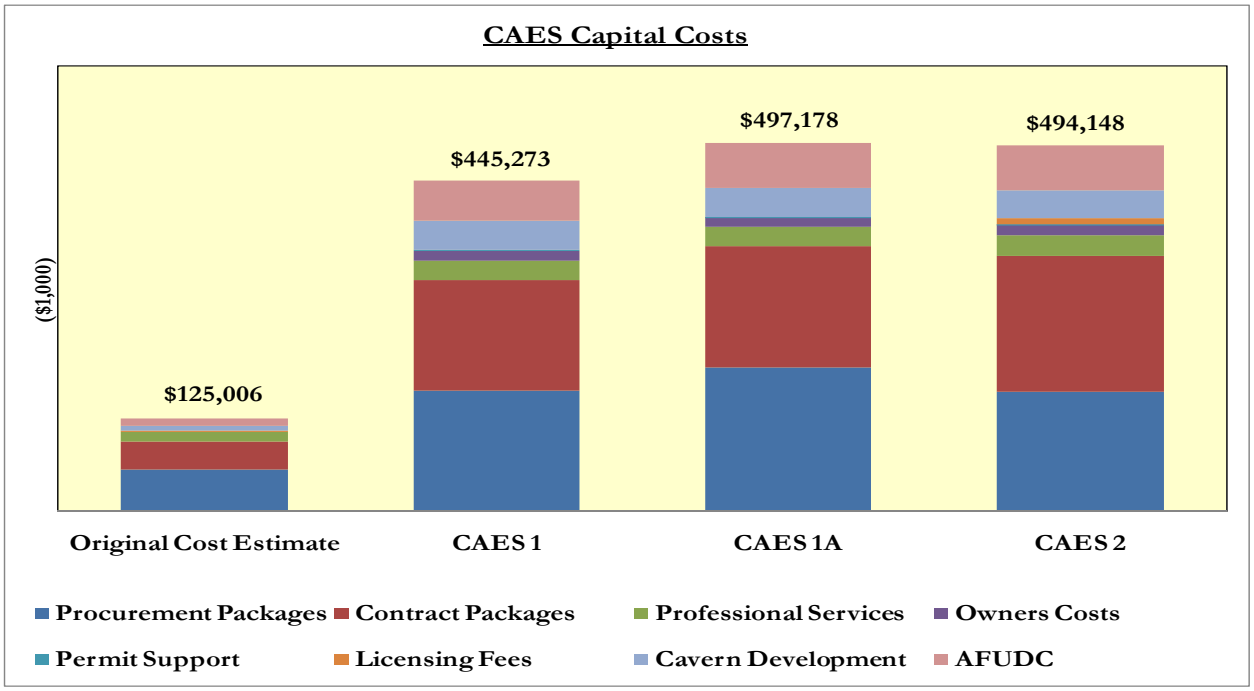
Compressed Air Energy Storage (CAES) is a hybrid energy storage and generation concept that has many potential benefits especially in a location with increasing percentages of intermittent wind energy generation. The objectives of the NYSEG Seneca CAES Project included: in Phase 1, development of a Front End Engineering Design for a 136MW to 210 MW utility-owned facility including capital costs; project financials based on the engineering design and forecasts of energy market revenues; design of the salt cavern to be used for air storage; development of technical data required for environmental permit filings; and development of technical data required for a NYISO interconnection filing; in Phase 2, objectives included plant construction with a target in-service date of mid-2016; and Phase 3 objectives included commercial demonstration, testing, and two-years of performance reporting. NYSEG has concluded that the economics of the project are not favorable for development in the current and forecast wholesale electric market in New York State, and further project development work is not warranted.

NYSEG evaluated two expansion cycle designs for the plant during Phase 1 of the project to determine whether the CAES technology provides sufficient customer benefit to proceed with Phase 2 project construction. The first CAES cycle evaluated (Cycle #1/1A) is provided by Dresser-Rand and employs air expansion turbine generators with natural gas combustors to pre-heat the storage air prior to admitting it into the expanders. The CAES 1 cycle is rated at 136 MW and the CAES 1A cycle is rated at 210 MW.

The second CAES cycle (Cycle #2) evaluated, also nominally rated at 210 MW, is provided by a joint venture between Energy Storage & Power and MAN Diesel Turbo. Cycle #2 consists of a simple cycle combustion turbine with an air to air heat exchanger downstream of the combustion turbine exhaust that is used to pre-heat the storage air prior to admitting it into the air expanders. NYSEG's engineering consultant, WorleyParsons, thoroughly evaluated the CAES designs and concluded that any of the designs would perform acceptably and that the dispatch cost of Cycles 1 and 1A is remarkably stable between 100% and 30% load. CAES Cycle 2 dispatch is remarkably stable between 100% and 50% load. The performance of the units is not significantly affected by ambient temperature and relative humidity. While the plant may experience some minor performance degradation over time, proper maintenance should provide long term, stable operation.

Detailed Front End Engineering Design (FEED) during Phase 1 of the project determined that CAES plant capital equipment costs were much greater than the $125.6-million originally estimated for the project. WorleyParsons issued RFPs for major and minor plant equipment as part of the FEED process, and the capital cost estimates for the technology were based on the results of these RFP's. There were a limited number of qualified bidders for the major equipment items and bidders generally responded with "Budget" quality

proposals with many exceptions to the RFP terms and conditions. The "Budget" equipment costs were significantly higher than the original estimates, and bidders appeared to add contingencies to address perceived costs associated with government contracting terms and conditions. In addition, the original proposal included the selected use of used equipment which was no longer available at the time the FEED process was underway. The capital cost estimates are shown below and are compared with the original estimate.



	Original Estimate	CAES 1	CAES 1A	CAES 2
Procurement Packages	$56,078,400	$162,300,876	$193,630,735	$161,099,191
Contract Packages	$37,715,710	$149,078,498	$162,956,933	$183,969,191
Professional Services	$13,194,000	$26,419,800	$26,419,800	$27,585,800
Owner's Costs		$13,682,133	$13,682,133	$13,682,133
Permit Support		$710,000	$710,000	$710,000
Technology Licensing Fees	$734,700			$7,350,000

	Original Estimate	CAES 1	CAES 1A	CAES 2
Cavern Development	**$7,400,000**	**$38,920,122**	**$38,920,122**	**$38,920,122**
AFUDC	**$9,883,293**	**$54,161,656**	**$60,857,797**	**$60,831,375**
Total	**$125,006,103**	**$445,273,086**	**$497,177,520**	**$494,147,812**

Project capital costs were increased as well due to a change in the Design Basis of the project. The original proposal called for a CAES 2 design with a generation rating of approximately 150 MW, and a compression train rating of approximately 65 MW. This Design basis assumed a storage cavern of approximately five million cubic feet of free space. Early in the FEED process, the team was advised by Inergy/US Salt (the cavern field owner and operator) that they would provide the project with a new cavern rather than an existing cavern. Preliminary reviews by the project team also indicated that most if not all of the existing salt caverns at the site had been mined in a fashion in which the salt on the roofs of the caverns had largely been mined out leaving a bare rock face on the ceiling. The absence of a substantial layer of salt on the roofs of these caverns, combined with the potential for cavern to cavern leakage made the potential re-use of existing caverns for the storage of high pressure air problematic. The development of a new cavern, specifically designed for CAES cycle duty became the Design Basis for the project. Based on solution mining rates at the Inergy/US Salt operation, a five million cubic foot cavern could be developed within the project development time line, and this formed the Design Basis for the project.

Preliminary cycle operational requirements as recommended by Customized Energy Solutions (project energy markets and modeling consultant) indicated that to maximize economic value, the CAES plant would need to be able to be fully re-charged during off-peak hours on a daily basis. This would allow the plant to provide its full generating capability during on-peak periods. Given the limited size of the air storage cavern, preliminary engineering review indicated that the Design Basis for the compression train would need to be between 150 and 200 MW in size. This large increase in compressor size from the original plant proposal (65 MW) contributed to a significant increase in plant cost.

In addition, initial discussions indicated that compression trains independent from the generation train would provide maximum flexibility in responding to ancillary services market revenue opportunities. Initial evaluations also indicated that the Design Basis should incorporate the capability to de-couple the compressor motors from the compressors so that the motors could be operated as synchronous condensers for VAR support. The separate compression and generation trains as well as the synchronous condenser capability also added to the capital cost for the project.

Parsons Brinkerhoff Energy Storage Services (PBESS) was engaged to confirm the initial Design Basis assumptions about cavern design, capacity, time to create, and ability to

support CAES plant operation duty cycle requirements over the 30 years design life of the facility. As will be detailed later in this report, the initial air storage cavern Design Basis was increased from a single five million cubic foot capacity cavern to three five million cubic foot caverns with associated air production wells and piping. The result of this change in storage cavern Design Basis increased project capital costs significantly. In addition, the development time required to complete the three cavern system was estimated at approximately six years. This meant that the CAES plant would initially go into service with only one third of the required storage capacity and would not achieve full capability until after approximately five years of commercial operation. This protracted commercial phase-in resulted in significantly reduced wholesale market revenues during the five year period and contributed to the overall unfavorable economics for the CAES project.

The Seneca CAES plant would have been interconnected to two NYSEG 115 kV circuits located approximately one half mile west of the proposed plant site. While no transmission system upgrades would have been required to interconnect the plant, the interconnection would have required the construction of a substation at the plant site as well as a 115 kV switchyard at the interconnection point as well. The costs of this interconnection were not fully assessed as part of the original cost estimate.

The Seneca CAES plant, located in the heart of the New York Finger Lakes wine and tourism area, would have undergone an extensive licensing period under the newly enacted New York State Article X licensing process. The direct costs of this licensing process were included in the cost estimates. In addition, the anticipated design and operational requirements necessary to receive licensing approvals (including noise abatement, visual impacts, stack and cooling tower plume abatement, stormwater management and waste water discharge requirements) were incorporated into the Design Basis and contributed to the capital cost of the project. These costs were not fully assessed as part of the original project cost estimate.

The Seneca CAES Project was proposed as a rate based investment under rate regulation by the New York Public Service Commission. The plant capital cost estimate includes an Allowance for Funds Used During Construction (AFUDC) which NYSEG would accumulate during plant construction and which would then be incorporated into the overall capital cost of the plant as it entered commercial service. Over the nearly four year plant construction schedule, these costs were estimated at $60-million and were not fully assessed as part of the original project cost estimate.

As a result of all of these factors, the Phase 1 FEED developed an installed CAES plant cost estimate of approximately $2,300/KW for the 210MW CAES 1A and 2 cycles. The capital cost for the 136 MW CAES 1 cycle was even higher due to the lower capacity of the cycle.

Wholesale electric market revenue estimates were developed by Customized Energy Solutions (CES) based on sophisticated modeling which took into account hourly price forecasts for the life of project; costs of inventory of air stored in cavern; scenario modeling

based on anticipated events in New York and the region; and energy policy and market trends. The modeling developed for this project revealed several major findings:

- The retirement of existing coal and other aging base load generation will require the addition of new generation which will largely take the form of natural gas peaking and combined cycle units. While some penetration of renewable energy will be likely to continue, the modeling indicates that the majority of the new capacity additions will be gas fired.

- As a result, the modeling indicates that energy prices in the New York market will be set by the marginal cost of natural gas generating units. The result of this is that the differential between on-peak and off-peak wholesale energy market prices will be very small for many hours of the year (essentially driven by the heat rates of the least efficient NGCC units and the most efficient NGCC units). Energy arbitrage revenues for the CAES plant are significantly diminished in this market environment.

- Capacity revenues forecast in the NYISO market do increase during the study period as the current excess capacity in the NYISO is reduced over time. However, increased capacity revenues are not forecast to occur until well after the Seneca CAES plant enters commercial operation. In addition, the capacity revenue increases associated with the need for new capacity will be driven by the cost of new NGCC or NGCT units which are significantly less costly than the CAES technology. Even when the capacity prices do increase, they would not be sufficient on their own to support the construction of a CAES plant.

- The current NYISO market structure does not provide Ancillary Services market revenues to support new investment in capturing this market segment. Some of the capabilities in which CAES technology excels (fast start, VAR support, frequency regulation) are little valued in the current market and are not forecast to grow significantly in the forecasts used for this project. While NYSEG and CES believe that situation may change with the further retirement of base load fossil units, there was no way to develop defensible estimates of these future market revenue streams.

- The location of the Seneca CAES plant would not impact or reduce transmission congestion costs and there was no credit given to the project for congestion relief. A larger plant or a plant located in a different NYISO Zone may have impacted congestion, but this plant does not.

- The dispatch modeling performed by CES indicated that the CAES plant would reduce statewide emissions of CO_2 by over two million tons during a 30 year study period. The societal value of this emission reduction was not monetized and was not included in the calculation of project economics.

1.2 General Approach to CAES Development – Lessons Learned

At the conclusion of Phase 1, the project team documented the lessons learned from Phase 1 which may assist future CAES project developers. The following are the key aspects of the assessment approach. First, develop an initial approach, with the expectation that some project parameters and assumptions may need to flux as project limitations are discovered. The project management team should identify the initial scope to include:

- generation size range;
- compression size range;
- minimum air store recharge time;
- the maximum hours of generation at full load on a full air charge; and
- the expected number of cycles per year.

Next, conduct a preliminary assessment of the electric transmission system capability. Be sure to determine if the transmission system has the generation take-away capability assumed in the initial general scope and if it can supply charging energy, which is typically assumed to be at night time or other off-peak time period. Identify the potential interconnection costs and the costs for any upgrades, if necessary. Evaluate the cost/benefit of resolving capacity and technical issues.

The next step is to develop the preliminary air storage medium assessment and design basis:

- Characterize the initial storage medium design basis (volume, geology, depth, etc).
- Using the initial general scope for the above-ground plant, evaluate the ability of the storage medium to support desired operating envelope.
- Modify the operating envelope; determine recommended operating pressure range for the CAES plant based on a preliminary geotechnical assessment.
- Modify the initial storage medium design basis (within technically allowable limits) to best meet initial general scope of project established above.
- Identify key CAES cycle performance and operational data needed to verify preliminary design basis.

From the above analysis, prepare the preliminary project design basis and key assumptions supporting the design basis. Next, develop preliminary wholesale market forward base case price curves including:

- Hourly on-peak versus off-peak energy forecasts to assess arbitrage value
- Installed capacity forecasts
- Ancillary services market revenue forecasts
- Natural gas and air emission allowance price forecasts

Then, perform preliminary dispatch modeling for the CAES cycle(s) to evaluate potential market revenue streams and verify assumptions on operating duty cycle. Note: NYSEG chose to evaluate the costs and revenue potential of two CAES technologies throughout Phase 1.

- Market revenue forecasts
- Variable cost forecasts (fuel, charging energy, air emission allowances)

Next, perform preliminary financial modeling and refine the preliminary design basis as appropriate. The primary objective is to support decision-making on further detailed project definition and development.

- Identify critical cycle characteristics and potential sensitivities, such as size, charging time, generating time, and capital costs.
- Conduct a preliminary assessment of sensitivity to wholesale gas and/or electric prices.

Refine the design basis as necessary for Front End Engineering Design (FEED) effort including at least the following:

- Size of compression and generation trains
- Operating duty cycle desired
- Air pressure range across the duty cycle
- Special electrical transmission system interconnection requirements
- Desired operating duty cycle characteristics to maximize potential revenues including:
    - Start/stop times and frequency
    - Automatic generation control response rates
    - Ramping capabilities
    - VAR support requirements
    - Black start

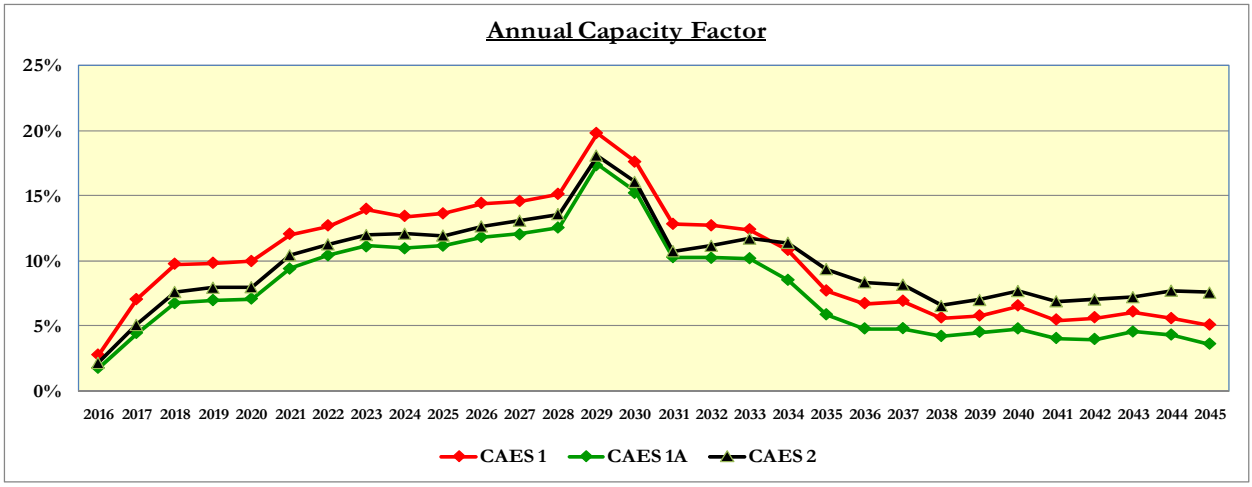
Next, develop the detailed Front End Engineering Design including cost and schedule estimates. NYSEG's engineering consultant, Worley Parsons generated its detailed cost estimates using an RFQ process for the major equipment. Using an RFP process has the benefit of being very reliable and defensible, however it is time consuming so adequate time in the schedule should be allocated if possible. During the RFP process, it may be worth considering requesting costs in various size ranges to allow for various scenario assessments during market and dispatch modeling, which is the next step.

Perform detailed market and dispatch modeling using the technical details from the FEED effort. Many scenarios may be modeled to determine whether there is an ideal ratio of above-ground capacities (both generation and compression), below ground capacities (well drilling and cavern development greatly influence schedule and cost), revenues, and costs.

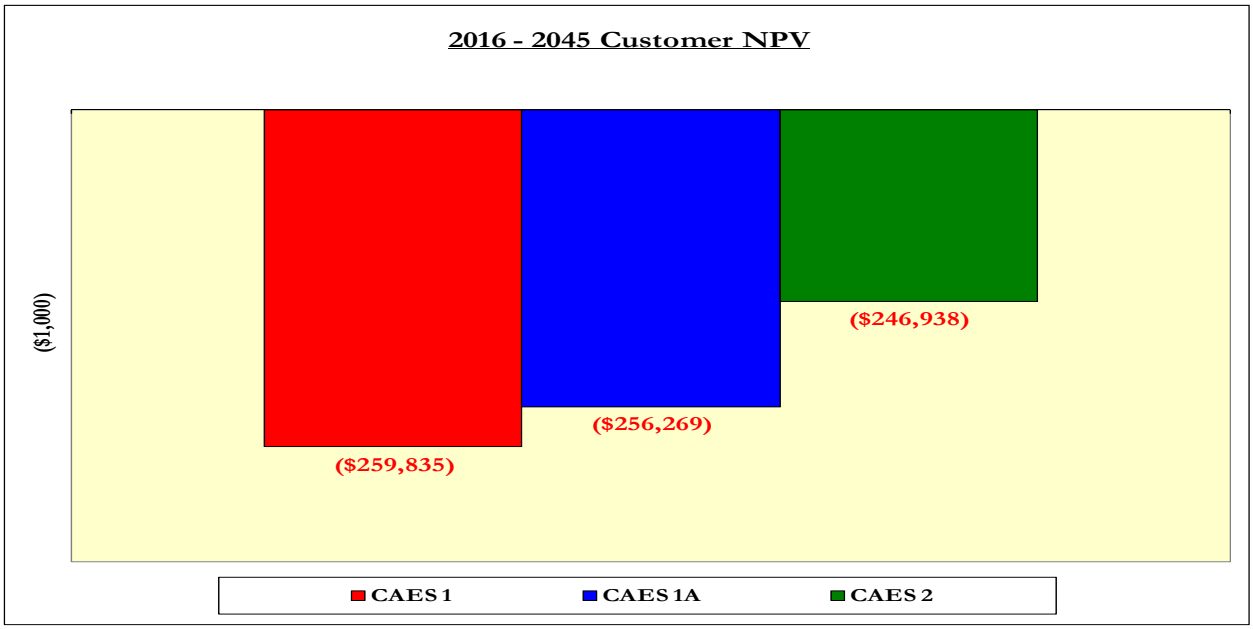
Next, conduct detailed financial modeling to make a Go/No Go decision on the project. Finally, implement a project development plan if the financial results are attractive.

1.3 Conclusions & Recommendation

The CAES plant designs tended to operate at very low annual capacity factors (under 20%) throughout the study period as illustrated in the chart below.



The plant operating profiles tended to be patterned after the operational duty cycle of a natural gas fired peaking unit. Given that the capital cost of this plant was estimated at two to three times the cost of a simple cycle natural gas combustion turbine, it is not surprising that in all but six years of the 30 years of the study period, the total market revenues received from plant operation would be less than the total revenue requirement of the plant. The CAES technology modeled in this study resulted in a negative net present value of over $240-million as shown below. As a result, it was recommended that NYSEG not proceed with further development of the Seneca CAES project.



2 General Overview of Project and Phase 1 Study Approach

2.1 Project Background

On November 30, 2010, NYSEG formally accepted a $29.6-million grant from the U.S. Department of Energy to evaluate and develop, if economically feasible, a Compressed Air Energy Storage (CAES) Plant. The scope of the project included the phased planning, design, engineering, construction, operation, performance monitoring, and cost/benefit assessment of an advanced compressed air energy storage (CAES) plant using an underground salt cavern. The proposed site was located in NYSEG's service territory in the Town of Reading, New York, at the southern end of Seneca Lake, in New York State's Finger Lakes region. A large volume, natural gas storage facility owned and operated by Inergy Midstream, LLC, is also located near this site and would have provided a source of high pressure pipeline quality natural gas for use in the CAES plant. The site has an electrical take-away capability of 210 MW via two NYSEG 115 kV circuits located approximately one half mile from the plant site.

The Seneca CAES plant would have had a rated capacity of between 136 MW and 210 MW, and would have provided sufficient storage to allow full operation during peak time periods, operating in support of the transmission system and market needs, i.e., approximately 10 to 12 hours per day. The plant would have been capable of recharging the air storage cavern in approximately 8 hours. These capabilities would have been sufficient to provide a wide range of operational benefits on the NYSEG transmission system and provide DOE and the US with a credible demonstration of an advanced CAES plant integrated into a modern, de-regulated wholesale electric market.

2.2 CAES Technology Overview and Design Basis

The Seneca CAES Project would have consisted of a separate, electrically driven compression cycle and a natural gas-fired expansion cycle. NYSEG evaluated two expansion cycle designs for the plant during Phase 1 of the project to determine whether the CAES technology provided sufficient customer benefit to proceed with Phase 2 project construction. The first CAES cycle evaluated (Cycle #1/1A) would have employed air expansion turbine generators with natural gas combustors to pre-heat the storage air prior to admitting it into the expanders. The CAES 1 cycle was nominally rated at 136 MW and the CAES 1A cycle was rated at 210 MW. The second CAES cycle (Cycle #2) evaluated was also nominally rated at 210 MW and consisted of a simple cycle combustion turbine with an air to air heat exchanger downstream of the combustion turbine exhaust that would have been used to pre-heat the storage air prior to admitting it into the air expanders.

The design basis for the project was developed through discussions with the dispatch modeling and engineering consultants retained for the project. The basis is shown below:

- Single fuel (natural gas only) operation. No back-up fuel provided.

- The generation train of the CAES plant must be able to operate up to 10 hours at full load; the air storage cavern system must be able to be re-charged to maximum pressure within eight hours by the compressor trains.

- The design must support daily cycling operation (full cavern working inventory discharge and re-charge) with up to 260 cycles per year.

- The large electric motors driving the air compressors must be able to quickly be de-coupled from the compressors so that the motors can be operated as synchronous condensers for VAR support.

- The CAES plant must be designed to provide "Black Start" capability.

- The operation of the facility must be capable of changing from generation to compression (or vice versa) within 10 minutes.

- The facility must be capable of providing regulation support service in response to automated signals from the NYISO dispatch center at a machine ramp rate of at least 8 MW/minute.

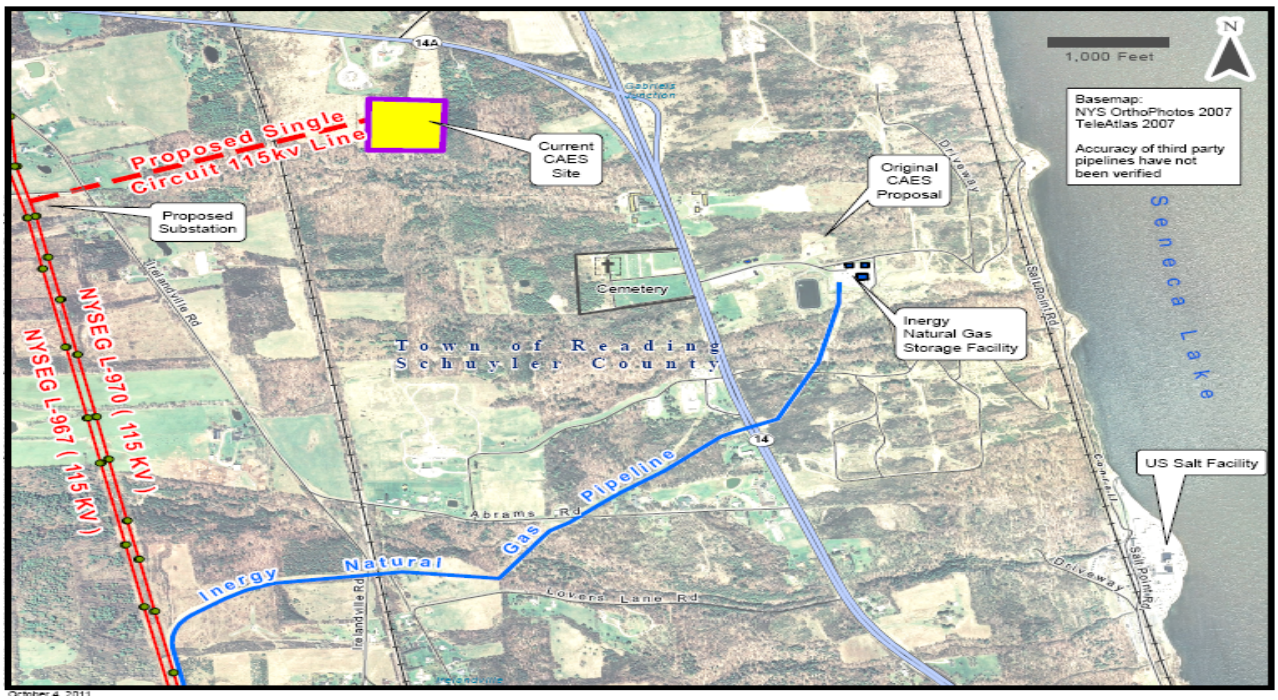
- Must meet stack emissions of 2.0 ppmvd NOx and CO @ 15% O2 with post combustion emission controls.

- The facility must be designed to operate stably while being in emission compliance limits between 25 % minimum to 100% load.

2.3 Project Site

The proposed site is located in the Town of Reading, New York, at the southern end of Seneca Lake, near Watkins Glen, in New York's Finger Lakes region. The surrounding land use includes a proposed propane storage and trucking center located adjacent to the CAES plant site, a natural gas storage facility, and a solution salt mining facility. The plant would be situated on a terrace surrounded by a natural screen of forested land so as to minimize its visibility from the road and lake. The landowner of the proposed site is Inergy, the company that owns the salt solution mining facility at this property. Inergy would have developed a new air storage cavern facility to be designed by NYSEG specifically for the Seneca CAES project. Under an agreement with Inergy, upon identification of a suitable cavern, NYSEG has the right to lease the cavern system and an above-ground plant site on Inergy's property for the CAES Project for a term of years sufficient to build, demonstrate, and operate the project.

The original location for the CAES plant site assumed that Inergy would offer NYSEG the use of an existing salt cavern, but as noted above, Inergy proposed to develop a new cavern for the CAES project and this site is located approximately one mile west of the originally proposed site as illustrated below:



2.4 Seneca CAES Project Phases

There are three phases of the proposed project:

– Phase 1: Develop a Front End Engineering Design including project capital costs; project financials based on the engineering design and updated forecasts of energy market revenues; design of the salt cavern to be used for air storage; development of draft environmental permit exhibits; development of draft NYISO interconnection filing information and exhibits.

– Phase 2: Plant construction with a target in-service date of mid-2016.

– Phase 3: Commercial demonstration, testing, and two years of performance reporting

The estimated total expenditures for Phase 1 are shown below:

Phase 1 Task	2011	2012 Estimate	Total
Project Management	**$295,100**	**$50,926**	**$346,026**
Dispatch and Financial Modeling	**$385,100**	**$0**	**$385,100**
Cavern Design	**$355,900**	**$345**	**$356,245**
Front End Engineering Design	**$1,564,300**	**$12,000**	**$1,576,300**
Licensing/Legal	**$81,600**	**$250**	**$81,850**
Total Direct	**$2,682,000**	**$63,510**	**$2,745,510**
DOE & NYSERDA Funding	**($1,217,100)**	**($403,854)**	**($1,620,954)**
Total Net Cost	**$1,464,900**	**($340,344)**	**$1,124,556**

2.5 Phase 1 Study Approach

NYSEG planned that Phase 1 would be completed by the end of 2011 at an estimated cost of $5-million. The DOE agreed to fund 50% of the cost of Phase 1, and the New York State Energy Research and Development Authority (NYSERDA) agreed to co-fund $250,000 during Phase 1. The Phase 1 Study was composed of four principal elements: Front End Engineering Design (FEED) and cost estimates for the CAES technologies; design of an air storage cavern and well system including development cost and schedule estimates; development of forward market price forecasts and a CAES dispatch model to evaluate the potential economic benefit from operating the technology in the New York wholesale electric marketplace; and development of a financial model by NYSEG/Iberdrola USA to demonstrate the NYSEG customer economic impact of building and operating the project.

The Engineering Contractor selected for this project was WorleyParsons. Their general scope of work included the following elements:

- Develop detailed project construction schedules, capital cost and cash flow estimates for both CAES cycles.
- Develop specific technical data required for plant permitting and licensing for both CAES cycles.

- Develop specific technical data and exhibits required for the New York Independent System Operator Interconnection Request process.

- Develop detailed operational data, including fuel and compression energy requirements, to support dispatch modeling for both CAES cycles.

- Develop electric and natural gas interconnection facility plans, drawings, equipment lists, construction schedules, and cost estimates.

- Develop plant staffing plans for both CAES cycles consistent with Good Utility Practice.

- Develop a Transmission Impact Study to demonstrate the impact and system benefits of the CAES technology on the electric transmission system.

- Identify design/operating risks of the CAES cycle technologies, assess the risk profile and potential mitigation measures and costs to support NYSEG's Risk Mitigation Plan filed with the DOE.

The Dispatch Modeling Consultant selected for this project was Customized Energy Solutions (CES). Their general scope of work included the following elements:

- Support NYSEG and WorleyParsons in optimizing CAES cycle designs to maximize wholesale electric market revenue opportunities while minimizing plant capital costs. The optimization required the development of an hourly dispatch model to be able to evaluate the market revenue opportunities for an air storage cycle.

- Evaluate alternative electricity and ancillary services revenue streams that could be available for the CAES plant operating within the NYISO market.

- Develop long term forecasts of wholesale electric market prices, natural gas prices, ancillary services revenues, and emission allowance prices for use in evaluating the economics of CAES technology operating in the NYISO market.

- Develop long range forecasts of wholesale market revenues and variable operating costs using the market price forecasts and dispatch model.

Parsons Brinkerhoff Energy Storage Services (PBESS) was retained to develop an air storage cavern and well system design for the CAES project. The scope of this engagement included the following elements:

- Review of site geology and verification that suitable salt formations exist at the plant site recommended by Inergy.

- Development of a cavern design, solution mining plan, and air production well design, cost, and schedule estimates for the project based on the design basis for the CAES plant.

The financial modeling performed for the project was based on an assumption that the New York Public Service Commission would authorize the recovery by NYSEG of all costs of constructing and operating the Project through the NBWC (or an equivalent non-bypassable delivery charge) with the customer receiving a credit for all wholesale electric revenues generated by the Project. When the Project is operating, NYSEG would bid the Project's energy, capacity and ancillary services products into the NYISO markets at NYSEG's actual incremental cost of the product and then credit back to the customer all revenues received from the NY ISO in connection with the sale. Since NYSEG is committing to flow back to its customers all of the revenues associated with the sale to the NY ISO of all products provided by the Project, the Commission should be satisfied that there will be no competitive or market power issues resulting from NYSEG's ownership or operation of the Project. NYSEG would have no financial stake in the outcome of the sale of Project products.

The financial model takes into consideration a number of cost estimates, including (a) the estimated cost of constructing the project itself; (b) the estimated costs of operating the project, including fixed and variable operating and maintenance expenses; (c) a number of long-range forecasts of wholesale electricity prices in the region (detailed in Section 8 below); and (d) projections of how the project is likely to be dispatched in light of the projected wholesale electricity prices.

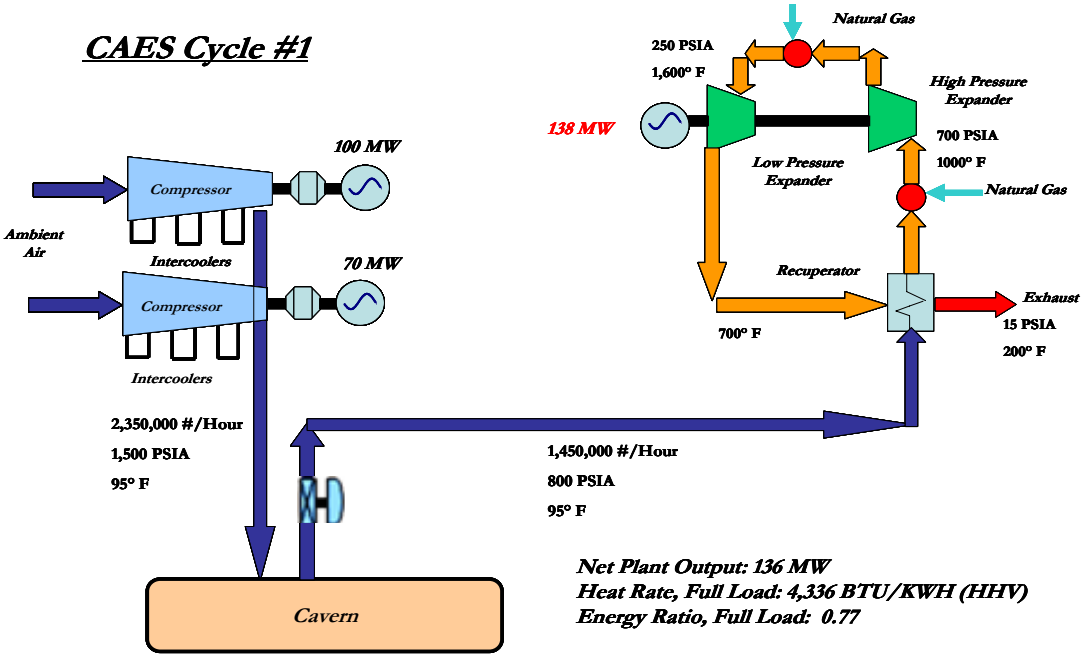
Key assumptions used in the financial model included:

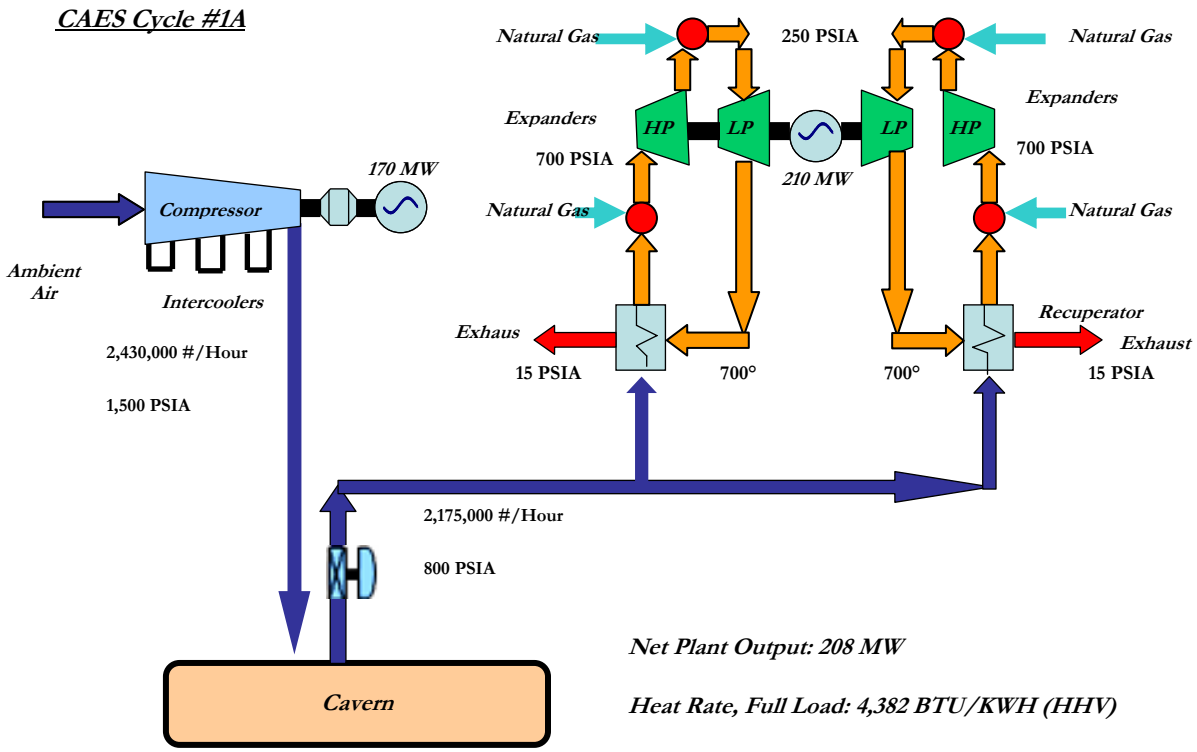
- DOE ARRA funding of $29.6-million; NYSERDA funding of $1-million.
- The DOE and NYSERDA Grants are taxable upon receipt, but the project qualifies as an R&D expense under IRS Code Section #174 and would be expensed for tax purposes in the year expended.
- Capital Structure: 48% Equity, 52% Debt
- Equity Return = 10%, Debt Rate = 5.5%

2.6 CAES Technologies Evaluated

During Phase 1, NYSEG evaluated two competing technologies. The CAES 1/1A technology was supplied by Dresser-Rand Corporation and is a significantly upgraded design based on the McIntosh Storage Plant built in Alabama in 1991. NYSEG evaluated two variations of this design, which have been designated as CAES Cycle 1 and CAES Cycle 1A.

Cycle 1A includes a larger generation plant (nominal 210 MW) and a single compressor train. CAES Cycle 1 is a smaller generation plant (nominal 136 MW) which is the "standard" Dresser-Rand configuration. The cycle diagrams are shown below:





Key characteristics of this overall cycle design include:

- Split generation and compression trains with the ability to switch modes of operation (i.e., compression to generation or vice versa) within approximately 10 minutes.
- Full load capability on the generation train within 10 minutes; similar capability on the compressor trains as well.
- Most of the components in the cycle would be sourced from the U.S., with the compression train primarily sourced in New York (NYSEG service territory).
- Dresser-Rand would provide both the compression and generation trains, control systems, recuperator, stack, and air pollution control equipment. Performance guarantees on the equipment and the overall cycle would be part of the Dresser-Rand offering.
- The high pressure air expander is a mechanical drive steam turbine that has been adapted to run on air; the low pressure expander was designed specifically for CAES cycle operation.
- The air expander generator as well as the compressor motors can be equipped with fast acting hydraulic clutches so they can be de-coupled from the turbo machinery and operated as synchronous condensers to provide VAR support (leading and lagging) to the transmission system.

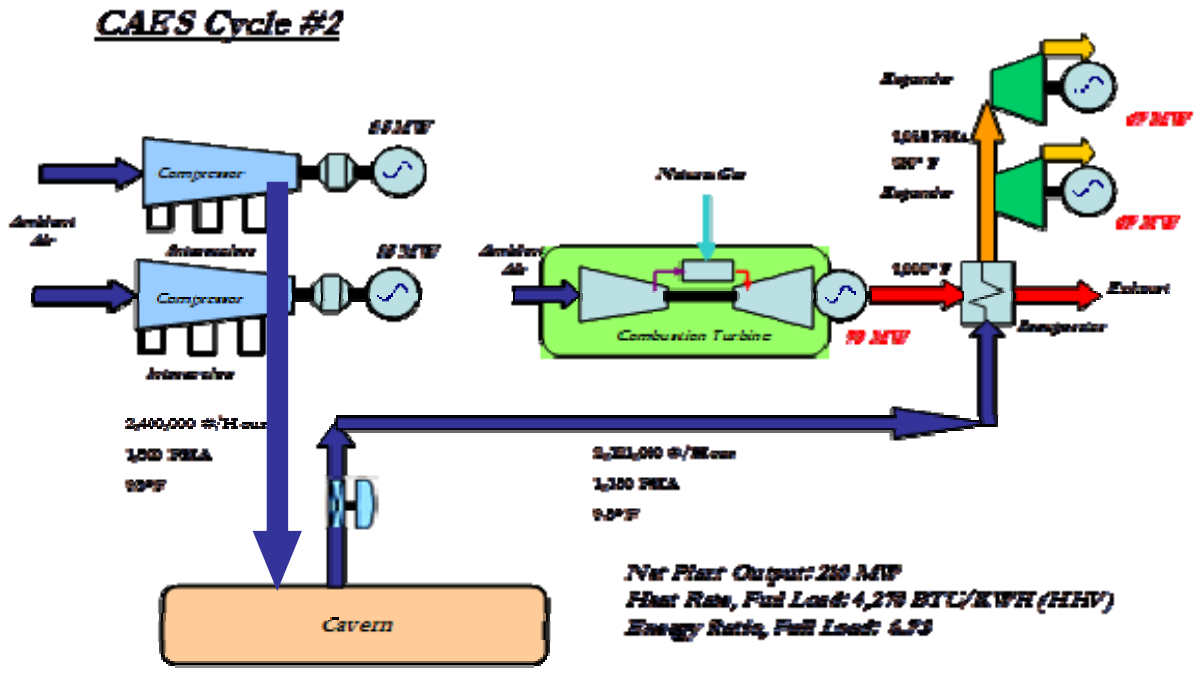
- Compressor start-up will be performed using a variable frequency drive to minimize starting load impacts on the electric transmission system.

- Air pollution control will be achieved through a CO catalyst and through a combination of water injection and SCR for NO_x control.

- The expander generator can provide rapid response to automatic generation control signals from the NYISO, with normal response rates of 8 MW/minute and emergency response rates of up to 25 MW/minute.

- The cycle can be configured to provide black start capability with the addition of an on-site natural gas fired generator to provide the required station service capability for start-up. The costs to provide this capability are included in the project cost estimates.

The CAES 2 (nominal 210 MW) technology is based on a design and patent developed by Energy Storage & Power (ES&P) with major equipment supplied by MAN Diesel Turbo (MDT) Corporation. The generation cycle is similar to a natural gas combined cycle in that it is based on using a simple cycle combustion turbine which then supports a bottoming cycle. The design is illustrated below:



Key characteristics of this design include:

- This cycle is a new design in the CAES arena and would be the first of its kind.

- Split generation and compression trains with the ability to switch modes of operation (i.e., compression to generation or vice versa) within 10 minutes.

- Full load capability on the generation train within 30 minutes due to the start-up time associated with the combustion turbine; the compressor trains can be at full output within 10 minutes if required.

- The CAES 2 cycle we have modeled is based on a GE Frame 7 EA combustion turbine which is made in the U.S. Most of the other components in the cycle would be sourced from Europe.

- ES&P/MDT formed a Joint Venture under U.S. law. MDT would provide both compression and expander trains. They would not provide the control systems, recuperator, stack, and air pollution control equipment, so the project A/E firm would need to develop the designs and procurement packages for those components. Performance guarantees on the equipment and cycle would be part of the MDT offering.

- The air expanders are mechanical drive steam turbines that have been adapted to run on air.

- The air expander generators as well as the compressor motors can be equipped with fast acting hydraulic clutches so they can be de-coupled from the turbo machinery and operated as synchronous condensers to provide VAR support (leading and lagging) to the transmission system.

- Compressor start-up will be performed using a variable frequency drive to minimize starting load impacts on the electric transmission system.

- Air pollution control will be achieved through a CO catalyst and an SCR for NO_x control.

- The expander generators can provide rapid response to automatic generation control signals from the NYISO, with normal response rates of 8 MW/minute and emergency response rates of up to 25 MW/minute.

- The cycle can be configured to provide black start capability with the addition of an on-site natural gas fired generator to provide the required station service capability for start-up. The costs to provide this capability are included in the project cost estimates.

3 Plant Siting and Licensing

The CAES project would be licensed under the new Article X siting law which was enacted at the end of the June, 2011 legislative session. Cavern solution mining, cavern use for air

storage, electric interconnection, and above ground plant licensing would be part of the Article X application. The natural gas transmission line needed to serve the CAES plant would be licensed under existing New York Article VII regulations.

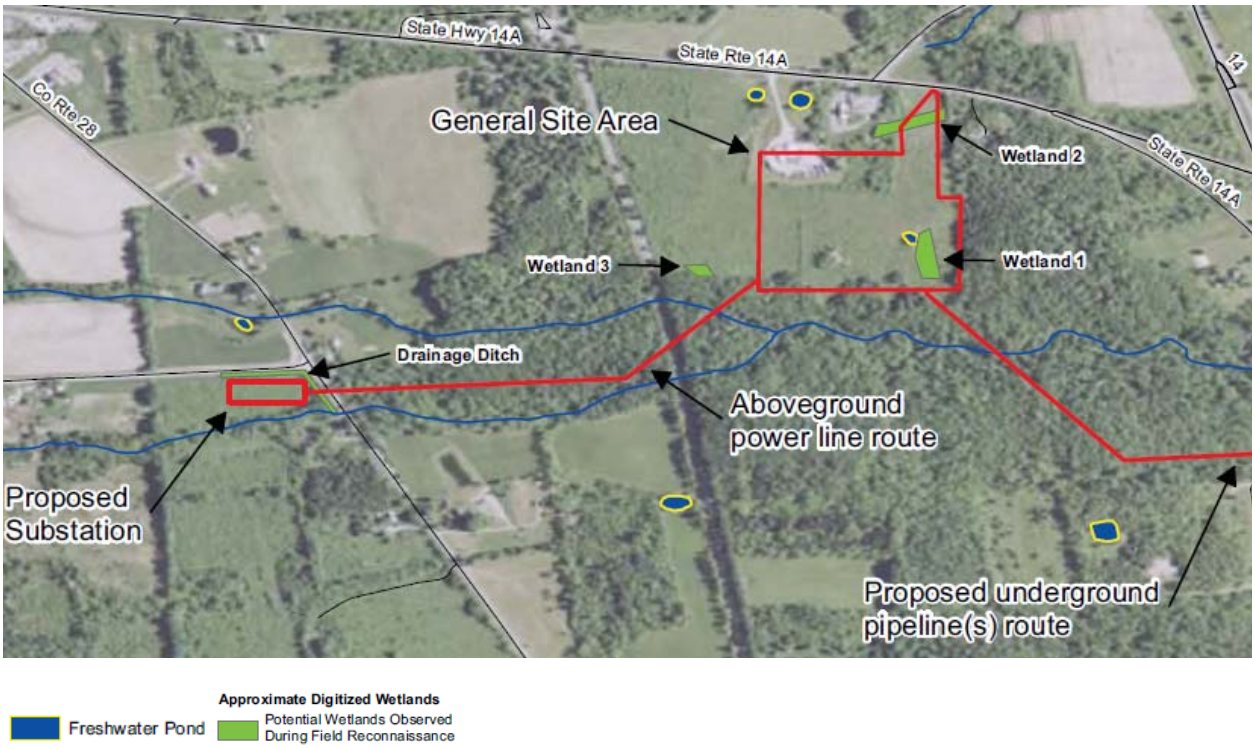
Regulations to implement the new Article X law are being developed by the New York State PSC and DEC. This development effort is expected to be completed by July, 2012 at which time the application for the Seneca CAES plant would have been filed. Under this schedule, the New York State Siting Board approval would have been received in December, 2013 and plant construction would have begun shortly thereafter. Development of the air storage cavern system would also be allowed to begin following the Siting Board Approval. The CAES project cost estimate includes approximately $2-million to cover the costs of the Article X licensing process.

While the Article X process is likely to be lengthy and costly, we anticipated that the project would have been successfully licensed within the schedule and cost estimates noted above. The results of the Phase 1 studies are detailed in the following sections.

3.1 Wetlands Assessment

As part of the Phase 1 wetlands assessment for the CAES Project, both a desktop review and a preliminary field reconnaissance was conducted of the areas proposed to be disturbed by the construction and operation of the CAES Facility, including both the plant site and the linear utility lines. The outcome of the desktop review resulted in the identification of one small open-water feature at the CAES plant site and three potential wetland areas (non-New York State Department of Environmental Conservation (NYSDEC) designated) at the CAES plant site. The field reconnaissance confirmed that the areas identified in the desktop assessment are potential jurisdictional wetlands based on observations of wetland vegetation, soil characteristics, hydrology, and potential connectivity to the tributaries to Seneca Lake (see Figure 1). The preliminarily CAES plant footprint was anticipated to impact the potentially jurisdictional federal wetland areas. In addition to these three wetlands, a roadside drainage swale was noted along Jennings Road and State Route 28 near the proposed substation location. Based on this preliminary field reconnaissance, no wetlands were observed along the proposed underground pipeline route corridor leading approximately south and east of the Project site.

Figure 1 – Potential Wetland Areas on Proposed CAES Facility Site



As a result of the preliminary field reconnaissance, under Phase 2 of the Project a request for formal jurisdictional wetland delineations would have to be submitted to the US Army Corps of Engineers (USACE), Buffalo Division. If the potential wetlands were determined jurisdictional, wetlands impact mitigation may have included both avoidance and minimization of impacts to jurisdictional wetland areas. Where impacts to wetlands cannot be avoided, compensatory mitigation options have been identified by USACE and in the US Environmental Protection Agency's (USEPA) Wetlands Compensatory Mitigation Rule. For the CAES Project, the primary focus of any compensatory mitigation requirements would likely have been to restore the wetland functions and services lost due to the Project by re-establishing a wetland in a suitable location within the Oswego River/Finger Lakes Watershed/Seneca Lake sub-watershed. Creation of a new wetland for compensatory mitigation would require a site that meets criteria for successfully developing wetlands. Compensatory mitigation measures typically require the restoration or creation of a larger wetland area than the area of wetland lost. Specific wetlands permitting requirements for the Project would have been determined as part of Phase 2.

If the wetland loss associated with the CAES Project had not qualified for a USACE Nationwide Permit (i.e., a streamlined permitting process), then an Individual USACE Permit would have been required. Wetland mitigation is a typical component of the USACE permitting process. The estimated time to receive a permit from USACE is approximately 9 to12 months following submittal of a completed permit application package. If all three wetlands were permanently impacted by the CAES Project, using the preliminary estimate of 1.3 acres of total wetland in the CAES Project footprint, a 3.9-acre (3X ratio factor) created

wetland area may have been required to compensate for the wetlands lost. This equates to an approximate wetlands construction cost of $390,000. Purchase of 4 acres of land for the wetland mitigation area construction could cost $100,000, depending on the location selected. Following construction of a wetland mitigation area, long-term maintenance and monitoring would likely be required for a period of at least 5 years at a cost of approximately $25,000 per year. These costs have been included in the project cost estimate and financial analysis.

3.2 Environmental Justice Assessment

A review and an analysis was conducted of potential environmental justice areas that could be affected by the CAES Project, identified existing environmental burden conditions on the area, and evaluated additional burden of any significant adverse environmental impact. Based on this review of the socioeconomic and demographic data, development of the CAES Project in Schuyler County, New York would not result in disproportionately high or adverse impacts to low income populations, or to minority or other identifiable groups. No impacts to environmental justice populations as defined by the applicable policies and regulations are anticipated by the CAES Project.

3.3 Cultural Resources

A Cultural Resources Survey was performed to establish whether any previously-identified historic properties exist within the Project's Areas of Potential Effects (APE's) and to investigate the potential existence of previously unidentified historic properties. No archaeological sites are known to exist within the direct APE, nor within two miles of the project area. However, a limited subsurface archaeological testing was recommended for Phase 2 of the Project to evaluate the level of prior disturbance throughout the Project area and to confirm the low sensitivity finding. A review of previously recorded historic architectural resources indicated that there are no such resources within the direct APE. However, once the indirect APE was determined, a survey would have been needed to determine whether any significant historic structures exist within the indirect APE.

The likely scenario for Phase 2 of the CAES Project is that, after consulting with the New York State Historic Preservation Office (NYSHPO), they would have asked for a limited archaeological survey of some portion of the direct CAES Project footprint. The cost for this level of archaeological survey would range from $50,000 to $65,000. For a modest architecture survey of a reasonable visual APE, the range of costs would be $20,000 to $30,000. For this mid-range effort, it would take approximately two to three weeks to complete the field work and another three to four weeks to prepare the findings report after the fieldwork is completed. These costs have been included in the project cost estimate and financial analysis.

3.4 Land Use Assessment

In general, the local and regional land use laws and plans share a similar goal of protecting viable farmland as a cornerstone of the local economy and to maintain the rural character of

the region. The Project's proximity to a proposed industrial land use (Finger Lake LPG storage), an existing industrial land use (salt mining), and a commercial land use (truck repair facility) would likely be considered more compatible than locating the Project in a more residential or strictly agricultural area within the Town of Reading. A portion of the Project (water intake structure and associated pipeline, pump house, and underground pipelines) is within the Seneca Lake Protection Area. The Town of Reading's Land Use Law permits no structures within 25 feet of the mean high water line of Seneca Lake. Construction of the water supply intake structure and its associated water intake pipeline for the Project would have been located in Seneca Lake and appear to conflict with the structures within 25 feet of the mean high water line requirement in the Land Use Law. Additional investigation regarding the potential for a variance from this requirement would have been required.

3.5 Vegetation & Wildlife

The terrestrial ecological resources within the Project area have been identified as to the type of vegetation, wildlife, wildlife habitat, and wildlife travel corridors. Wildlife may have been subject to some disturbance and displacement during the construction phase of the CAES Project. These impacts are anticipated to be minor and temporary, ceasing upon completion of the Project. Given the abundance and broad range of forested and open field habitats that exist nearby the CAES Project site that will not be disturbed, impacts to wildlife and wildlife corridors were anticipated to be minor. A review of the USFWS database of federally listed endangered and threatened species and candidate species revealed no federally protected animal species known to occur within Schuyler County. The New York State Natural Heritage Program indicated that no rare or state-listed animals and plants, significant natural communities, or other significant habitats occur on or in the vicinity of the CAES Project. A separate listing of the Endangered, Threatened and Special Concern Fish and Wildlife Species of New York State and their habitat ranges, identified Schuyler County within the range of four avian and bat species. Based on information provided by the Natural Heritage Program, the four protected species listed are not anticipated to be within the vicinity of the CAES Project.

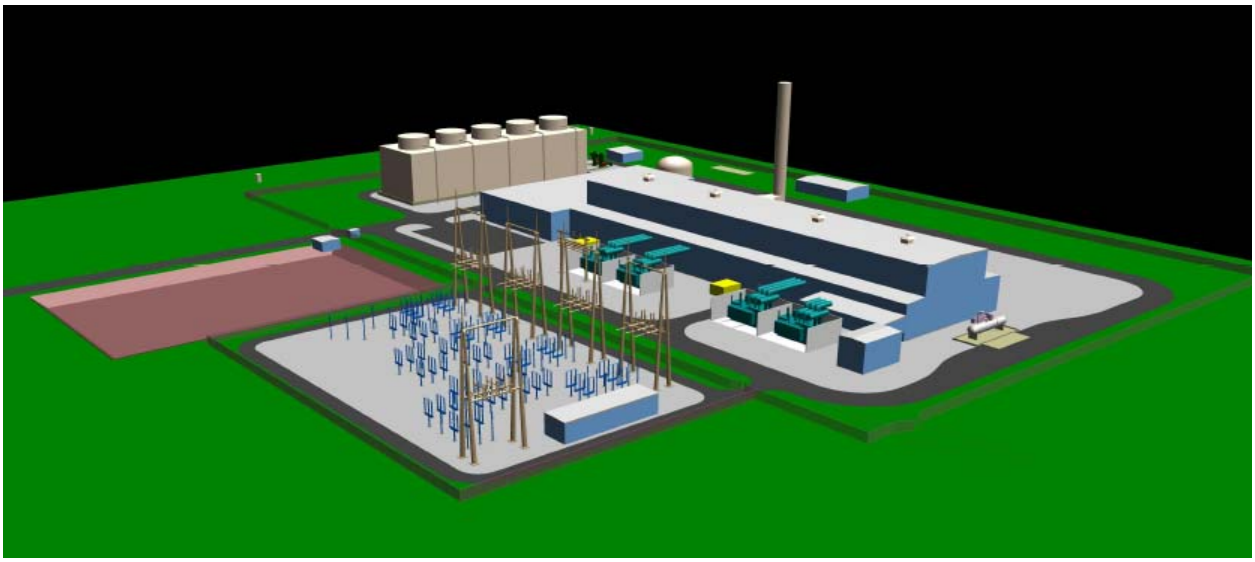
3.6 Water Resources

Potential impacts on water resources from the construction and operation of the Project were assessed. Construction of the plant, the underground pipelines, and the aboveground power lines may have temporarily impacted Seneca Lake and two of its tributaries. The CAES facility was expected to withdraw approximately 0.47 million gallons per day (mgd) from Seneca Lake. According to the NYSDEC inflow to Seneca Lake is approximately 470 mgd from tributaries and groundwater inflow. As such, the CAES water intake rate represents approximately 0.1 percent of the average inflow to Seneca Lake. To supplement the make up water demand and to minimize the amount of water withdrawn from Seneca Lake, storm water runoff was to be collected and stored in an on-site retention pond. Cooling tower blowdown from the facility would have been the principal wastewater discharged to Seneca Lake where it would be diluted and mixed with water in Seneca Lake. For this assessment, a mixing zone is assumed to exist. However, consultation with

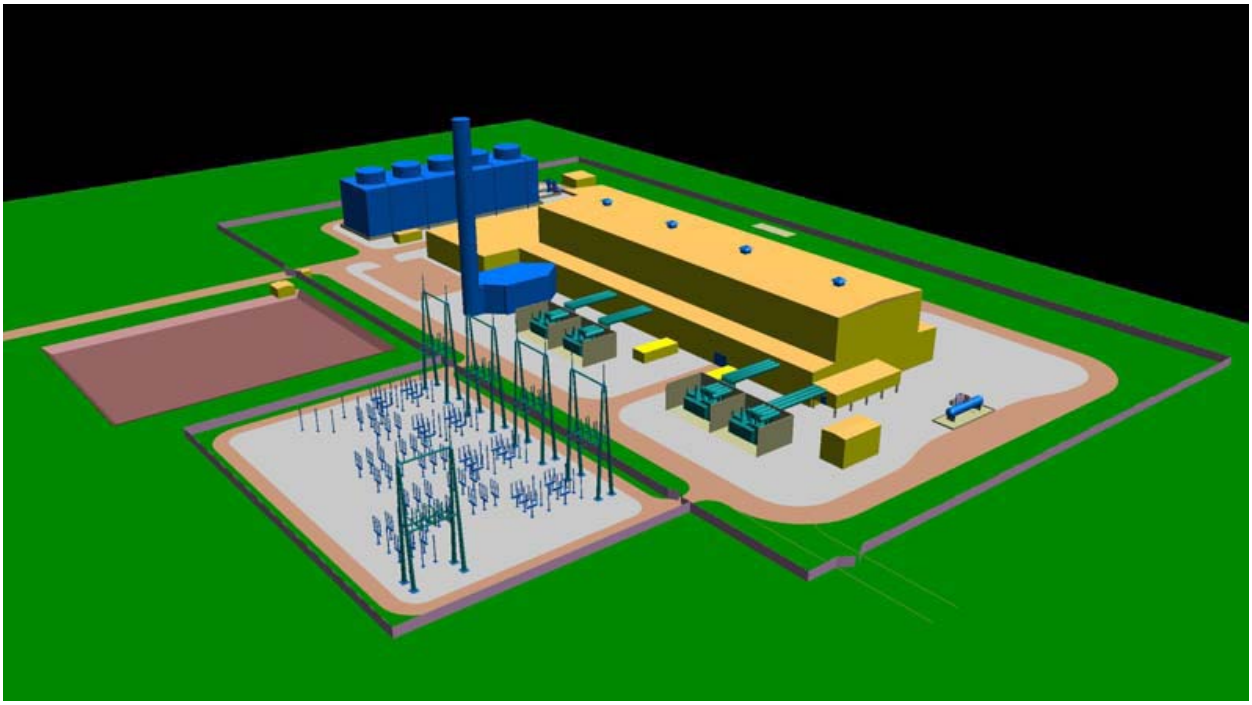
NYSDEC would have been required to determine acceptable analysis methodologies to evaluate the impacts of discharging cooling tower blowdown into Seneca Lake.

3.7 Visual Impacts

Visibility impacts associated with proposed structures on the CAES plant site were assessed based on the surrounding ground surface elevation and potential screening forest cover.



Proposed Site Layout (Cycle 1) Looking Southeast



Proposed Site Layout (Cycle 2) Looking Southeast

The area with the highest potential visibility of structures on the main plant site is the eastern side of Seneca Lake. The eastern shoreline of the lake has a high predicted visibility due to the lower elevation and direct line of site created by the open water. The forest cover on the eastern side of the lake, however, extends to the shoreline and so when vegetation screening is taken into account, the potential visibility decreases dramatically away from the shoreline. The potential visibility of the site decreases further east, due to elevation changes with the ridge dropping away to the east. North, south, and west of the site generally have lower predicted visibility because of topographic variations and existing forest cover screening the site from view.

3.8 Air Resources

Potential impacts on air resources from the construction and operation of the Project were assessed. Impacts during construction of the plant would have been temporary and minimized by implementing a fugitive dust control plan. Air emissions from the CAES Plant would be controlled to meet applicable new source performance standards and new source review/prevention of significant deterioration of air quality requirements. During Phase 2 air quality dispersion modeling would have been performed to demonstrate that the emissions from the CAES Plant would not cause a violation of national ambient air quality standards.

4 Air Storage Cavern and Air Production Well Design

4.1 Background

NYSEG had an agreement with Inergy under which Inergy had agreed to provide NYSEG with a suitable air storage cavern (either new or existing) and surface area sufficient to accommodate the above-ground plant for the anticipated term of the project. This agreement also contains terms specifying the proposed lease term, annual rent, and rental escalation provisions for both the cavern and ground portions of the lease, which have been factored into the economic calculations in this report.

In March, 2011, Inergy proposed to provide NYSEG with a new storage cavern and adjacent ground lease on a site approximately one mile west of the existing salt cavern field. The proposed site is located on a property owned by Inergy that is located on the west side of NYS Route 14.

The proposed site is adjacent to a proposed propane and butane unloading facility that Inergy is currently in the process of licensing. There is sufficient room on the site to locate the CAES plant and still maintain safe distances (per NFPA guidelines) from the propane and butane unloading facilities. The site does have a number of positive attributes, including:

- The area is on a flat, level parcel with minimum of cut and fill required.

- The site is within one half mile of the electric transmission interconnection and there is a very direct transmission corridor from the plant site to the 967 and 970 lines.

- The site is well screened to the east and south by mature trees; there will be very limited visual impact as seen from the lake and the eastern shore.

- This area of Central New York overlays an extensive formation of bedded salt beginning at the 2,300 foot level below the surface and the development of new, solution-mined salt caverns should not be an issue.

- There are some adjoining properties to the plant site that could be acquired to provide a buffer zone around the plant; the only residential structure in the immediate vicinity of the site is on one of these properties.

The original Seneca CAES DOE proposal was based on a January, 2008 study conducted by Parsons Brinkerhoff Energy Storage Services (PBESS) and EPRI. That study determined that an existing cavern (Gallery #2 on the US Salt property adjacent to the former NYSEG Seneca Natural Gas Storage facility) of approximately 5 million cubic feet in size could operate safely and reliably in support of a 180 MW CAES plant. The plant operating range studied was between 1,670 psig and 400 psig. The results of this study formed the basis of the cavern agreement between Inergy and NYSEG.

During Phase 1 of the Seneca CAES project, NYSEG again retained PBESS to review the CAES plant design basis and to develop a new cavern design, solution mining plan, cost estimate, and schedule, along with an air production well design. NYSEG, working with WorleyParsons the Phase 1 General Technical Contractor and with Customized Energy Solutions the Phase 1 Dispatch Modeling Contractor, developed a preliminary design basis for the CAES cycles and the air storage cavern. The preliminary design basis for the air storage cavern is shown below:

Maximum wellhead operating pressure	1,500 psig
Minimum wellhead operating pressure	750 psig
Maximum wellhead flow rate (at 480 psig)	660 #/second
New Cavern compressed air recharge cycle length	8 hours
New Cavern compressed air discharge cycle length	10 to 12 hours
Expected Number of Charge/Discharge Cycles	260 cycles/year
Temperature of compressed air at wellhead	95^{o} F
Cavern Free Void Space	5 million ft^{3}

PBESS performed an initial series of thermodynamic and geo-mechanical modeling based on their knowledge of the salt formations in this area and on the design basis assumptions noted above. The results of their modeling revealed the following:

- During daily compression cycles, cavern wall temperatures would rise to approximately 140° F; during daily discharge, the cavern wall temperatures would fall to approximately 60° F as the stored air expands out of the cavern.

- The modeling indicated that this rapid temperature change is large enough and occurs quickly enough for the salt on the cavern ceiling and walls to go from compression (normal state due to the weight of the overburden above the cavern) into tension; this would cause spalling of salt which would lead to deterioration of the cavern particularly at the air production well penetration.

- Under these circumstances, the cavern and well system would fail early in the operating life of the CAES plant.

PBESS recommended the following measures to address these findings:

- Limit wellhead operating pressures to between 1,500 psig and 1,150 psig (the rate of cavern ceiling and wall cooling is directly proportional to the change in cavern pressure, so limiting the operating pressure range would directly limit the temperature differentials indicated in the modeling during air withdrawal and avoid the spalling of the cavern ceiling and walls noted above).

- Maintain at least 50 ft of salt on the ceiling of the cavern to ensure the integrity of the pressure boundary of the cavern for 30 years of plant operation.

- Limit the cavern diameter to 270 ft or less to maintain a safe roof loading on the cavern during operation.

- Limiting the operating pressures would require a cavern size increase to meet the airflow requirements of the CAES plant. The cavern would need to be approximately three times larger than the 5 million ft^3 single cavern originally planned for the project.

- Based on the geology in the area, the development of a new, larger single cavern was not recommended. PBESS recommended that the maximum cavern size be approximately five million cubic feet in size.

- Based on this recommendation, PBESS recommended that a series of three new caverns, each approximately 5 million ft^3 operating in parallel would be the best design option for the CAES plant. Under this plan, the CAES plant could be placed

into commercial operation at a much earlier time (with limited operating time at full load) with at least one cavern ready for service.

The final design basis for the air storage cavern system is shown below:

Number of Caverns Required	3
Maximum wellhead operating pressure	1,500 psig
Minimum wellhead operating pressure	1,150 psig
Maximum wellhead flow rate (at 480 psig)	660 #/second
New Cavern compressed air recharge cycle length	8 hours
New Cavern compressed air discharge cycle length	10 to 12 hours
Expected Number of Charge/Discharge Cycles	260 cycles/year
Temperature of compressed air at wellhead	95^{o} F
Total Cavern Free Void Space	15 million ft^{3}
Total Usable Air Storage Inventory	17.8 million #

PBESS proceeded to develop the detailed cavern designs, well designs, and solution mining plan based on this design basis.

4.2 Cavern Design

PBESS was tasked with developing a three cavern design. This work scope included the cavern design, solution mining plan, well design, and overall cost and schedule estimates. The cavern system would have been developed in cooperation with Inergy/US Salt. The solution mining program is based on a brine acceptance rate of 350 GPM at the US Salt plant. Based on this take-away rate, PBESS estimated that it would take approximately two years to solution mine each cavern. As a result, the CAES plant would enter commercial operation with only one cavern in service which would have limited the operating hours but would not have limited the maximum generation output of the plant. The second and third caverns would come on line at approximately two year intervals following cavern number one. Current schedule estimates indicate that full three cavern operation would not be achieved until 2021. The capability of the cavern system is summarized below:

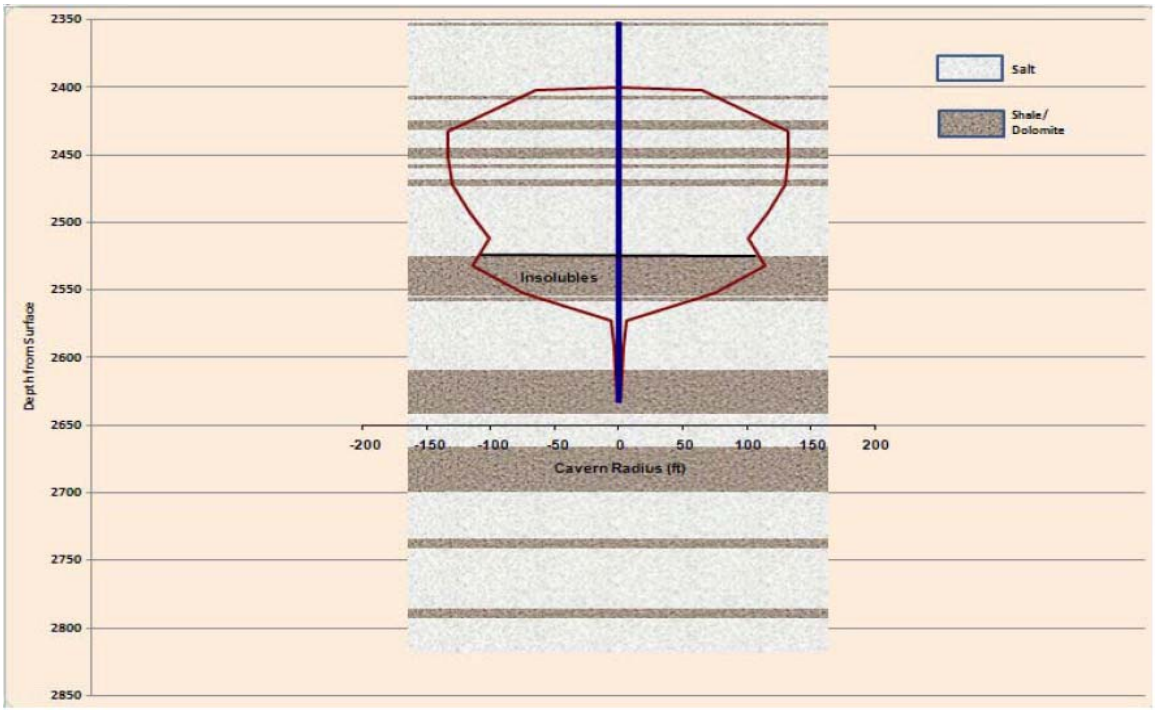
- The CAES cycles require a working gas capacity of 17.8 million lbs of air. Using the proposed cavern system design:
  - Three caverns operating in parallel would provide about 18 million lbs or 102 percent of this capacity (34 percent per cavern)

- Two caverns operating in parallel would provide about 11 million lbs or 62 percent of this capacity (31 percent per cavern)

- A single cavern operating alone would provide about 5.1 million lbs or 29 percent of this capacity

The dispatch modeling/financial modeling for the project incorporates this phased-in cavern development approach. If the Seneca CAES project were proceeding into Phase 2 development, NYSEG would have discussed with Inergy/US Salt whether there may have been opportunities to modify and enhance the brine take-away rates in order to accelerate the development of the cavern system. The caverns would have been developed using conventional solution mining techniques well known in the industry. The proposed cavern design would include a single air production well for each cavern, with Cavern #1 using a 20 inch diameter well (to permit full load operation during development of Caverns #2 and #3). Caverns #2 and #3 would utilize 16 inch air production wells. The well liners would be 316 Stainless Steel for corrosion resistance.

The cavern design is shown in the schematic below. The cavern roof spans and profiles have been developed by PBESS to ensure reliable operation for the thirty year design life of the CAES plant.



4.3 Cavern and Well System Cost and Schedule Estimate

The cavern and well system development schedule has been incorporated into the overall project schedule and has been used in the dispatch model. Milestones for the cavern system included:

- Begin Cavern #1 Development in December, 2013 upon receipt of Article X approval; cavern and well system ready for service in July, 2016. (This date includes the time after completing cavern #1 for the above grade commissioning and start-up activities that need the cavern in operational status.)

- Begin Cavern #2 Development in April, 2016; cavern and well ready for service in November, 2018.

- Begin Cavern #3 Development in September, 2018; cavern and well ready for service in March, 2021.

The estimated cost to develop the cavern and well system is $39-million, and has been included in the project cost estimates.

5 CAES Front End Engineering Design

5.1 Equipment Description CAES 1 and 1A

The CAES 1 and CAES 1A cycles consist of separate compression and generation trains each capable of being independently operated. All of the major turbo machinery would be provided by Dresser-Rand, and Dresser-Rand would offer performance guarantees for the equipment and for the cycle.

The CAES 1 compression trains consist of two independently driven compressors which would take air at atmospheric pressure and compress the air to 1,500 psig. One train would be equipped with a 100 MW synchronous A/C motor, and the other with a 70 MW synchronous A/C motor. Both compressor trains include a low pressure compressor (axial flow), followed by intermediate and high pressure compressors (centrifugal) in series. Both compressors are equipped with interstage cooling to achieve high efficiency and both are equipped with an after-cooler on the discharge of the high pressure compressor to maintain air temperatures entering the well and cavern system to 95°F. The interstage and after stage cooling would reject low grade waste heat to a mechanical draft cooling tower with tower make-up water to be supplied from Seneca Lake. The compressors and electric motor drives would be coupled using a hydraulic clutch assembly that would allow the motors to be quickly and easily de-coupled from the compressors so that the motors can operate a synchronous condensers to provide VAR support to the transmission system. The compressor motors would also be capable of being operated with a leading power factor of approximately 96% to provide the VAR support while they are running that would otherwise require installation of 115 kV switched capacitors. The compressor motors would be started

using a Variable Frequency Drive so that starting transients are not imposed onto the 115 kV transmission system.

The CAES 1A design is similar to the above description except that it is a single train using a single large motor drive (170 MW) to power the compressors.

The CAES 1 generation train consists of two air expanders coupled to a common electric generator. The net output of the generation train is expected to be 136 MW. Both air expanders would be preceded by an external combustor firing natural gas. The high pressure air expander would be a steam turbine that has been converted to operate on air. The low pressure expander has been specifically designed for CAES cycle operation. The electric generator can provide limited VAR support at the same time as it is generating, and the generator would also be equipped with a fast acting hydraulic clutch so that it can be decoupled from the air expanders. The generator can then be operated as a synchronous condenser similar to the compressor motors to provide significant VAR support to the 115 kV transmission system. The CAES 1A generation train consists of a single generator driven at either end by an HP/LP expander combination. Clutches on either end of the generator allow it to be driven by either one or both of the expander trains. Both expander trains would have their own recuperator and stack.

The recuperator would include both a CO catalyst and SCR to maintain emissions compliance. The high and low pressure combustors would also utilize demineralized water injection to help maintain NO_x compliance. Make-up demineralized water equipment and storage tanks would also be part of the cycle design.

A substation located at the CAES plant site would connect the plant to NYSEG's transmission system. A 115 kV switchyard would be built adjacent to NYSEG's Lines 967 and 970 where the physical interconnection would occur. This new switchyard would include all circuit breakers and metering equipment specified in NYSEG's Interconnection Standards. A 115 kV single circuit wood pole line approximately one half mile long would connect the plant substation with the Interconnection Point switchyard.

A natural gas interconnection would be made to Inergy's Seneca West Transmission Pipeline near the Seneca Natural Gas Storage compressor building. A new, one mile natural gas transmission line would be built by NYSEG's Gas Department to serve the CAES plant. The pressure in the Seneca West Pipeline varies during the course of seasonal operation so a small natural gas compressor station would need to be installed at the CAES plant site to ensure that 950 psig natural gas is available to supply the high pressure combustor. The low pressure combustor operates at 400 psig which is well below the minimum Seneca West pressure so no upstream natural gas compression would be required. At full load, the CAES 1 plant would consume approximately 15 dekatherms per hour. At full load, the CAES 1A plant would consume approximately 23 dekatherms per hour.

The CAES 1 and 1A plants would be housed in a building to provide noise shielding and to allow the plant to be operated and maintained in the central New York climate. The building

would also incorporate a control room, small office, maintenance shops, and locker rooms. A meeting room and small visitor's center would also be part of the site plan. The height of the compressor/generator building would be approximately 50 feet, and the exhaust stack(s) would be 180 feet tall with a diameter of approximately 16 feet.

The air storage caverns were planned for an area to the east of the plant as shown on the General Arrangement drawing. Production air pipelines from the wells to the plant would be built underground for personnel safety.

The plant would be equipped with a 400,000 gallon water tank to provide make-up water for cooling tower evaporative losses as well as for plant fire protection. A diesel-fired fire pump and associated fire detection and deluge systems would be installed to comply with NFPA guidelines. Propane and butane detection equipment would also be installed within the plant and at the plant boundaries, and appropriate berms would be included as part of the site plan to guard against any spills that could occur at the Inergy propane and butane unloading facility.

A natural gas fired back-up generator would be installed to provide required station service electrical support needed for plant "Black Start" operation if it is economic to provide that capability. This generator would allow the air expanders and critical plant equipment to start without the need for offsite power.

The plant control system would be a Digital Control System (DCS) designed to interface through NYSEG's SCADA system to the New York ISO dispatch center. The CAES plant would be able to respond to automatic generation control signals directly from the NYISO. The DCS would also need to comply with FERC/NERC Cyber Security standards and the CAES plant would need to provide the DOE with an Interoperability and Cyber Security Plan that details how this compliance would be achieved and maintained.

5.2 Equipment Description CAES 2

The CAES 2 cycle consists of separate compression and generation trains each capable of being independently operated. All of the major turbo machinery with the exception of the combustion turbine would be provided by MAN Diesel Turbo (MDT), and MDT would offer performance guarantees for the equipment and for the cycle. A General Electric Frame 7EA combustion turbine has been modeled in the analysis of the CAES 2 cycle.

The compression trains consist of two independently driven compressors which would take air at atmospheric pressure and compress the air to 1,500 psig. Each train would be equipped with an 85 MW synchronous A/C motor. Both compressor trains include a low pressure compressor (axial flow), followed by a high pressure compressor (centrifugal) in series. Both compressors would be equipped with interstage cooling to achieve high efficiency and both would be equipped with an after-cooler on the discharge of the high pressure compressor to maintain air temperatures entering the well and cavern system to 95°F. The interstage and after stage cooling would reject low grade waste heat to a

mechanical draft cooling tower with tower make-up water to be supplied from Seneca Lake. The compressors and electric motor drives can be coupled using a hydraulic clutch assembly that would allow the motors to be quickly and easily de-coupled from the compressors so that the motors can operate as synchronous condensers to provide VAR support to the transmission system. The compressor motors would also be capable of being operated with a leading power factor of approximately 96% to provide the VAR support while running that would otherwise require installation of 115 kV switched capacitors. The compressor motors would be started using a Variable Frequency Drive so that starting transients are not imposed onto the 115 kV transmission system.

The generation train consists of two parallel air expanders with separate electric generators. The generation train also includes a GE Frame 7 EA combustion turbine. The net output of the composite generation train is expected to be 226 MW, but site electrical take-away capability would limit the unit to approximately 210 MW net output. Both expanders would be steam turbines that have been converted to operate on air. The electric generators could provide limited VAR support at the same time as they are generating, and the generators could also be equipped with a fast acting hydraulic clutch so that they could be decoupled from the air expanders. The generators could be operated as synchronous condensers similar to the compressor motors to provide significant VAR support to the 115 kV transmission system. The combustion turbine generator would not be equipped with clutches and would not be operated as a synchronous condenser.

The recuperator would include both a CO catalyst and SCR to maintain emission compliance.

A substation located at the CAES plant site would connect the plant to NYSEG's transmission system. A 115 kV switchyard would be built adjacent to NYSEG's Lines 967 and 970 where the physical interconnection would occur. This new switchyard would include all circuit breakers and metering equipment specified in NYSEG's Interconnection Standards. A 115 kV single circuit wood pole line approximately one half mile long would connect the plant substation with the Interconnection Point switchyard.

A natural gas interconnection would be made to Inergy's Seneca West Transmission Pipeline near the Seneca Natural Gas Storage compressor building. A new, one mile natural gas transmission line would be built by NYSEG's Gas Department to serve the CAES plant. The combustion turbine would operate at 350 psig which is well below the minimum Seneca West pressure so no upstream natural gas compression would be required. At full load, the CAES 2 plant would consume approximately 23 dekatherms per hour.

The CAES 2 plant would be housed in a building to provide noise shielding and to allow the plant to be operated and maintained in the central New York climate. The building would also incorporate a control room, small office, maintenance shops, and locker rooms. A meeting room and small visitor's center would also be part of the site plan. The height of the compressor/generator building would be approximately 50 feet, and the exhaust stack would be 180 feet tall with a diameter of approximately 16 feet.

The air storage caverns were planned for an area to the east of the plant as shown on the General Arrangement drawing. Production air pipelines from the wells to the plant would be built underground for personnel safety.

The plant would be equipped with a 400,000 gallon water tank to provide make-up water for cooling tower evaporative losses as well as for plant fire protection. A diesel-fired fire pump and associated fire detection and deluge systems would be installed to comply with NFPA guidelines. Propane and butane detection equipment would also be installed within the plant and at the plant boundaries, and appropriate berms would be included as part of the site plan to guard against any spills that could occur at the Inergy propane and butane unloading facility.

A natural gas fired back-up generator would be installed to provide required station service electrical support needed for plant "Black Start" operation if it is economic to provide that capability. This generator would allow the air expanders and critical plant equipment to start without the need for offsite power.

The plant control system would be a Digital Control System (DCS) designed to interface through NYSEG's SCADA system to the New York ISO dispatch center. The CAES plant would be able to respond to automatic generation control signals directly from the NYISO. The DCS would also need to comply with FERC/NERC Cyber Security standards and the CAES plant would need to provide the DOE with an Interoperability and Cyber Security Plan that details how this compliance would be achieved and maintained.

5.3 Operational Capabilities

The CAES 1/1A and 2 designs offer a number of operational capabilities that would provide significant flexibility in meeting both current and future wholesale electric market needs. Among these capabilities are the following:

- The compression trains could be started very rapidly (approximately 10 minutes to full operation) to capture short term opportunities in which wholesale electric market prices might fall to very low levels due to system upsets or short term (one to two hour) transients. While NYSEG would likely limit the number of starts per year to maintain long term equipment material condition, the compression train would have a high degree of flexibility to take advantage of short term low or negative prices in the wholesale markets.

- The compression trains would be large enough to charge the cavern system in under 8 hours to allow the CAES plant to operate in daily cycling mode to maximize wholesale electric market revenue opportunities.

- The compressors could be quickly and easily decoupled from the electric drive motors so that the motors could operate as synchronous condensers to provide VAR support to the transmission system during any hour in which compression operations

are not required. These are very large electric motors and would be capable of providing significant levels of leading and lagging power factor support. The use of a Variable Frequency Drive (VFD) would allow the motors to be started very quickly in response to a decision to operate in synchronous condenser mode.

- The CAES 1 and 1A air expander-generators could be started very quickly and could achieve full load within approximately 10 minutes from a signal to start.

- The CAES 2 combustion turbine and air expander-generators could be started quickly and could achieve full load within approximately 30 minutes from a signal to start.

- The cycles would be capable of responding to load changes very rapidly (up to 25 MW /minutes if required) and would be capable of providing 8 MW/minute of regulation service in direct response to automatic generation control signals from the NYISO.

- The air expander-generators could provide limited VAR support during operation and could provide significant VAR support when not in generation service using a clutch and VFD similar to the compressor motors.

- The CAES 1/1A design could operate between full load and 10% load while remaining in environmental compliance.

- The CAES 2 design could operate between full load and 25% load while remaining in environmental compliance.

- The combustion turbine, air expanders, and compressors are based on established designs and product experience in the refining, petrochemical, and oil/gas production markets, and the vendors have extensive engineering and maintenance support capabilities.

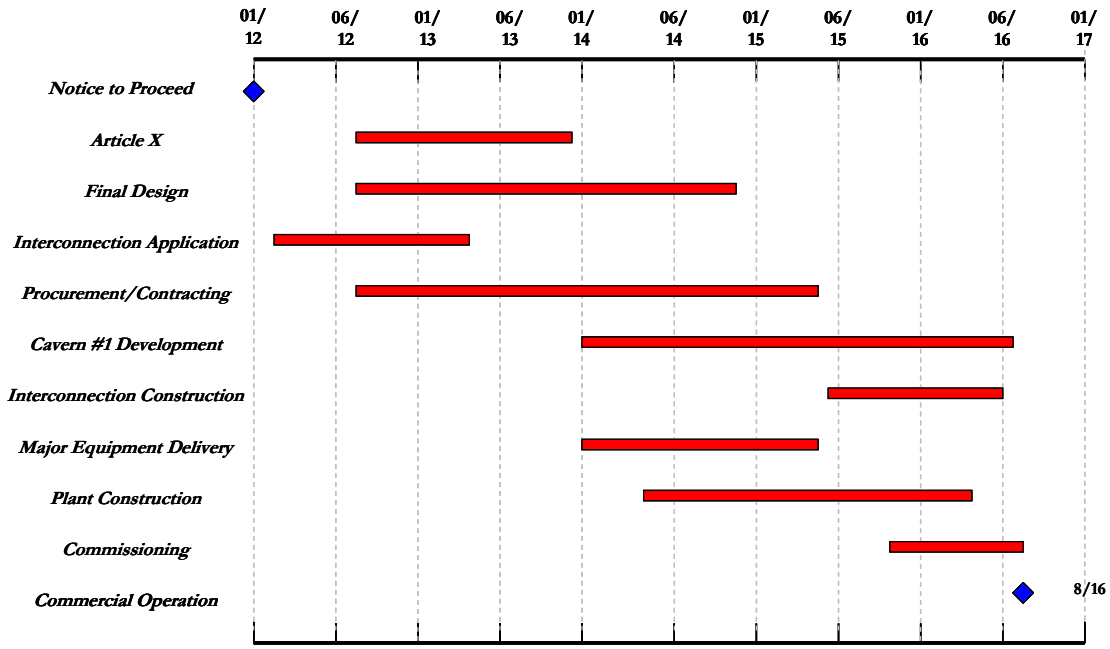
5.4 Operational Performance

CAES Cycle 1/1A performance across a major portion of the load range would be remarkably stable between 100% and 30% load. CAES Cycle 2 performance across a major portion of the load range would be remarkably stable between 100% and 50% load. The performance of the units would not be significantly affected by ambient temperature and relative humidity. While the plant may experience some minor performance degradation over time, proper maintenance should provide long term, stable operation.

6 CAES Project Development Schedule

The licensing and construction of the above ground portion of the plant would take approximately four and one-half years from the Notice to Proceed. The schedule would be

essentially the same for both CAES cycles. The solution mining of the first storage cavern would also occur during this period. A high level illustration of this schedule is shown below:



7 Project Cost Estimates

The capital cost estimates for the CAES 2 cycles were developed by WorleyParsons using a "bottom up" approach based on detailed Front End Engineering Design and supported by vendor quotes for major equipment and systems. Bulk materials, construction costs, transportation costs, and contingencies were developed using WorleyParsons standard project estimating practices. NYSEG provided estimates for Owner's Costs and AFUDC. The project cost estimates developed by WorleyParsons were escalated to the periods in which the expenditures would actually be made according to the overall project schedule. WorleyParsons engaged Cambridge Energy Research Associates (CERA) to obtain escalation indices for each year during Phase 2 for the project. Indices were obtained for 12 key equipment and bulks categories. CERA offered the indices based upon two different scenarios, "Global Redesign" and "Vortex". The "Global Redesign" is the base (most likely) case, is the only one used by CERA for short term forecasting, and therefore was used by WorleyParsons for this project. While individual indices rose/fell by up to approximately 20% in a single year, the overall escalation for the above grade plant averaged just over 2% per year.

CAES 1 Project Development Cash Flow Estimate in Nominal $
Total Cost

Direct Plant Costs	Year → Total↓	2012 Total↓	2013 Total↓	2014 Total↓	2015 Total↓	2016 Total↓
Procurement Packages	$162,300,876		$23,164,721	$1,142,530	$121,788,790	$16,204,835
Contract Packages	$149,078,498			$14,694,783	$117,457,406	$16,926,309
Professional Services	$26,419,800	$4,049,564	$4,225,632	$5,813,232	$7,947,304	$4,384,068
Owners Costs	$13,682,133	$5,177,947	$1,374,151	$2,134,726	$1,785,764	$3,209,545
Permit Support	$710,000	$95,000		$490,000	$25,000	$100,000
AFUDC	$49,195,892	$383,715	$1,951,376	$4,134,493	$15,382,679	$27,343,629
Total	$401,387,199	$9,706,226	$30,715,880	$28,409,765	$264,386,943	$68,168,385

Cavern Development Costs	Year → Total↓	2012 Total↓	2013 Total↓	2014 Total↓	2015 Total↓	2016 Total↓
Final Engineering, Cavern Development	$38,920,122	$4,979,376	$957,666	$8,817,233	$437,666	$23,728,181
AFUDC	$4,965,764	$204,951	$449,320	$851,655	$1,232,586	$2,227,253
Total	$43,885,886	$5,184,327	$1,406,986	$9,668,888	$1,670,252	$25,955,434

	Year → Total↓	2012 Total↓	2013 Total↓	2014 Total↓	2015 Total↓	2016 Total↓
Direct Plant Cost	$352,191,308	$9,322,511	$28,764,504	$24,275,272	$249,004,264	$40,824,756
Cavern Development	$38,920,122	$4,979,376	$957,666	$8,817,233	$437,666	$23,728,181
AFUDC	$54,161,656	$588,666	$2,400,696	$4,986,148	$16,615,265	$29,570,881
Total	$445,273,086	$14,890,553	$32,122,866	$38,078,653	$266,057,195	$94,123,819

CAES 1A Project Development Cash Flow Estimate in Nominal $
Total Cost

Direct Plant Costs	Year → Total↓	2012 Total↓	2013 Total↓	2014 Total↓	2015 Total↓	2016 Total↓
Procurement Packages	$193,630,735		$27,800,272	$1,244,338	$145,011,679	$19,574,446
Contract Packages	$162,956,933			$16,077,060	$128,010,827	$18,869,046
Professional Services	$26,419,800	$4,049,564	$4,225,632	$5,813,232	$7,947,304	$4,384,068
Owners Costs	$13,682,133	$5,177,947	$1,374,151	$2,134,726	$1,785,764	$3,209,545
Permit Support	$710,000	$95,000		$490,000	$25,000	$100,000
AFUDC	$55,194,679	$383,715	$2,142,175	$4,577,177	$17,276,680	$30,814,932
Total	$452,594,280	$9,706,226	$35,542,230	$30,336,533	$300,057,254	$76,952,037

Cavern Development Costs	Year → Total↓	2012 Total↓	2013 Total↓	2014 Total↓	2015 Total↓	2016 Total↓
Final Engineering, Cavern Development	$38,920,122	$4,979,376	$957,666	$8,817,233	$437,666	$23,728,181
AFUDC	$5,663,118	$213,749	$486,959	$948,372	$1,427,077	$2,586,961
Total	$44,583,240	$5,193,125	$1,444,625	$9,765,605	$1,864,743	$26,315,142

Total Cost	Year → Total↓	2012 Total↓	2013 Total↓	2014 Total↓	2015 Total↓	2016 Total↓
Direct Plant Costs	$397,399,601	$9,322,511	$33,400,055	$25,759,356	$282,780,574	$46,137,105
Cavern Development Costs	$38,920,122	$4,979,376	$957,666	$8,817,233	$437,666	$23,728,181
AFUDC	$60,857,797	$597,464	$2,629,134	$5,525,549	$18,703,757	$33,401,893
Total	$497,177,520	$14,899,351	$36,986,855	$40,102,138	$301,921,997	$103,267,179

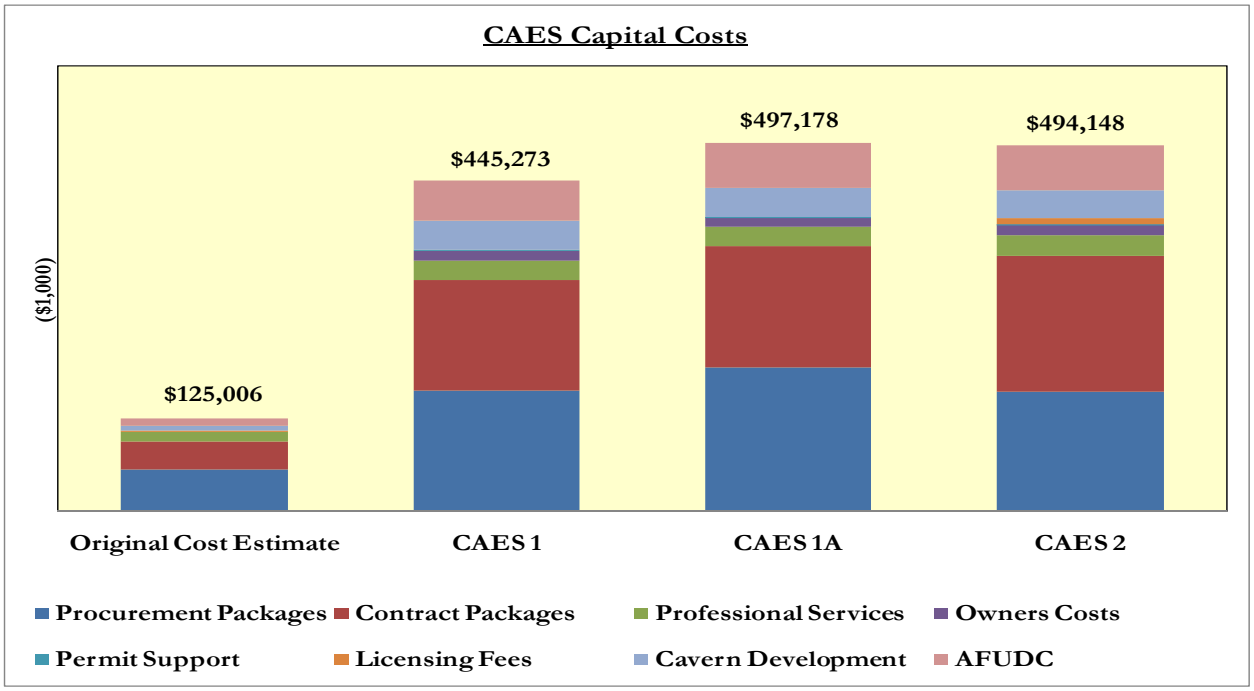
CAES 2 Project Development Cash Flow Estimate in Nominal $
Total Cost

Direct Plant Costs	Year → Total↓	2012 Total↓	2013 Total↓	2014 Total↓	2015 Total↓	2016 Total↓
Procurement Packages	$161,099,191	$0	$22,698,408	$1,466,471	$120,634,995	$16,299,318
Contract Packages	$183,969,191	$0	$0	$15,637,487	$146,568,563	$21,763,142
Professional Services	$27,585,800	$4,317,744	$4,505,472	$6,093,072	$8,215,484	$4,454,028
Owners Costs	$13,682,133	$5,177,947	$1,374,151	$2,134,726	$1,785,764	$3,209,545
Permit Support	$710,000	$95,000		$490,000	$25,000	$100,000
Licensing Fees	$7,350,000	$5,000,000				$2,350,000
AFUDC	$55,168,257	$600,553	$2,377,377	$4,616,473	$17,090,075	$30,483,779
Total	$449,564,572	$15,191,244	$30,955,408	$30,438,228	$294,319,880	$78,659,812

Cavern Development Costs	Year → Total↓	2012 Total↓	2013 Total↓	2014 Total↓	2015 Total↓	2016 Total↓
Final Engineering, Cavern Development	$38,920,122	$4,979,376	$957,666	$8,817,233	$437,666	$23,728,181
AFUDC	$5,663,118	$213,749	$486,959	$948,372	$1,427,077	$2,586,961
Total	$44,583,240	$5,193,125	$1,444,625	$9,765,605	$1,864,743	$26,315,142

Total Cost	Year → Total↓	2012 Total↓	2013 Total↓	2014 Total↓	2015 Total↓	2016 Total↓
Direct Plant Costs	$394,396,315	$14,590,691	$28,578,031	$25,821,755	$277,229,806	$48,176,032
Cavern Development Costs	$38,920,122	$4,979,376	$957,666	$8,817,233	$437,666	$23,728,181
AFUDC	$60,831,375	$814,302	$2,864,336	$5,564,845	$18,517,152	$33,070,740
Total	$494,147,812	$20,384,369	$32,400,033	$40,203,833	$296,184,623	$104,974,954

The total cost profiles are illustrated in the chart below:



8 Wholesale Electricity Price Forecasting and CAES Plant Dispatch Modeling

8.1 NYISO Market Overview

The NYISO facilitates and administers the markets for installed capacity, energy, ancillary services, and transmission congestion contracts.

Installed Capacity Market

The Installed Capacity (ICAP) Market was established to ensure that there is sufficient generation capacity to cover the capacity requirements determined by the NYISO. An ICAP resource is a generator or load facility that is accessible to the NYS transmission system, which is capable of supplying and/or reducing the demand in the NYCA and complies with the requirements of the reliability rules.

Energy Market

The energy market provides a mechanism for Market Participants to buy and sell energy at the Location Based Marginal Price (LBMP). The generators designated by Security Constrained Unit Commitment (SCUC) program to be available for the next day are dispatched against the Load Serving Entity (LSE) bid-in load and losses. From the dispatch, LBMP's are computed, and day-ahead forward contracts are established for generation and load accordingly. Subsequently, during real-time operation, changes in operating conditions, the influence of additional real-time supply bids and variations in actual load will cause the real-time schedules and prices to be different from the day-ahead schedules and prices.

Differences between the day-ahead and real-time generation levels and load consumption values are settled at the second settlement, or real-time price.

Ancillary Services Market

Ancillary services support the transmission of energy and reactive power from supply resources to loads and are used to maintain the operational reliability of the NYS power system. The ancillary services include:

- Regulation and Frequency Response Service: This service is accomplished by committing Generators, including Limited Energy Storage Resources (LESR's) and Demand Side Resources (Regulation Service Suppliers), whose output or demand is raised or lowered (predominately using Automatic Generation Control (AGC)) as necessary to follow moment-by-moment changes in load.

- Operating Reserves Service: The NYISO values Spinning Reserve to be the "highest quality" Operating Reserve, followed by 10-Minute Non-Synchronized Reserve and by 30-Minute Reserve (spinning and then non-synchronized). The price of higher quality Operating Reserves will not be set at a price below the price of lower quality Operating Reserves in the same location.

- Voltage Support Service (VSS): In order to maintain transmission voltages on the NYS Transmission System within acceptable limits, facilities under the control of the NYISO are operated to produce (or absorb) Reactive Power. The NYISO directs the Supplier's Resources to operate within their tested reactive capability limits. Payments to synchronous generators and synchronous condensers eligible for VSS are based upon a fixed dollar amount per MVAR-year. This service is cost based and is currently set at $3419/MVAR-year.

- Black Start Capability Service: Black Start capability represents the key Generators that, following a system-wide blackout, can start without the availability of an outside electric supply and are available to participate in system restoration activities. The NYISO identifies the generating units that are in critical areas for NYS Power System restoration. Transmission Owners, such as NYSEG, can also identify key generating facilities to provide local Black Start capability which are compensated by the Customers within the Transmission Owners Service Territory. The Black Start Service is cost based and requires annual testing and updated embedded cost information associated with maintaining the Service capability.

8.2 Market Price Forecasting

Customized Energy Solutions developed an economic dispatch model to forecast future market prices to calculate the LBMP, regulation, reserve and capacity prices. The model keeps track of marginal units required to meet load for each hour and then provides additional adjustment to account for the congestion and marginal loss to predict prices for the Zone C, where the Seneca facility would be located.

The model uses existing data on power plants to create a historical supply stack, which is then combined with assumptions on seasonal (summer and winter) capabilities and plant availability to generate available capacity (MW) estimates for each power plant in the supply stack. Historical fuel price and heat rate data is used to estimate the Marginal Energy Cost, which serves as an input in the dispatch model. The dispatch algorithm then allocates capacity from the power generating units to satisfy NYISO hourly demand on a merit order basis by dispatching plants with lowest marginal energy cost first. A regression analysis was also done to estimate loss and congestion costs when computing marginal prices (LBMP's). The resulting LBMP's are then sorted and arranged as price duration curves before being calibrated against actual historical day-ahead and real-time LBMP's from the NYISO.

In order to forecast the capacity prices, CES used both historical capacity prices for rest of the state region that applies to Zone C and studies about the cost of new entry that suggests that ~$90,000/MW-year revenue will be required for new peaking units that are required to support reliability needs. Since the capacity addition module of the forecasting model only adds new capacity when the reserve margins fall under 15%, it was decided to assume that for such years the capacity prices have to be at level of $90,000/MW-Year in 2009 real dollars. For future years, when there was no capacity addition required, it was assumed the capacity prices would remain on an average to the levels observed in rest of the state during previous six years (2005-10) of $25,000 / MW-Year (in 2009 real dollars). The model uses a GDP index to escalate to nominal dollars.

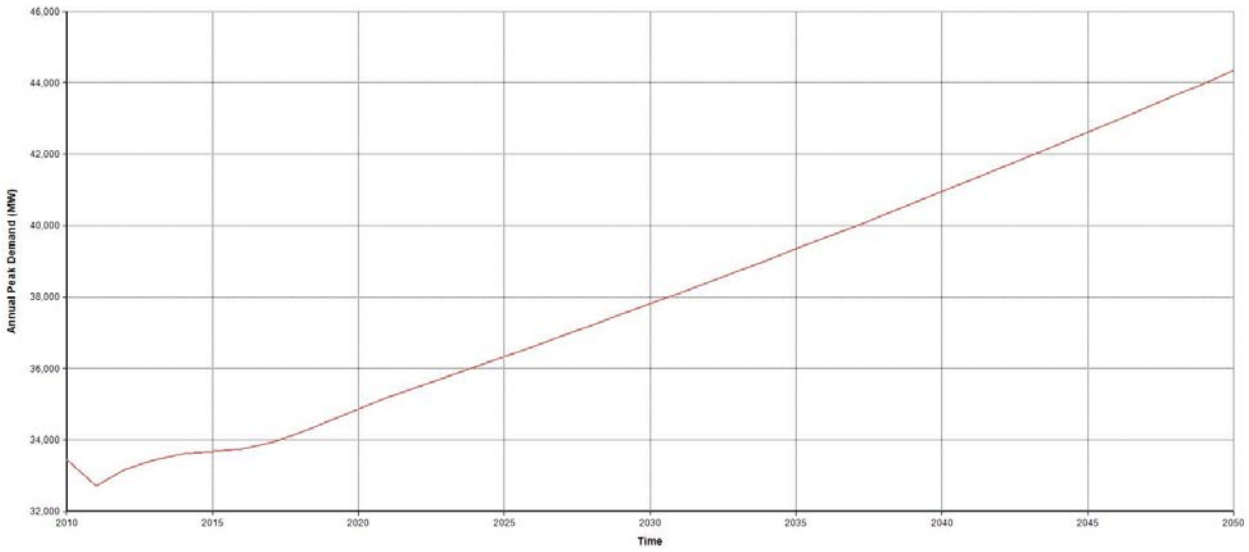
The model was also used to develop ancillary service price forecasts for Synch and Non Synch reserves. The historical analysis showed that these ancillary service prices were not significantly impacted by the varying inputs conditions that were observed within 2005–2010 historical period. As a result, a simple methodology of using the average of the previous six years prices was used to set the baseline prices, which were then adjusted for nominal values using the same GDP index used to adjust the capacity prices.

For frequency regulation prices, there are a number of factors that influence the market clearing prices for regulation. These include, energy price, regulation requirement (which changes from hour to hour and seasonally), as well as availability of regulation supply. Given the small size of the regulation market, the market has seen wide fluctuations in these prices over past six years since introduction of Standard Market Design (SMD) 2. As a result, CES decided to use a neural network model based on historical regulation prices to attempt to predict forward regulation prices using the forecasted energy prices and anticipated regulation requirements based on wind penetration.

8.2.1 Load Forecast Assumption

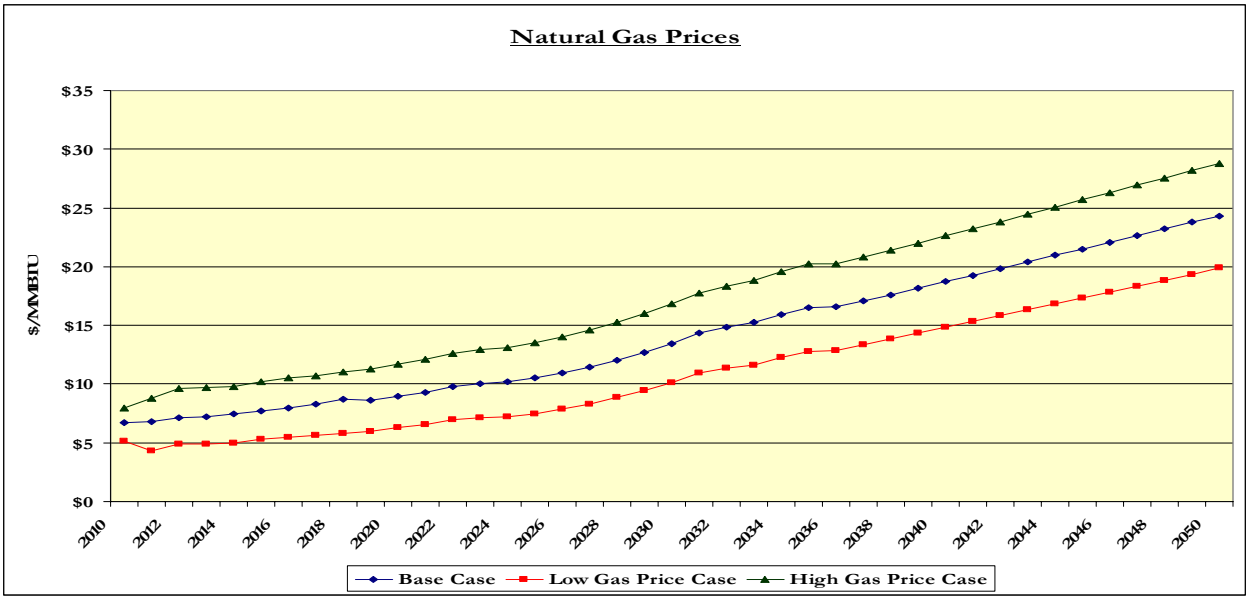
The load forecast used in the CAES base case was taken directly from the 2011 NYISO Load & Capacity Data Report, referred to as the Gold Book. The 2011 Gold Book forecast for peak load reflects an annual average growth rate of 0.73% for years 2011 through 2021. The 2011 growth rate is lower than the 2010 growth rate due to a lower econometric forecast and an increase in the projected amounts of energy reductions due to the New York State Electric Energy Efficiency programs. The base case includes a 0.8% peak load growth rate from 2021 through the study horizon.

The chart below shows the anticipated load growth over the decision horizon used in the base case. Please note that the Y axis of the chart shows values from 32 GW to 46 GW.



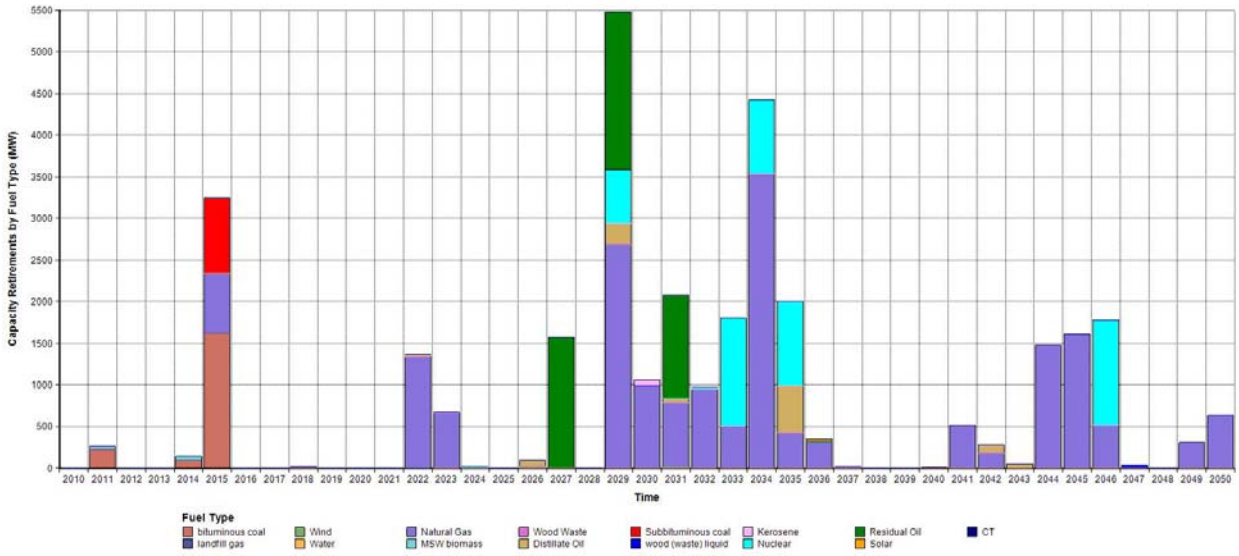
8.2.2 Natural Gas Price Assumptions

The starting point for the fuel forecast used in the CAES base case came from the 2010 U.S. Energy Information Administration (EIA) long term forecast of delivered fuel prices. The natural gas price forecast included in the CAES base case reflects 105% of the forecast Henry Hub prices to account for delivery to New York with an additional 5.5% added to account for delivery to NYISO Zone C. CES applied historical seasonal variations to the annual average fuel price to get the month by month variations using the data used by NYISO for CARIS studies. High and low gas price scenarios were developed using one standard deviation above and below historic gas prices for the past six years. The resulting data set on an annual basis is shown below:

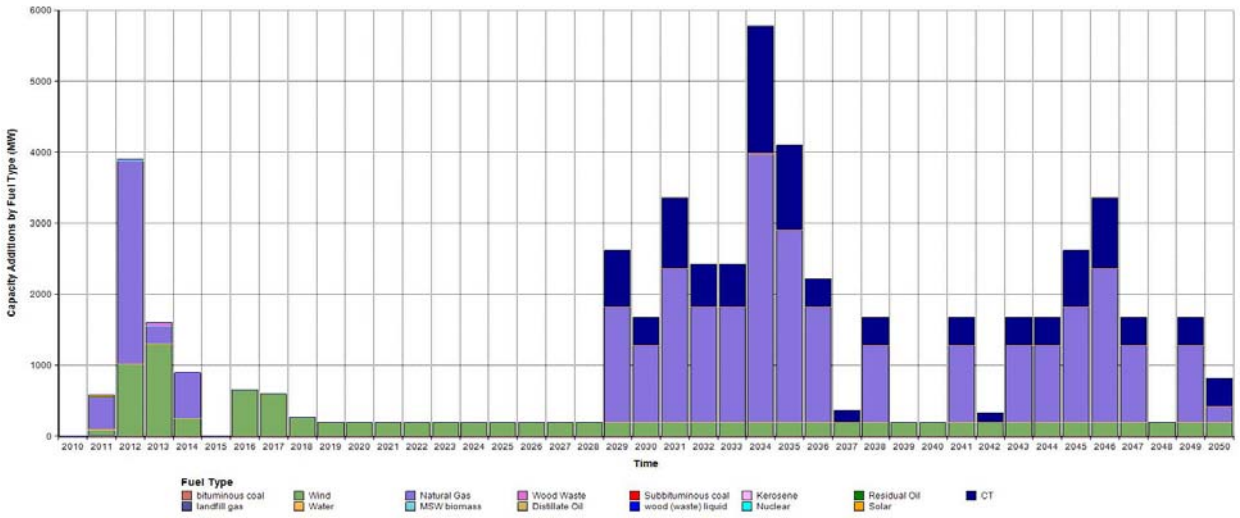


8.2.3 Anticipated Generation Retirements, Additions

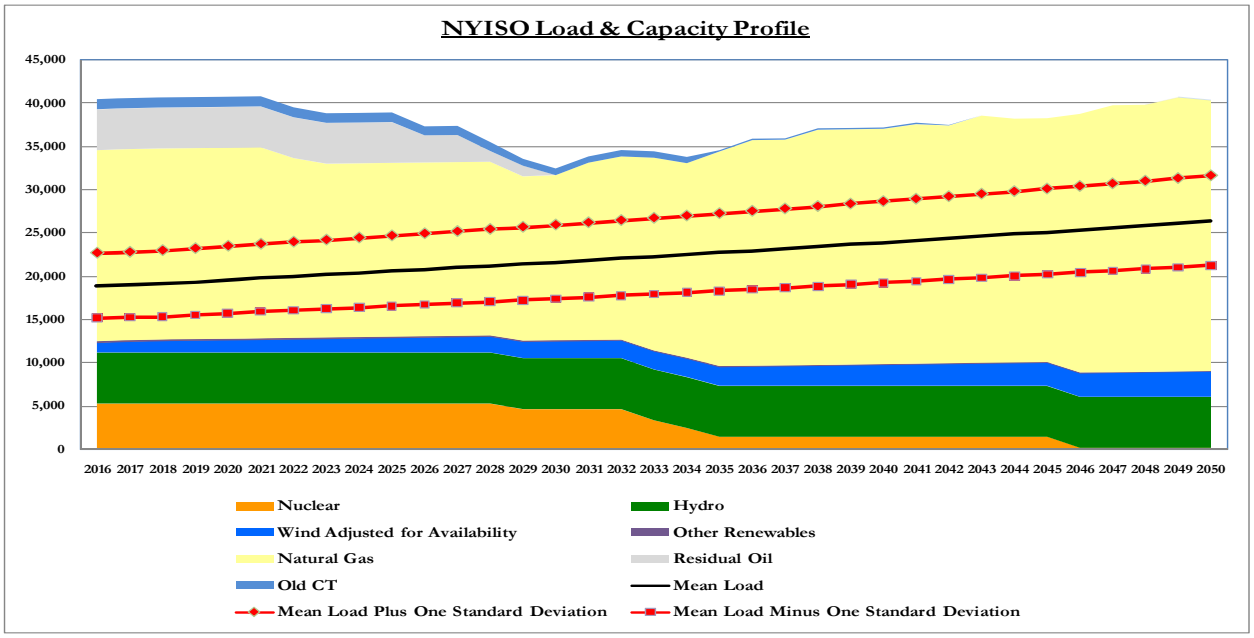
The table below illustrates the generation retirements assumed for the base case forecast:



The retirement of coal and other aging base load generation will require the addition of new generating capability which will largely take the form of natural gas peaking and combined cycle units. While some penetration of renewable energy will continue, the modeling clearly indicates that the majority of the new capacity additions will be natural gas fired. The chart below illustrates the capacity additions assumed for the base case forecast:

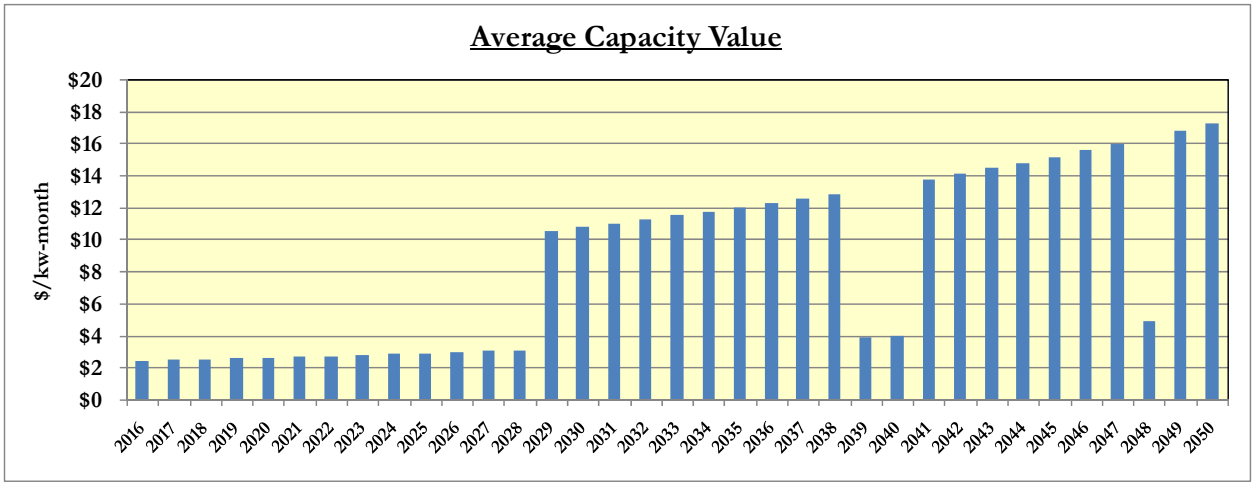


The chart below illustrates the resulting generation fuel mix used in the base case forecast. The chart also includes the load forecast superimposed on the capacity forecast. Note that the wind capability shown in the chart has been reduced to 25% of the installed capacity to better reflect the limited availability of this resource.



8.2.4 Base Case Market Price Forecasts

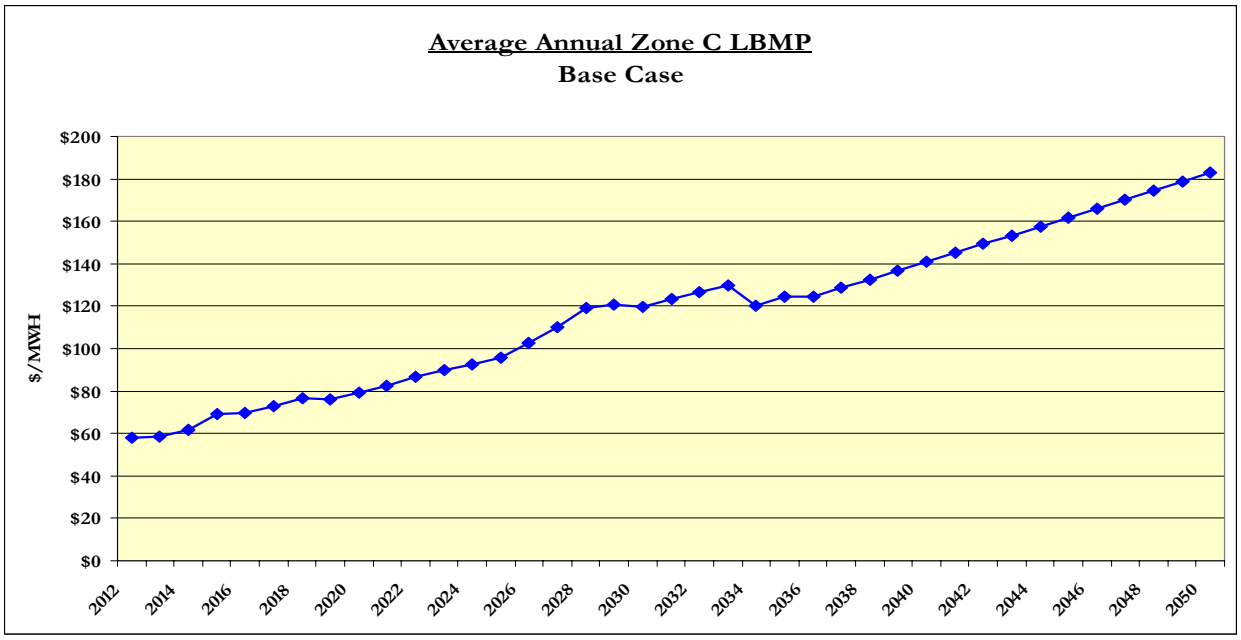
The market forecast modeling developed the following capacity price forecast for the base case:

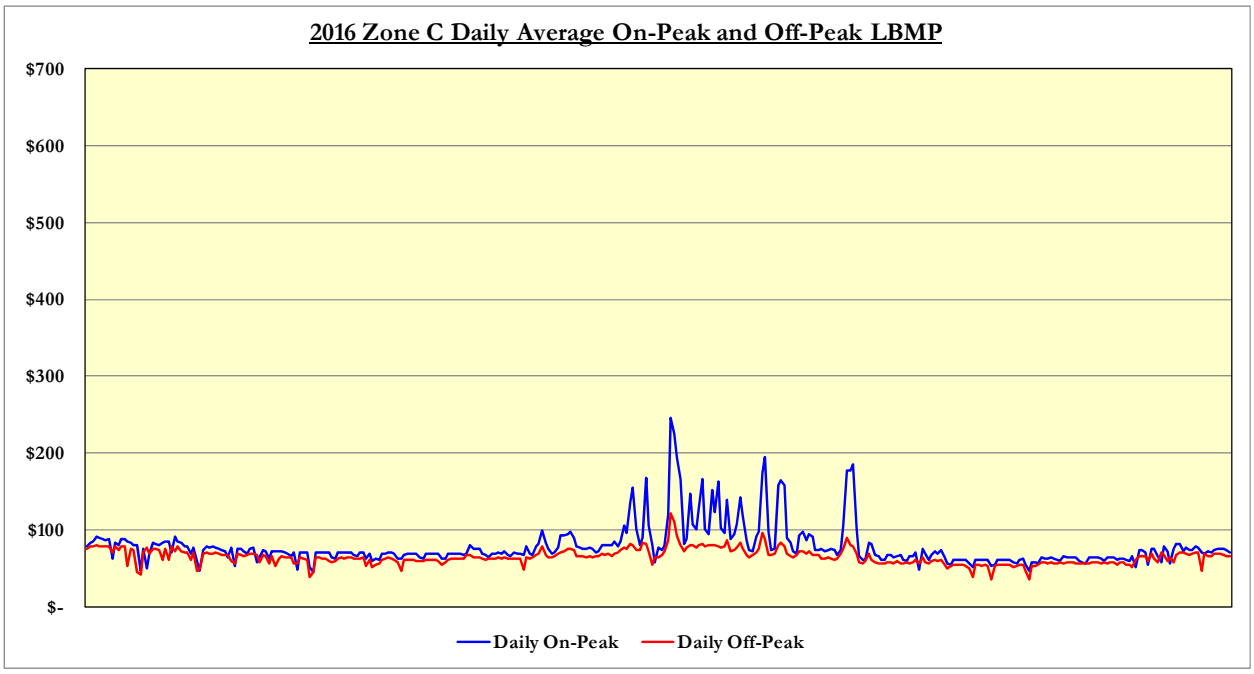


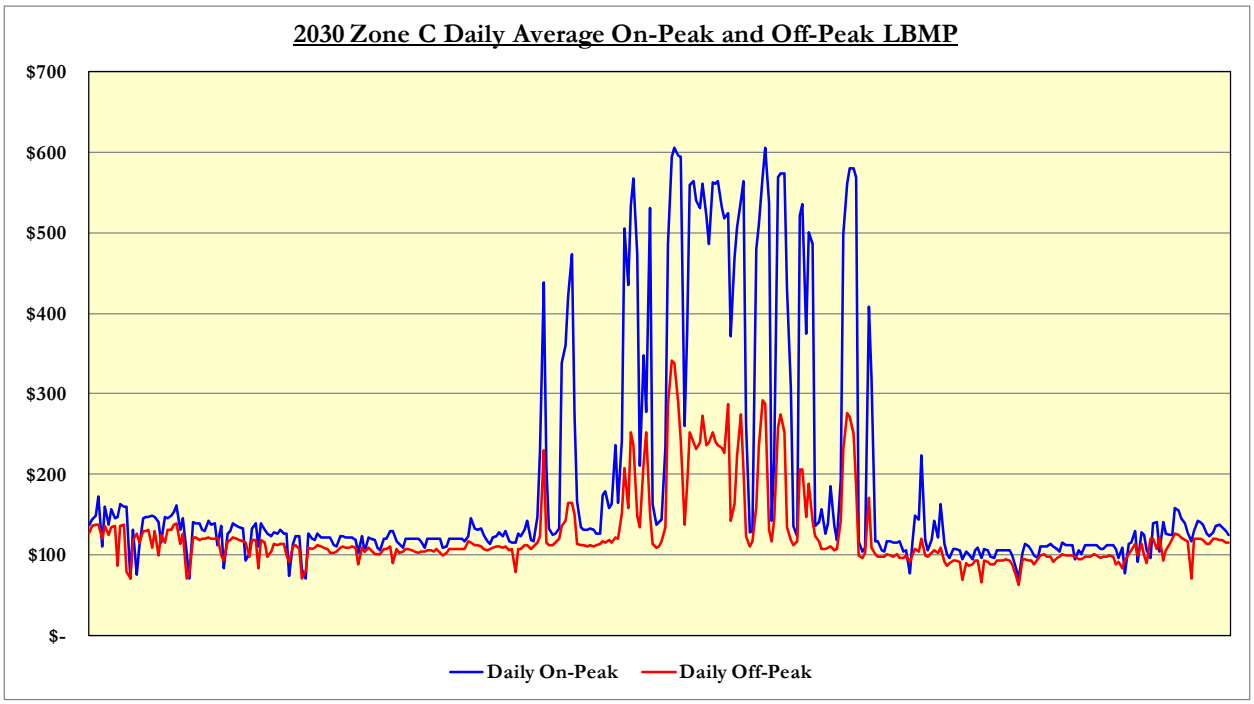
The capacity revenues forecast in the NYISO market do increase during the study period as the current excess capacity in the market is reduced over time. However, the increased capacity revenues are not forecast to occur until well after the Seneca CAES plant would enter commercial service. In addition, the capacity revenue increases associated with the need for new capacity will be driven by the cost of new NGCC or NGCT units which are significantly less costly than CAES technology. Even when capacity prices do increase, they would not be sufficient on their own to support the construction of a CAES plant.

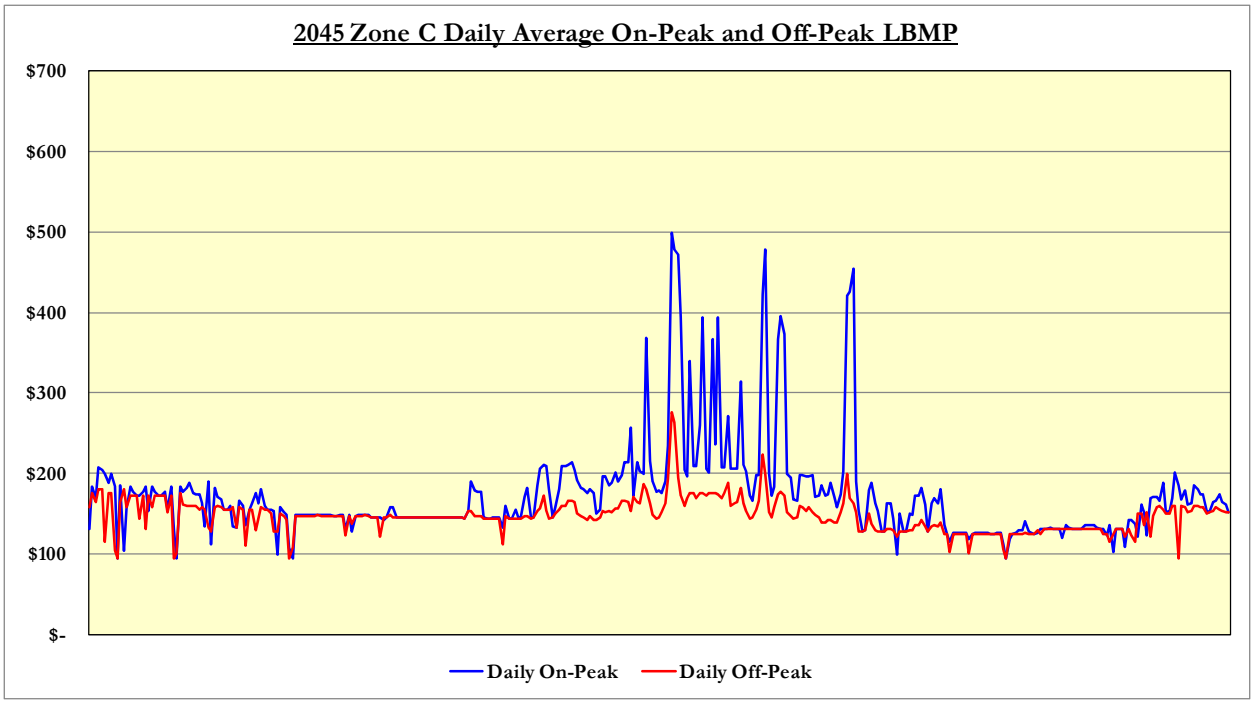
The modeling indicates that the energy prices in the New York market will be set by the marginal cost of natural gas generating units throughout the study period. The differential between on-peak and off-peak energy prices will be very small for many hours of the year (essentially driven by the heat rates of the least efficient NGCC units and the most efficient NGCC units). As a result, energy arbitrage opportunities for the CAES plant would be significantly diminished.

The chart below indicates the annual average wholesale energy price forecast in Zone C. The price trajectory is very strongly correlated to the forecast price of natural gas shown in Section 8.2.2 above. Successful financial performance of the CAES plant depends much less on the average price in the market on any given day, and much more on the differential between on-peak and off-peak periods. The three charts that follow the average annual price forecast give a view of the potential arbitrage opportunities in three selected years during the study period.


Average Annual Zone C LBMP
Base Case
$/MWH
$200
$180
$160
$140
$120
$100
$80
$60
$40
$20
$0
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
2042
2044
2046
2048
2050


2016 Zone C Daily Average On-Peak and Off-Peak LBMP
$700
$600
$500
$400
$300
$200
$100
$-
Daily On-Peak
Daily Off-Peak





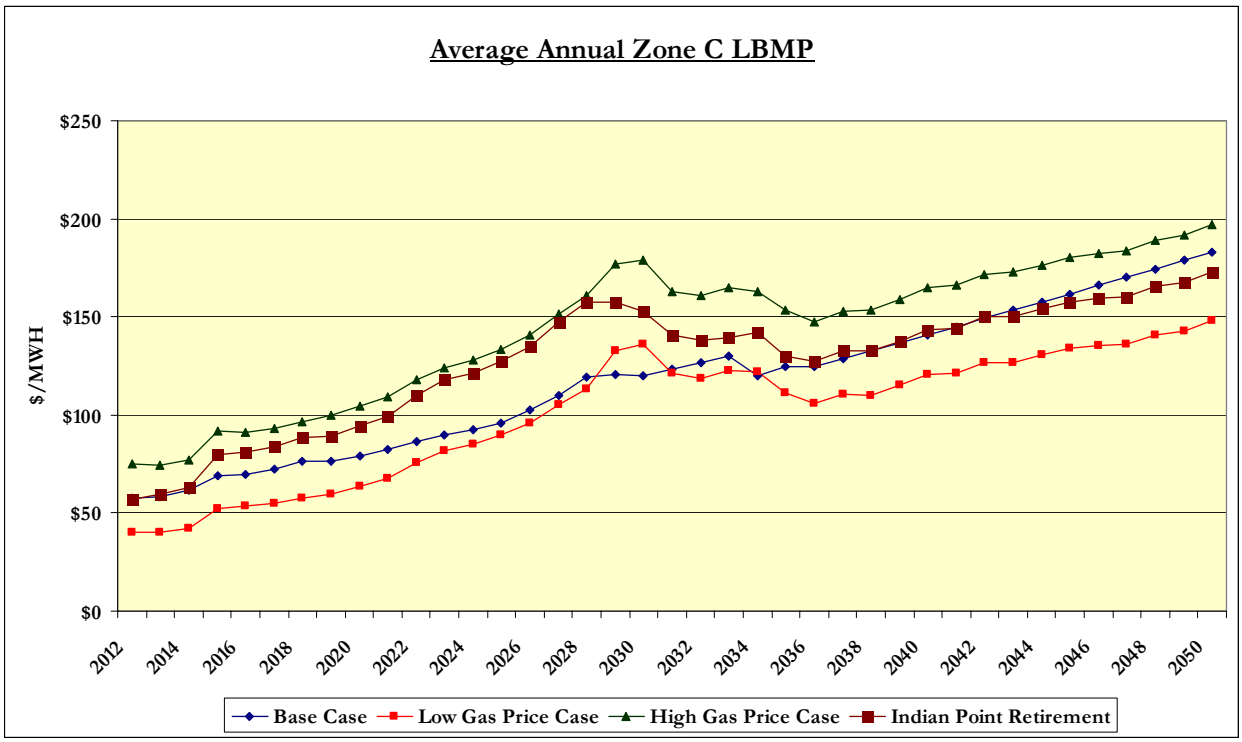
These slides clearly illustrate that there is very limited arbitrage opportunity for the CAES plant outside of a relatively narrow window during the summer months. The modeling results discussed in Section 8.4 confirm this observation.

8.2.5 Additional Market Price Scenarios

CES also developed additional market price scenarios as sensitivity cases. These scenarios included:

- Low gas price scenario (one historical standard deviation below the base case)
- High gas price scenario (one historical standard deviation above the base case)
- Indian Point Units 2 and 3 Retirement in 2016
- State Energy Policy Goals of 30% Renewables and 15% Energy Conservation by 2015
- High Wind scenario in which a total of 12,000 MW of wind is on line, phased in during the CAES study period

The resulting energy price curves are compared to the Base Case. The on-peak versus off-peak price differentials and patterns noted above for the Base Case are also observed in these additional market price scenarios.



8.3 Dispatch Modeling Approach

The Seneca CAES Plant was intended to support the system during all periods of the day to the full extent of the stored energy and the operating flexibility of the facility. The CAES Dispatch Model was developed to determine the net revenues from the operation of the CAES Facility and to keep track of the environmental emissions from the plant. The model is based on previous studies and research conducted by Customized Energy Solutions to determine the revenue opportunities for energy storage in the organized energy markets. The model used in this effort has been upgraded to include the flexibility in modeling provided by the Lumina Corporation in their Analytica Software for incorporation of ancillary service revenues to optimize the profitability of the CAES plant and maximizing the benefits to the NY grid.

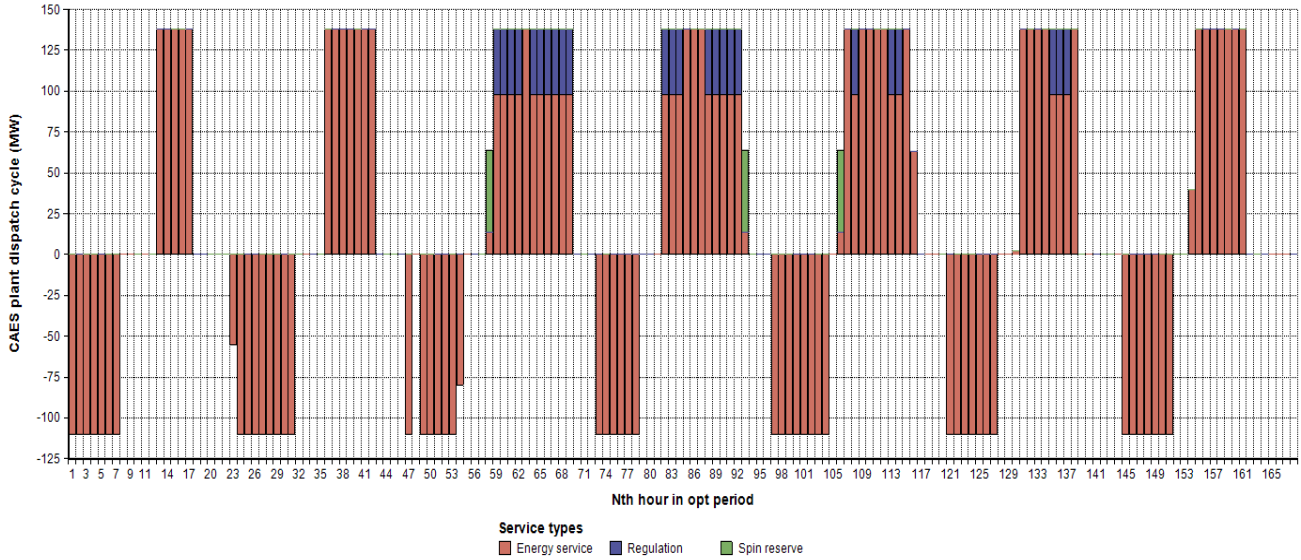
The model utilizes the technical parameters of the CAES design including energy ratio, input and output power ratings (including auxiliary power), heat rate and emissions at different operating points (10%,25%, 50%, 75% and 100%). Using all these parameters the model estimates the marginal dispatch cost for the CAES plant, and then utilizes inputs including hourly energy, ancillary services, and natural gas prices to determine the optimal operating pattern. The operational pattern can be calculated for daily as well as weekly operation. For the base case scenario, CES has optimized the CAES operations with weekly operational cycle starting with Saturday through Friday as the optimization period.

The CAES Dispatch Model was refined using actual hourly energy, ancillary service prices and natural gas daily price data for the period from 2005 through 2010. The model optimizes the CAES plant's operation over the course of a week starting with Friday night at hour 22. The first pass of the model matches the highest LBMP for generation for the week with the lowest LBMP for compression and continues to do this until there is no net revenue benefit when considering the energy ratio between the costs to charge the cavern to revenue gained by dispatching the generators from the facility. The model keeps track of the cavern inventory so that the maximum capacity and minimum capacity levels are not exceeded at anytime during the week evaluated. The model then determines the cost and revenues from the operation of the CAES designs that will maximize the net revenues to the Facility from energy arbitrage and the ancillary services.

Given the proposed unit sizes of 136 to 210 MW, the analysis assumed that the facility is not large enough (considering the 40 GW installed capacity in NY) to significantly change the pricing that occurred in the State or Zone C, the NYISO Market region where the plant would have been located. Based on the market size for the ancillary services, CES has limited the amount of ancillary services that can be provided to NYISO to 40 MW for regulation, 50 MW for Spinning reserve and 20 MW for non-spinning reserve to avoid a situation of price collapse in ancillary service markets in future scenarios.

During the optimization, the model stores sufficient air to provide energy and ancillary services during the selected optimization period based on an optimization algorithm. The optimization algorithm ensures that for all hours when the plant is discharged, the unit was

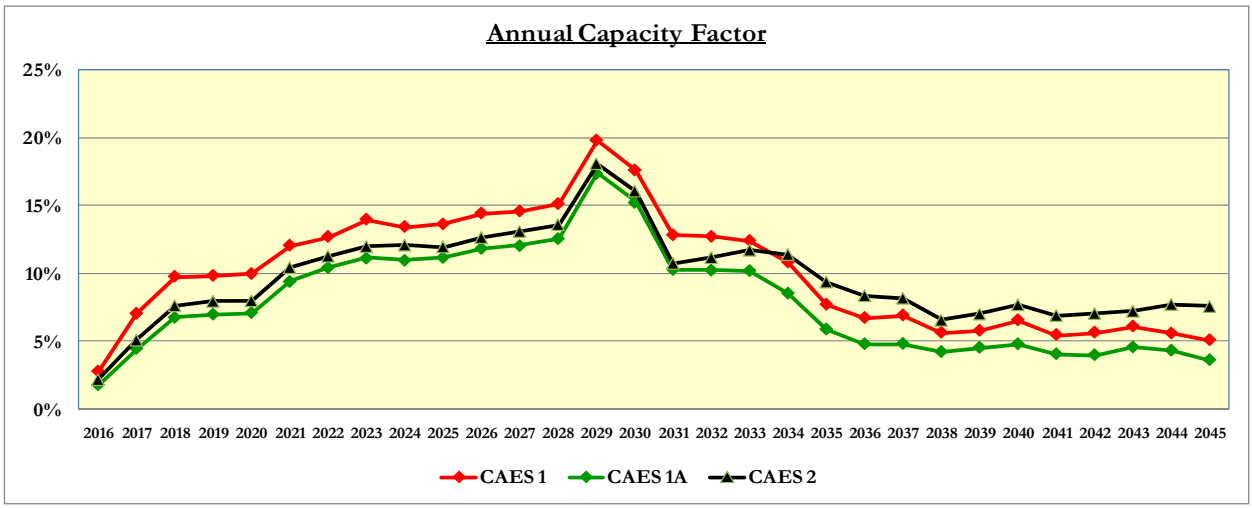
profitable to operate. Also, during each hour of operation the model compares the profitability of energy arbitrage versus the profitability of providing frequency regulation or synchronous reserves. For any hour when ancillary services are more profitable, the plant is dispatched for both energy and ancillary services as shown in an example of the weekly duty cycle chart below.

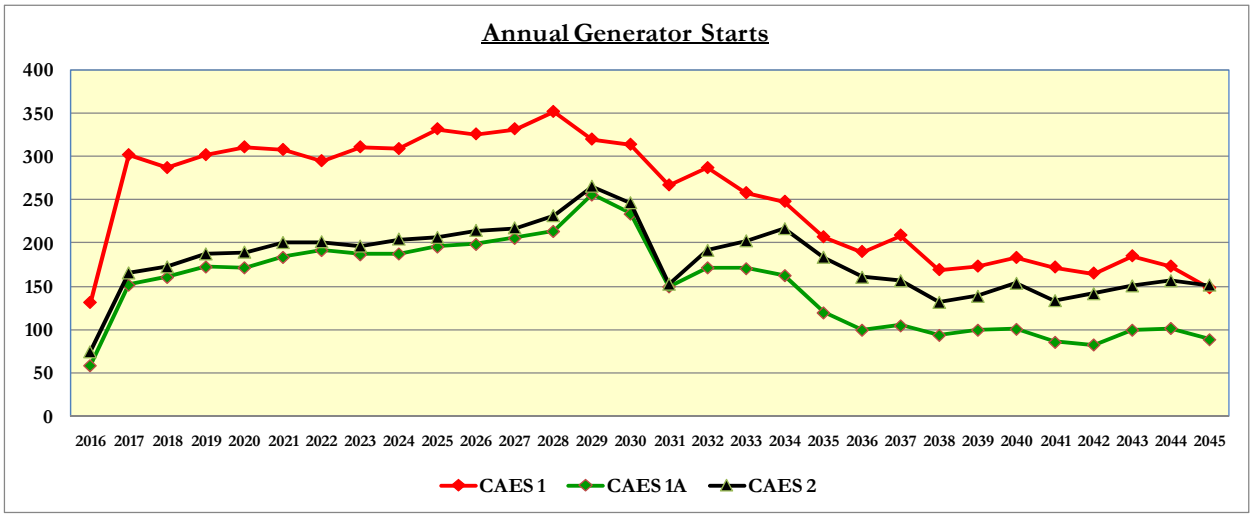


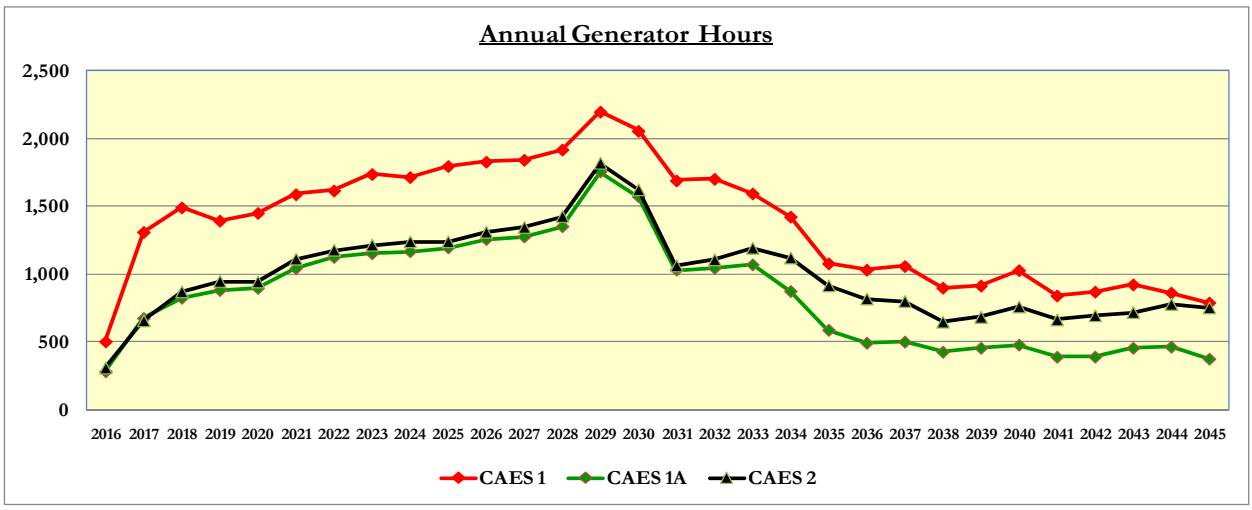
The dispatch model was run for each CAES technology under each of market price forecast scenarios noted above. The results of these model runs were directly input to the financial model scenarios discussed in the next section.

8.4 Dispatch Modeling Results

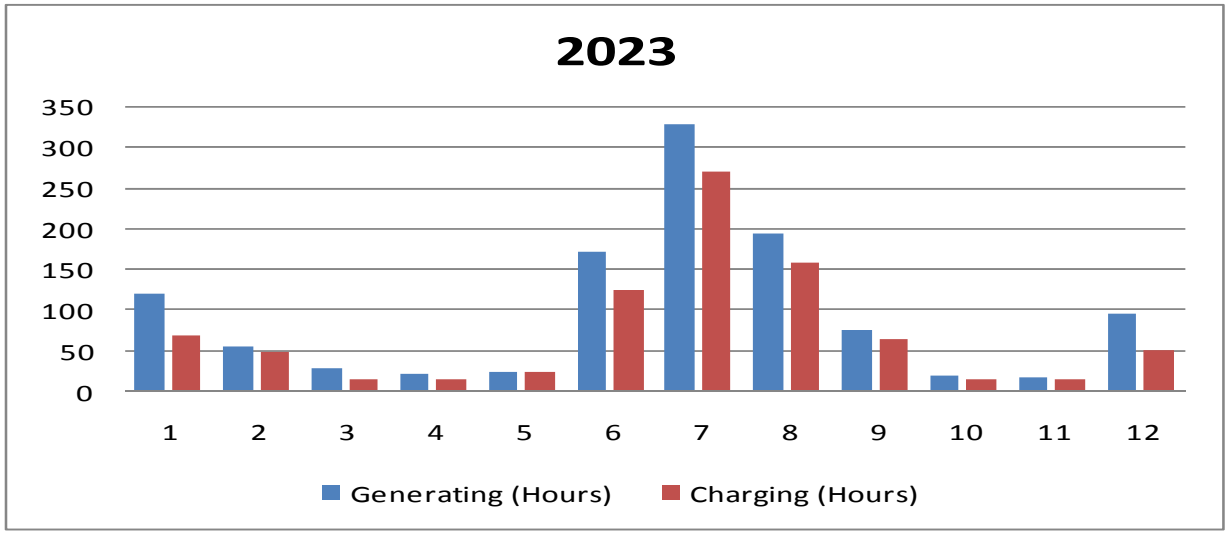
As noted above, the retirement of existing coal and other aging base load generation will require the addition of new generation which will largely be natural gas simple cycle and combined cycle units. This would severely limit the arbitrage opportunities for the CAES plant and would generally see the plant operated in a manner similar to a seasonally operated gas turbine peaking unit as illustrated in the charts below.

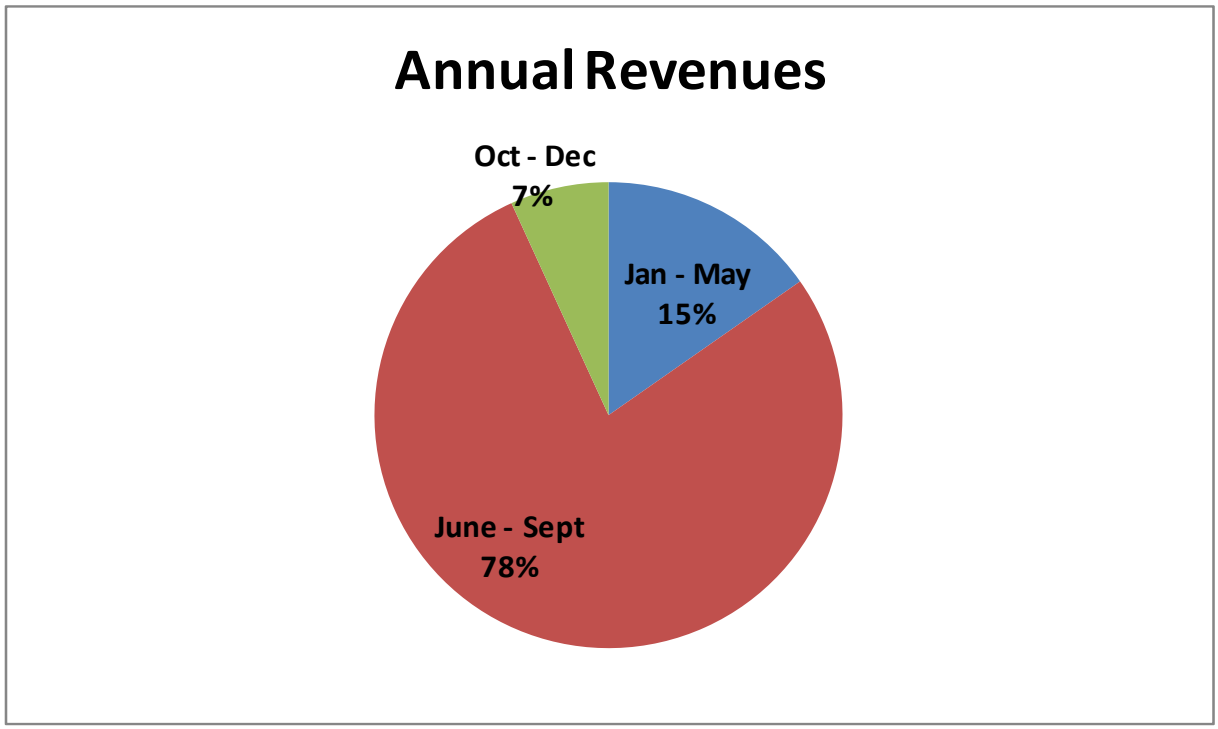

Annual Capacity Factor
25%
20%
15%
10%
5%
0%
2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045
CAES 1
CAES 1A
CAES 2

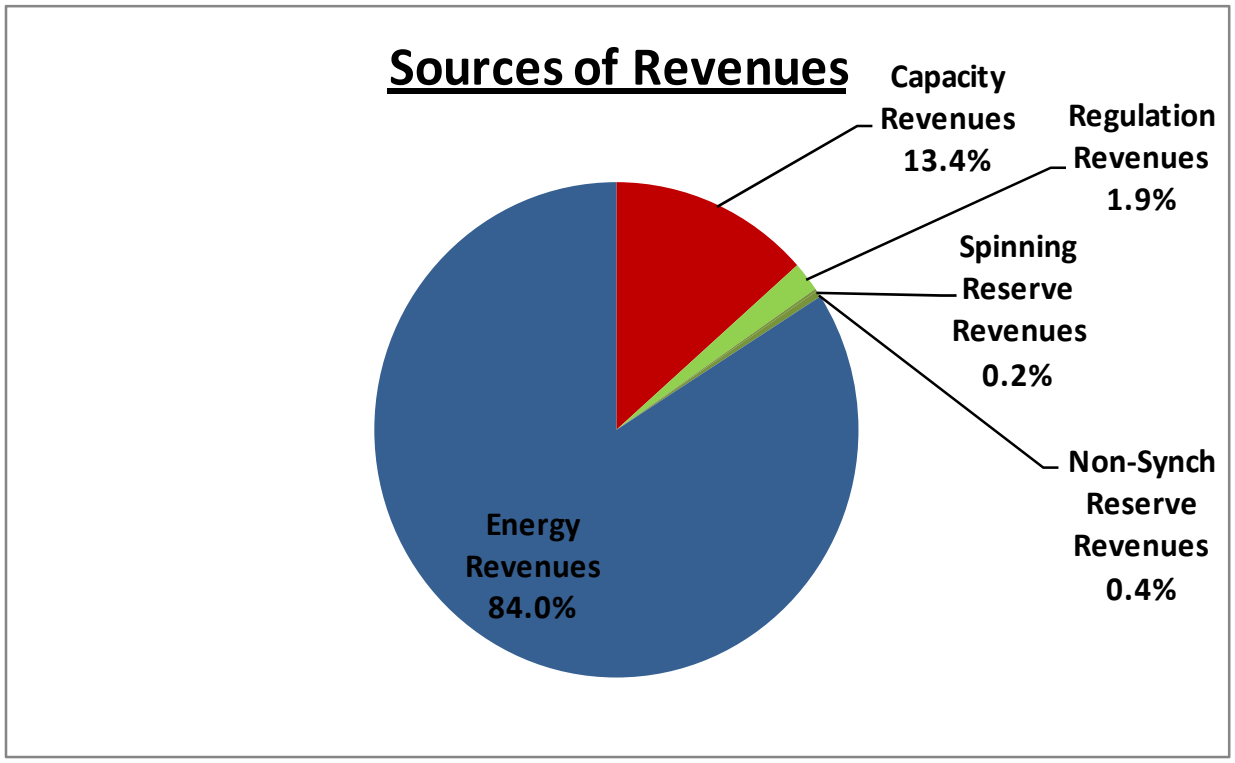

Annual Generator Starts
400
350
300
250
200
150
100
50
0
2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045
CAES 1
CAES 1A
CAES 2


Annual Generator Hours
2,500
2,000
1,500
1,000
500
0
2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045
CAES 1
CAES 1A
CAES 2

The seasonal operation of the CAES plant is best illustrated by the data from a representative year (CAES 1A 2023 results shown here). The seasonal operation and revenue opportunities are clearly very similar to what one would expect from a simple cycle gas turbine peaking unit.

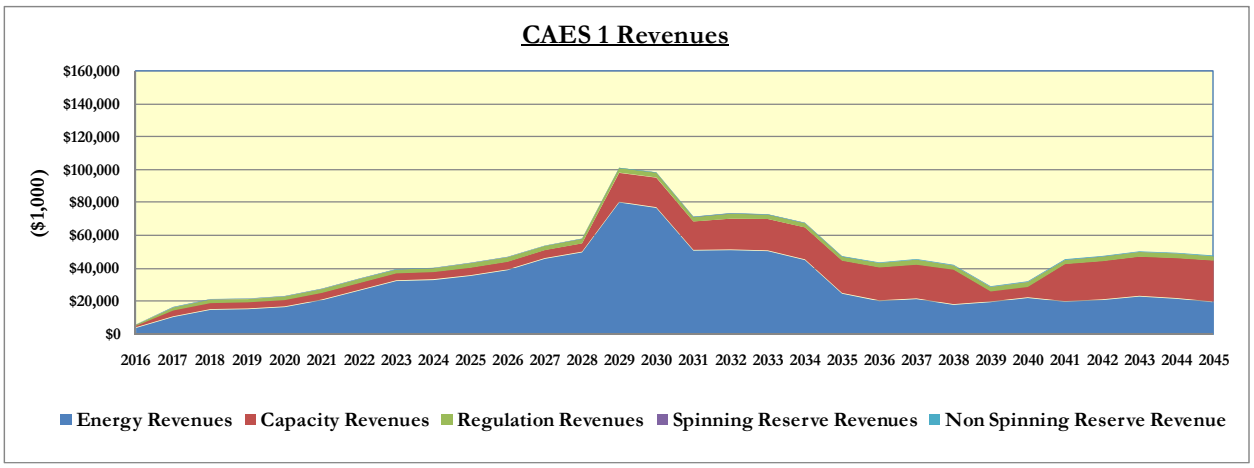


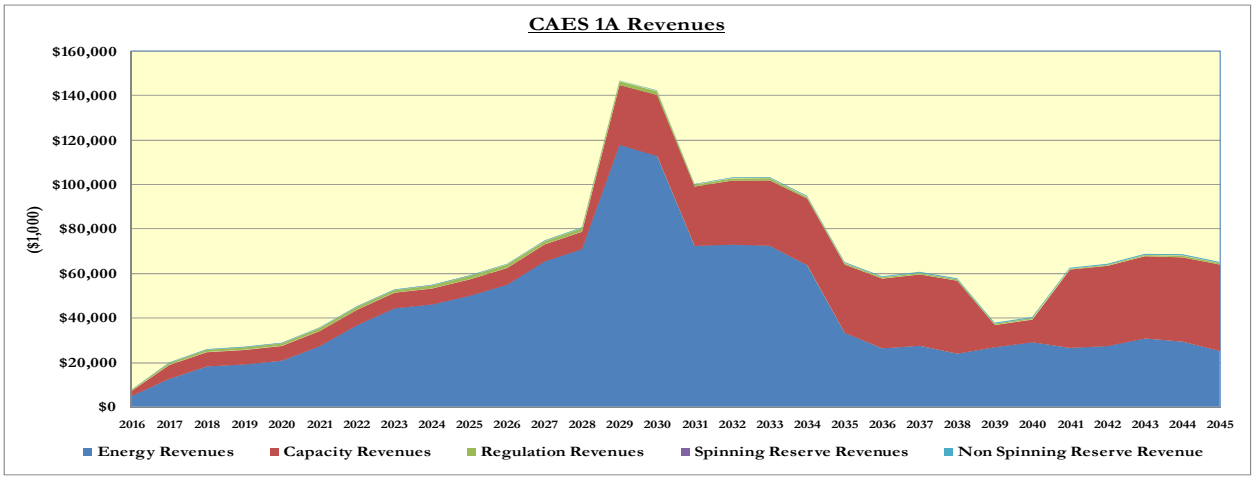


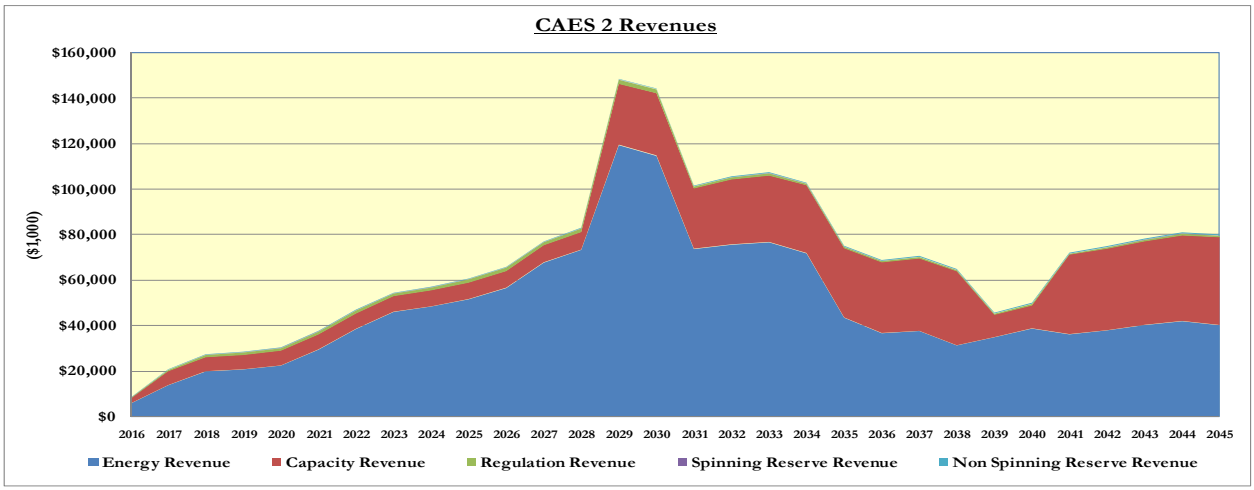


The modeling results also clearly indicate that the current NYISO market does not produce Ancillary Services revenues that would support new capital investments aimed at capturing this market segment. Some of the capabilities in which the CAES technology excels (fast start, VAR support, frequency regulation) are little valued in the current market design and are not forecast to grow significantly in the forecasts used for this project analysis. While NYSEG and CES believe that this situation may change with the continued retirement of base load generating units, there was no way to develop estimates of these potential future market revenues.

The model predicted the following gross revenue forecasts for each of the CAES technologies:







9 Financial Modeling

The capital cost forecasts, operating expense forecasts, and dispatch modeling results were input to the NYSEG financial model to evaluate the financial impact of the CAES plant on NYSEG's customers. Copies of the financial model results for the three Base Case CAES cycles are attached to this report. Key elements of the modeling include:

- The financial modeling performed for the project was based on an assumption that the New York Public Service Commission would authorize the recovery by NYSEG of all costs of constructing and operating the Project through the NBWC (Non-Bypassable Wires Charge) with the customer receiving a credit for all wholesale electric revenues generated by the Project.

- The financial model takes into consideration a number of cost estimates, including (a) the estimated cost of constructing the Project itself; (b) the estimated costs of operating the Project, including fixed and variable operating and maintenance expenses; (c) a number of long-range forecasts of wholesale electricity prices in the region; and (d) projections of how the Project is likely to be dispatched in light of the projected wholesale electricity prices.

- Key assumptions used in the financial model included:

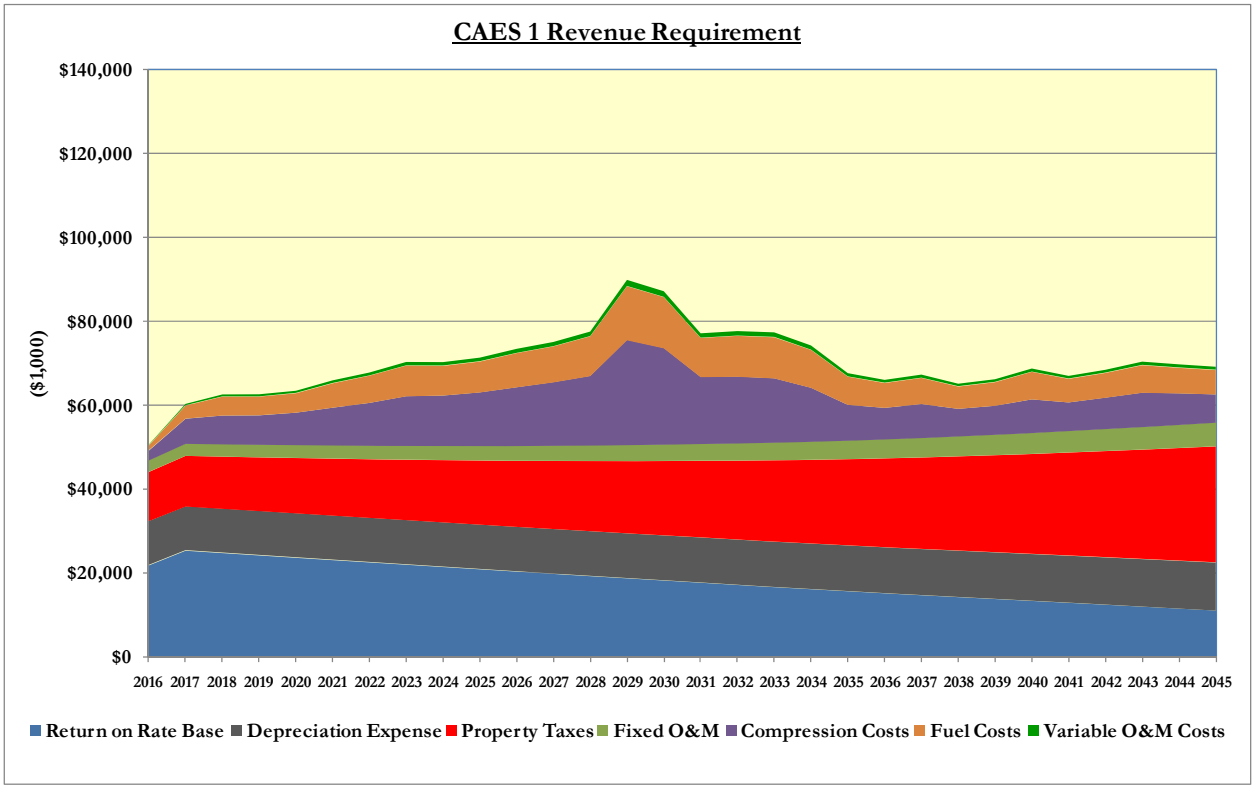
    - The DOE and NYSERDA Grants are taxable upon receipt, but the project qualifies as an R&D expense under IRS Code Section #174 and is expensed for tax purposes in the year expended.

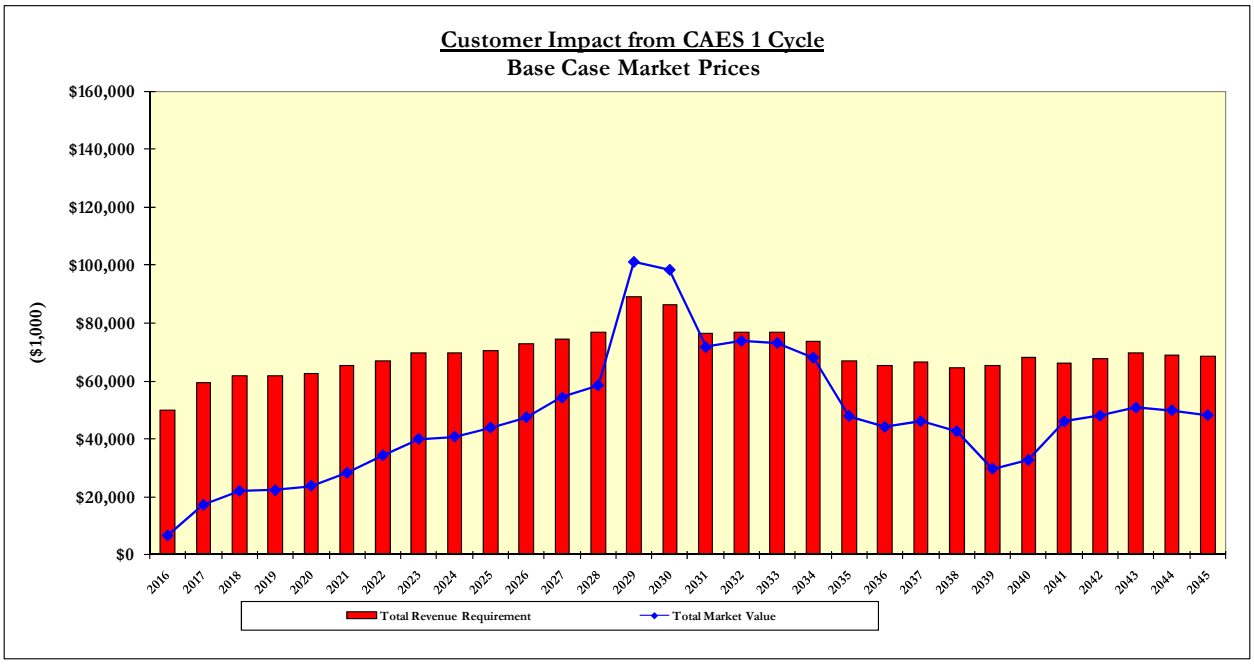
    - Capital Structure: 48% Equity, 52% Debt

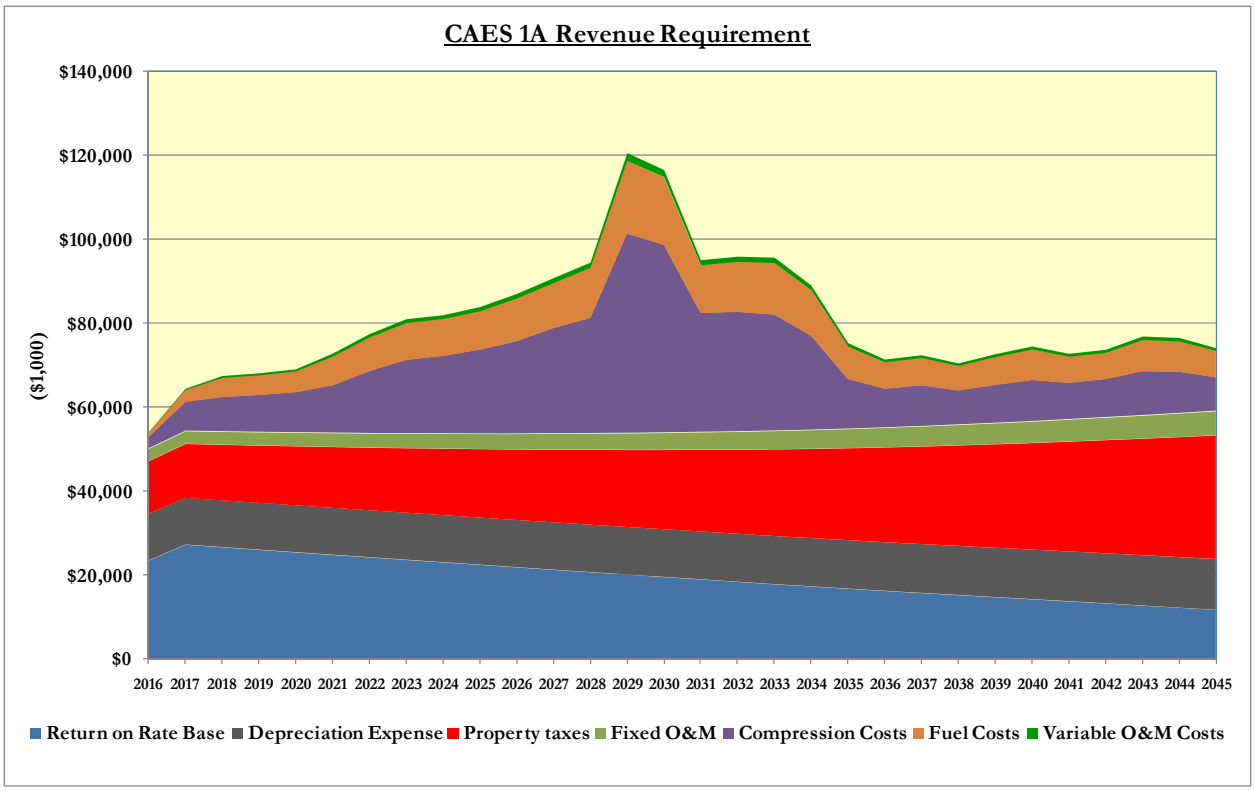
    - Equity Return = 10%, Debt Rate = 5.5%

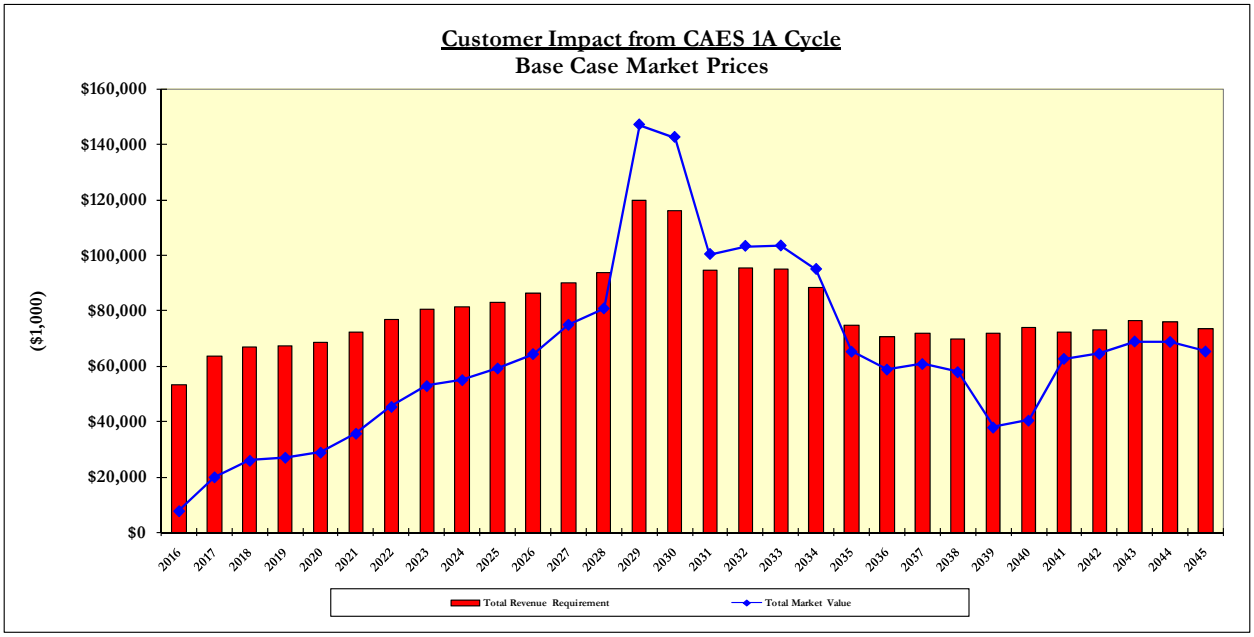
The financial modeling results indicate that the CAES technologies do not result in a net positive benefit for customers over the lifetime of the plant under any of the market scenarios that were modeled. The charts below illustrate the customer impact from CAES 1, CAES 1A, and CAES 2 under Base Case Market Prices.

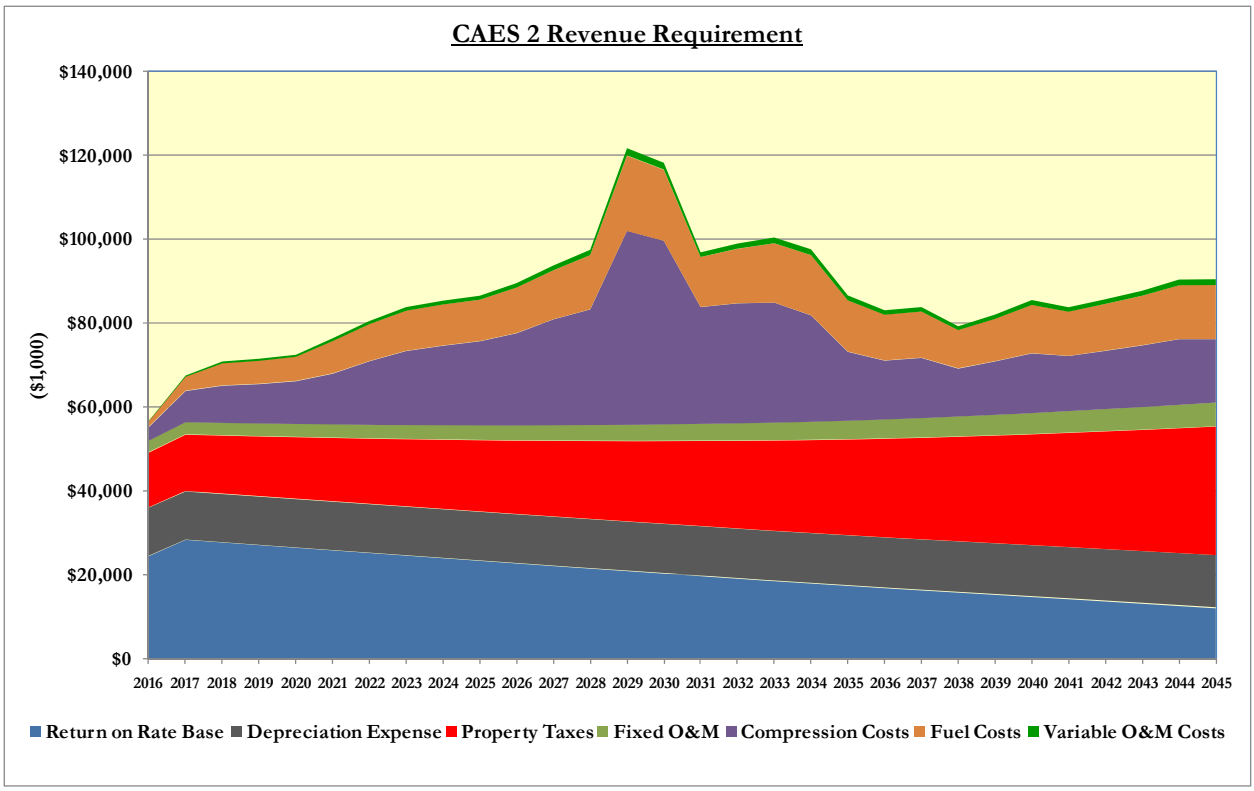
9.1 Base Case Modeling Results

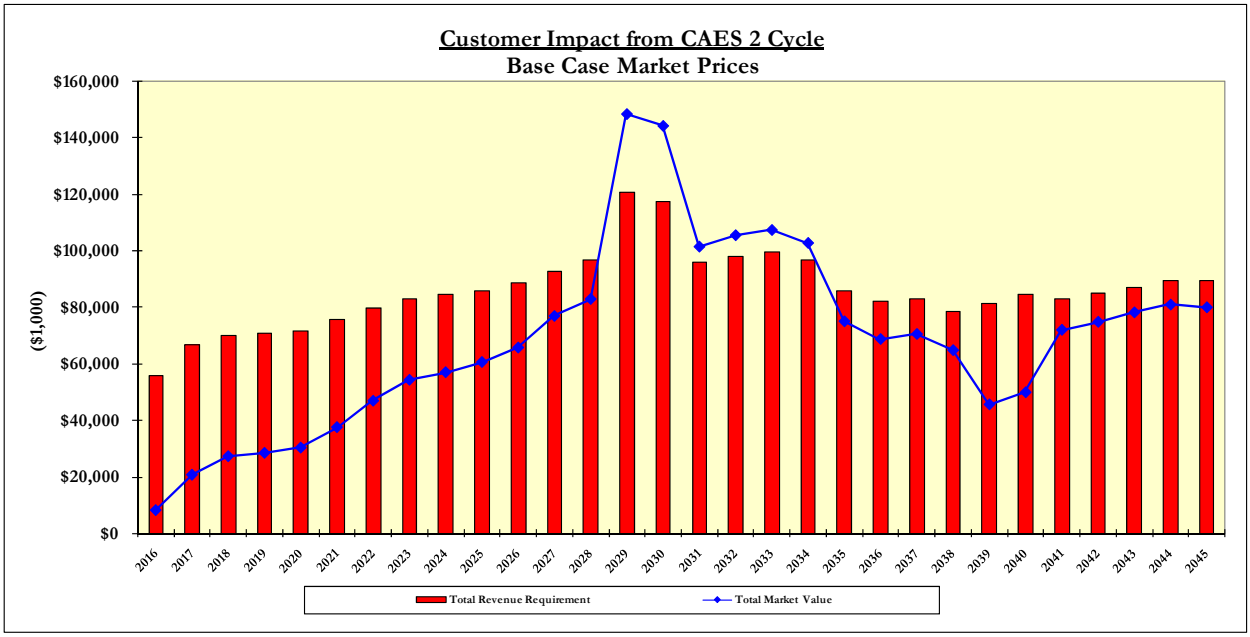




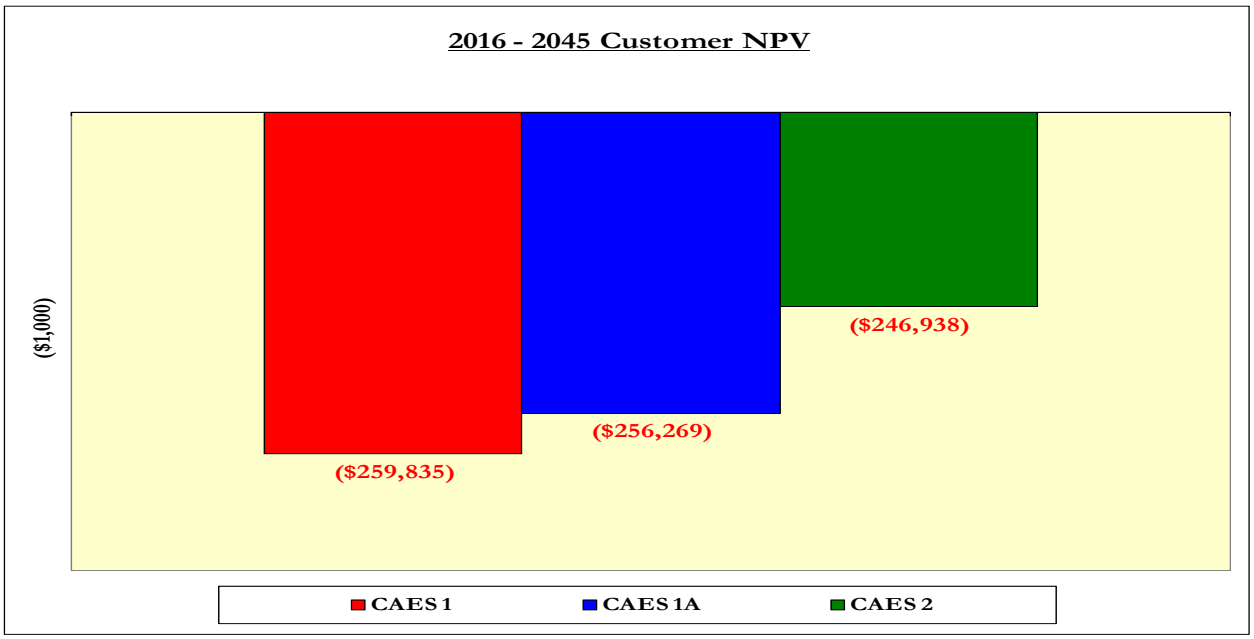

CAES 1A Revenue Requirement
$140,000
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$0
($1,000)
2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045
Return on Rate Base
Depreciation Expense
Property taxes
Fixed O&M
Compression Costs
Fuel Costs
Variable O&M Costs


Customer Impact from CAES 1A Cycle
Base Case Market Prices
$160,000
$140,000
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$0
($1,000)
2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045
Total Revenue Requirement
Total Market Value


CAES 2 Revenue Requirement
$140,000
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$0
($1,000)
2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045
Return on Rate Base
Depreciation Expense
Property Taxes
Fixed O&M
Compression Costs
Fuel Costs
Variable O&M Costs

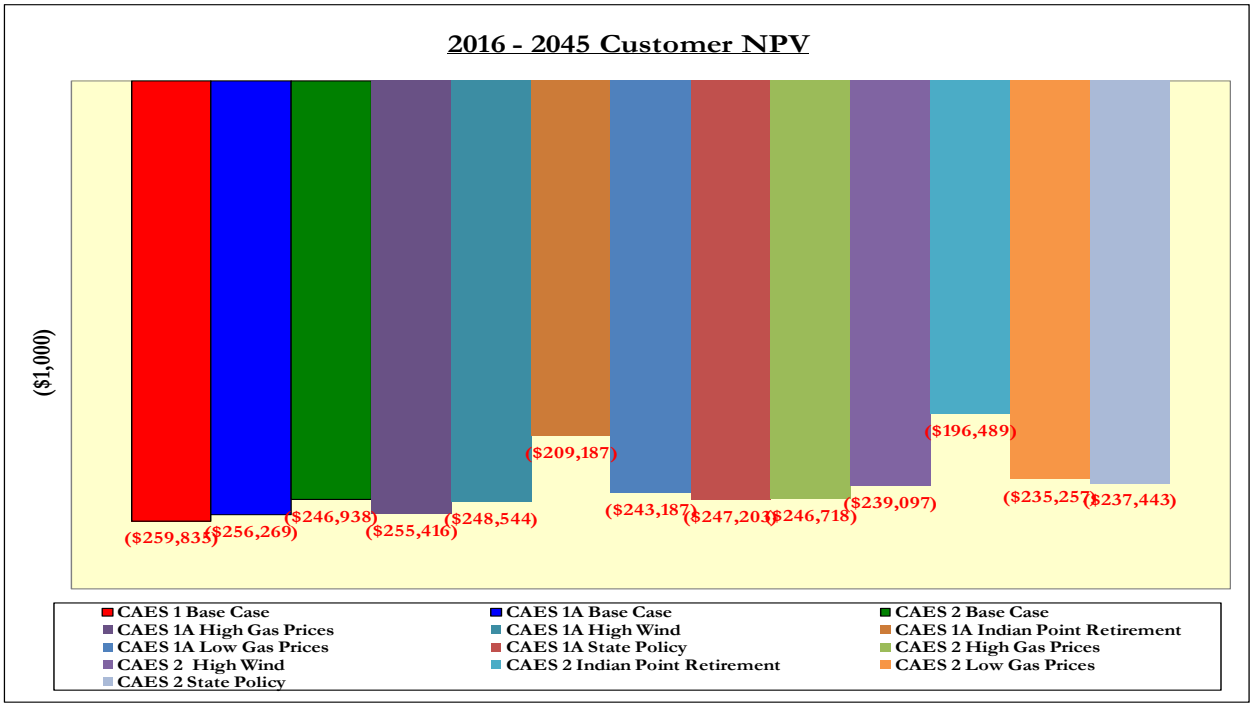

Customer Impact from CAES 2 Cycle
Base Case Market Prices
$160,000
$140,000
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$0
($1,000)
2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045
Total Revenue Requirement
Total Market Value

A Net Present Value of Customer Impact was calculated for the 30 year study life of the CAES project. The results of those calculations are shown in the chart below:



9.2 Sensitivity Analyses

The financial analysis team also evaluated the other market price scenarios discussed above. The net customer impact profiles were not significantly different from the Base Case scenarios.



A set of model runs was developed to illustrate the maximum allowable plant capital cost (including AFUDC and other Owners Costs) that would result in a zero customer impact NPV. The results of this analysis are shown in the table below.

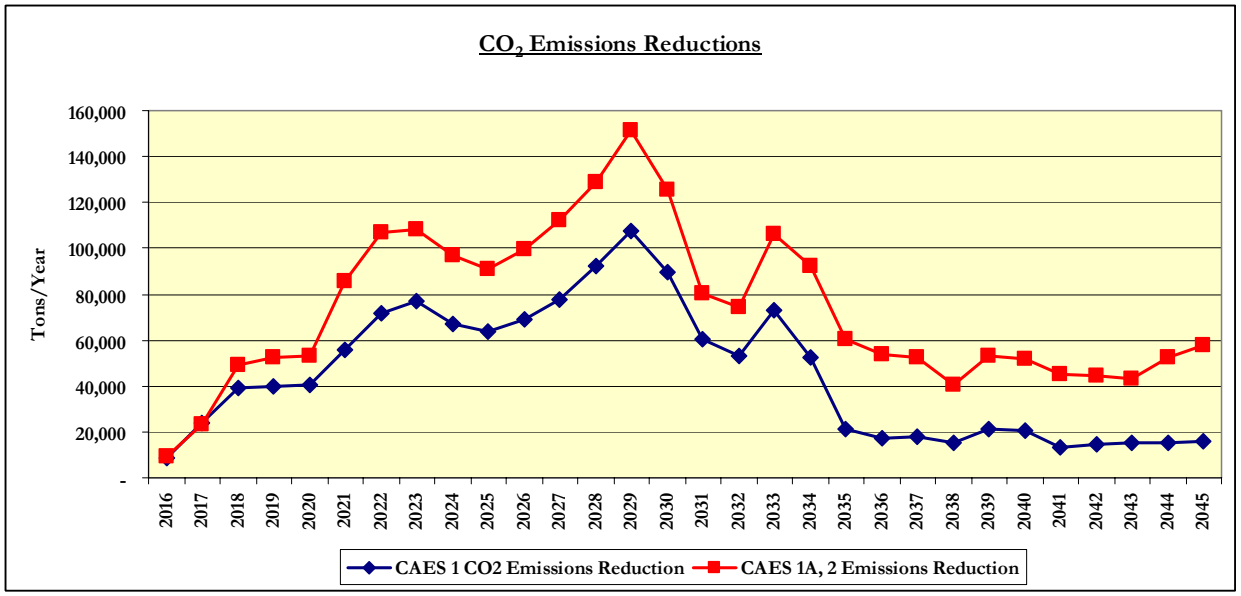
Cycle	Estimated Total Capital Cost Before Funding	Total Maximum Capital Cost Required for Customer NPV = $0
CAES 1	**$444,273,000**	**$170,062,052**
CAES 1A	**$497,178,000**	**$225,737,812**
CAES 2	**$494,148,000**	**$233,194,020**

10 Statewide Emissions Impact

The Seneca CAES facility was anticipated to be a renewable enabler. The method to illustrate the statewide reduction in CO_2 emissions resulting from the CAES facility operations was to identify the marginal plant from the economic dispatch and then account for the emission difference between the CAES plant and that marginal plant for the number of hours that the CAES plant was expected to run. It was assumed that the CAES plant would utilize off peak renewable energy sources for charging energy, and thus no emissions were accounted for in the compression cycle.

The following chart shows the anticipated emission impact of CAES 1A and 2 (210 MW) configurations. These results are very heavily influenced by the assumptions about generation retirements as well as emissions from the new units added in the generation mix. Since by 2029 a large number of older fossil units are retired, the anticipated emission impact is significantly lower in scenarios after that point in time as more efficient natural gas units are built to replace the older fossil units.

During the life of the project, the CAES 1A and 2 CO_2 emissions reduction was estimated at over 2.2-million tons. In a similar fashion, the CAES 1 CO_2 emissions reduction was estimated at more than 1.3-million tons.



11 Transmission System Benefits

WorleyParsons developed a transmission network model based on publicly available network information provided by the NYISO. The modeling was used to assess the electrical capabilities of the NYSEG transmission system with regard to take-away capability and maximum compressor load capability. The modeling also was aimed at assessing the impact on the electric transmission system from Seneca CAES operation. Specific areas of interest included: system overloads, fault current levels, buss voltage levels, stability, and congestion. The results of the transmission study did not indicate any significant transmission system operational improvements resulting from the construction of the CAES plant at this location.

12 Recommended CAES Technology

As noted above, none of the CAES technologies evaluated results in a positive economic benefit for customers. If the project were to proceed into development, final design and bidding for only CAES 1A and 2 cycle technologies would be recommended. Final engineering design and more in-depth risk assessments, followed by formal bidding for equipment and construction services, would be used to determine the recommended technology. As the cost estimates and modeling illustrate, there does not appear to be a clear financial advantage for either the CAES 1A or 2 cycles at this time, and it would make commercial sense to maintain an active competition between the two cycle providers through final design and bidding.

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WorleyParsons
resources & energy

EcoNomics

NEW YORK STATE ELECTRIC & GAS

Design Criteria

COMPRESSED AIR ENERGY STORAGE PROJECT

Document: CAES-1-DB-012-0001

Revision: C

Date: October 2011

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NEW YORK STATE ELECTRIC & GAS
DESIGN CRITERIA
COMPRESSED AIR ENERGY STORAGE PROJECT

SYNOPSIS

This document presents the Design Criteria for the Compressed Air Energy Storage project.

Disclaimer

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1. PROJECT DESCRIPTION

The Seneca Compressed Air Energy Storage (CAES) Project is a 130 to 210 MW Compressed Air Energy Storage plant that will consist of a separate, electrically driven compression cycle and a natural gas-fired expansion cycle energy storage plant. New York State Electric & Gas (NYSEG) will evaluate two expansion cycle designs for the plant during Phase 1 of the project and will select the most cost effective technology to proceed with Phase 2 project development should the CAES project be approved for development. The first expansion cycle to be evaluated (Cycle #1) will employ expansion turbine generators with natural gas combustors to pre-heat the storage air prior to admitting it into the expanders. The second expansion cycle (Cycle #2) to be evaluated will consist of a simple cycle combustion turbine with a waste heat recuperator downstream of the combustion turbine exhaust that will be used to pre-heat the storage air prior to admitting it into the expanders.

The Seneca CAES plant will provide sufficient storage to allow full operation during the peak time periods, operating in support of the transmission system and market needs, i.e., approximately 10 to 12 hours per day. This capacity is sufficient to provide a wide range of operational and smart grid benefits on the NYSEG utility power system and provide Department of Energy (DOE) and the United States with a credible demonstration of an advanced CAES plant integrated into a smart grid infrastructure in the state of New York. During operation, the CAES plant will cycle from a maximum pressure of approximately 1,500 psig down to a minimum pressure of approximately 1,150 psig. During charging periods, the compression system will increase cavern pressures back to the maximum noted above during an eight to ten hour charging cycle. The charge/discharge cycles can be expected to routinely occur on a daily basis over the 30 year design life of the facility. The cavern and well system design must affirmatively address this cycling duty and the Contractor will be expected to provide detailed assumptions and analyses supporting the design based on this cycling duty.

CAES plants use off-peak electricity to compress air into an underground reservoir or an above ground air storage system. When electricity is needed, the compressed air is withdrawn from the air store, heated via combustion with natural gas or preheated from the exhaust of a natural gas turbine, and passed through an expansion turbine to drive an electric generator. CAES plants burn about one-third the amount of fuel compared to conventional combustion turbines and produce about one-third the pollutants per kilowatt hour (kWh) generated compared to a conventional combustion turbine.

The advanced CAES facility will generally charge during off-peak periods when excess, low-cost electricity is available and discharge during on-peak hours. Unique to this project, the CAES facility will be capable of quickly switching from charging to discharging to further take advantage of system needs during on-peak periods when the wind generation is beyond the system needs or there is a sudden loss of wind generation. In doing so, more renewable energy can be captured and/or controlled while reducing the extreme volatility in market pricing and operation. In this way, there is a better asset utilization of wind/renewable energy and reduction in the need to purchase ramping and regulation from conventional fossil fuel based power plants.

The overall objective of the advanced CAES demonstration project is to improve reliability of the grid and do so by creating storage and more desirable dispatch for wind energy, which is expected to accelerate instability and congestion in the future when the predicted large amounts of wind generators (forecasted to be about 3,000 MW in New York Independent System Operator (NYISO) queue) are brought on line. The proposed advanced CAES project will enable New York State wind farms to store their output during periods of low demand and then dispatch this stored energy in response to market signals during peak and intermediate load time periods.

There are three phases of the proposed project:

- Phase 1: Develop final engineering design including project capital costs; develop project financials based on the engineering design and updated forecasts of energy market revenues; characterization of the salt cavern to be used for air storage; draft environmental permit exhibits; draft NYISO interconnection filing information and exhibits.

- Phase 2: Plant construction with a target in-service date of late 2016.

- Phase 3: Commercial demonstration, testing, performance reporting.

2. DESIGN CRITERIA

The criteria presented herein are subject to change during the development of the plant design. Final data are defined by the following approved engineering documentation (including but not limited to):

- Piping and Instrumentation Diagrams (P&IDs)
- Piping Line Specifications
- Equipment Procurement and Technical Specifications
- Vendor Data
- Water and Heat Balance Diagrams
- One Line Diagrams

2.1 Design Assumptions

The assumptions presented herein are subject to change during the development of the plant design. Final data are defined by approved engineering documentation.

- Compressed air operating pressures at the wellhead flange are 1,150 psig minimum and 1,500 psig maximum.
- For piping and fuel gas system sizing design, maximum compressed air operating pressure downstream of control valve is 850 psig for Cycle #1. For piping design, maximum compressed air operating pressure downstream of wellhead flange is 1,150 psig for Cycle #2.
- During compression, the average air flow rate at -2 °F. ambient and 170 MW at the wellhead flange is 690 lb. / second for Cycle #1 and 680 lb. / second for Cycle #2 at 1,150 psig and 95 °F.
- During generation, the average air flow rate at maximum generation at the wellhead flange is 400 lb. / second for Cycle #1 and 600 lb. / second for Cycle #2 at 1,150 psig and 95 °F.

- During generation, the minimum air temperature at the wellhead flange will be below dewpoint and will require insulation and water traps.
- Usable cavern volume will be approximately 15 million ft^3.
- Transmission line maximum limit is 210 MW generation capability.
- Transmission line maximum limit is 170 MW compression load capability.
- Circulating cooling water would range from 60 °F. in January to 80 °F. in July.
- Maximum of 8 to 10 hour compression cycle to go from minimum to maximum wellhead pressure.
- Fuel gas is available at 700 psig to 800 psig.
- Emission limits are approximately 2 ppm NOx, 2 ppm CO, 5 ppm NH_3 slip, and below the 40 tons / year Volatile Organic Compound (VOC) threshold.
- Redundancy and sparing philosophy 2 x 100 % (same as RG&E Russell Station project).
- Elevation is approximately 1,000 feet above MSL.
- Three design points for ambient weather conditions are -2°F, 50% RH; 45°F, 60% RH; and 87 °F, 46% RH.
- Fuel gas analysis same as RG&E Russell Station project.
- Two means of egress are required for the site.
- There is a propane and butane loading, unloading, and above ground storage facility on the property immediately adjacent to the site and at a higher elevation that the CAES plant.
- Cooling tower plume abatement is an option.
- Administration and maintenance facilities similar to RG&E Russell Station project.
- Perimeter noise levels to be 45 dBA.

- Construction limitations similar to RG&E Russell Station project due to nearby homes.
- Design for a manned facility.
- Administration building to include visitor center and parking for up to 20 visitor vehicles.
- New York State Department of Environmental Conservation State Pollutant Discharge Elimination System non-significant minor permit wastewater discharge limits are assumed and standard United States sanitary requirements for septic and drain fields are assumed.

SITE SPECIFIC DATA

General:

Location:	Reading Center, New York
Elevation (feet above mean sea level)	1,000
Outdoor Ambient Temperature Range:	(-)2 to 87 °F
Outdoor Ambient Design Temperature for HVAC (ASHRAE 2009)	
Summer (1.0% cooling):	87°F DB, 71°F WB
Winter (99.6% heating):	(-) 2°F DB
Design Indoor Temperature Range (Control Room, DCS Room, Office Areas, Electrical Rooms):	70 to 75°F
Design Indoor RH Range (Control Room, DCS Room, Office Areas, Electrical Rooms):	40 to 60% RH
Design Indoor Temperature Range for Ventilated Areas	45 to 90° F

Structural Data:

Building Design Codes:	IBC 2006 ASCE 7-05
Wind Load	
Exposure Category (IBC 2006, Section 1609.4)	C
Basic Wind Speed, V (IBC 2006), mph	90
Occupancy Category of Buildings and Structures (IBC 2006, Table 1604.5)	III
Importance Factor, I (ASCE 7-05, Table 6-1)	1.15
Snow Load	
Ground Snow Load, p_g (IBC 2006, Figure 1608.2)	35 psf
Exposure Category (IBC 2006, Section 1609.4)	C
Exposure Factor C_e (ASCE 7-05, Table 7-2)	1.0
Occupancy Category of Buildings and Structures (IBC 2006, Table 1604.5)	III
Importance Factor, I (ASCE 7-05, Table 7-4)	1.1
Rainfall	
Annual Average, inches	36
10 yr, 24 hr, inches	3.9
25 yr, 24 hr inches	4.5
Earthquake Loads	
Site Class (IBC 2006 Table 1613.5.2)	C
Mapped Spectral Response Acceleration, short period, Ss (IBC 2006 Figure 1613.5(1))	0.162 g
Mapped Spectral Response Acceleration, 1 second period, S_1 (IBC 2006 Figure 1613.5(2))	0.054g
Seismic Design Category (IBC 2006 Table 1613.5.6(1) & Table 1613.5.6(2))	A
Occupancy Category of Buildings and Structures (IBC 2006, Table 1604.5)	III
Importance Factor, I (ASCE 7-05, Table 11.5-1)	1.25

Electrical Data:

AC Power			
Medium Voltage	13.8 kV	3P, 3W	60 Hz
Low Voltage Power	480 V	3P, 3W	60 Hz
	208/120V	3P, 4W	60 Hz
Motors			
<= 1/3 hp motor (Except MOVs)	115 V	1P, 2W	60 Hz
> 1/3 hp but < 250 hp motor and MOVs	460 V	3P, 3W	60 Hz
>= 250 hp motor	13.2 kV	3P, 3W	60 Hz
Welding Receptacles	480 V	3P, 3W	60 Hz
Lighting	480 V	3P, 4W	60 Hz
DC Power			
Control Circuits	125 VDC	NA	NA
Instrument Power	120 VAC	1P, 2W	60 Hz

Mechanical Data:

Maximum Cooling Water Temperature, deg F	80
Site Air	
Instrument Air Maximum Pressure, psig	125
Instrument Air Dewpoint, ºF	-40
Service Air Maximum Pressure, psig	125
Instrument / Service Air Maximum Temperature, ºF	100
Noise Requirements	
Near Field (3 feet horizontally, 5 feet vertically from machine baseline	90 dBA
Far Field (Plant equiment measured 400' from plant site)	45 dBA

Notes:

None

SENECA CAES PROJECT VALUE DRIVERS

Purpose:

This document presents an overview on the different operating modes in which the Seneca CAES is anticipated to operate and the key parameters that will make such operation, and thus the project, successful.

Bidders should optimize these key parameters - moderated against the goals of producing a facility that is characterized by its safety, simplicity of operation, and reliability; and moderated by the incremental cost of further optimizing any particular key parameter.

Key Parameters:

Compression (Cavern Charging):

Minimum time required to charge 5 million cubic foot cavern from its minimum charge of 480 psig to 1,340 psig as measured at well head, limited by maximum available line capacity of 200 MVA with 0.85 power factor. Grade is approximately 1,000 feet above MSL and the top of the cavern is approximately 1,200 feet below MSL.

Turn down to allow compression at reduced available power down to 40 MVA.

Confirm whether compressor-motors can be de-coupled to operate in synchronous condenser mode. If feasible, provide “D” curves (leading and lagging), how much energy is required to spin them, and what is the maximum capacity.

Generation:

Minimum output value (meeting emissions limits).

Maximum output value (limited to same available line capacity as above.)

Heat rate and energy ratio – provide values for each 10% increase in output levels, starting at zero output.

Minimum start-up time – provide time to achieve each 10% increase in total output up to full load.

Confirm a minimum ramp rate of 8 MW/min, up and down, when operating above minimum load.

Minimum time to go from compression to generation. Minimum time to go from generation to compression. Target for both is 5 minutes or less.

SENECA CAES PROJECT VALUE DRIVERS

Minimum time to achieve synchronization.

Confirm whether expanders-generators can be de-coupled to operate in synchronous condenser mode. If feasible, provide "D" curves (leading and lagging), how much energy is required to spin them, and what is the maximum capacity.

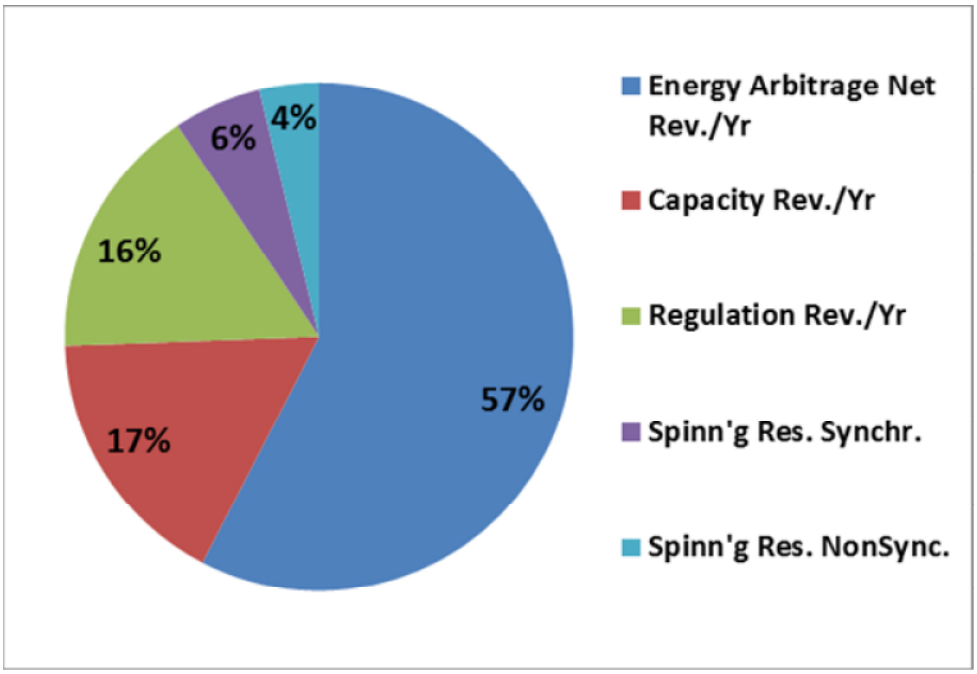
Combined:

What is the breakpoint for energy ratio or heat input with respect to going from 480 psig to 1,340 psig?

Other:

Confirm that black start capability can be provided and provide option price for this feature.

Expected Revenue Opportunity Breakdown:



WorleyParsons
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EcoNomics

NEW YORK STATE ELECTRIC & GAS

Mechanical Design Criteria

COMPRESSED AIR ENERGY STORAGE PROJECT

Document: CAES-1-DB-022-0001

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SYNOPSIS

This document presents the Mechanical Design Criteria for the Compressed Air Energy Storage project.

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1.0 INTRODUCTION

This document establishes the criteria for materials, design, fabrication, examination, testing, inspection, and certification required in the manufacture and installation of items for mechanical work.

While this document provides general guidance, it is not a substitute for good engineering judgement which should be applied as appropriate with the approval of the Lead Mechanical Engineer.

2.0 BASIS OF DESIGN

2.1 Plant Operating Modes

The plant will be designed for operating modes involving daily starting and stopping. The plant will be designed to operate over the range of conditions given in the project heat balances.

Equipment sizing will be performed based on conditions shown on the heat balances and water balances.

Units

The project will use the standard unit system.

Guaranteed Values

The guaranteed performance data will be achieved under the conditions detailed below.

Ambient Air Conditions

All guaranteed values will be achieved at the specific ambient conditions for the project including dry bulb temperature, relative humidity, and barometric pressure.

Combustion Turbine and Burners Fuel

All guaranteed values will be achieved when the equipment is burning natural gas.

Plant Load

The guaranteed net output for the plant, and the guaranteed auxiliary power consumption will be achieved when operating at the 100% MCR base load, at the below ambient conditions.

2.2 Basis for Performance Guarantees

Plant Performance Guarantees, under the stated ambient conditions:

- Fuel: Natural Gas
- Guarantee values:

  Net plant output: 135,800 kW Cycle #1

  209,900 kW Cycle #2

  Net plant heat rate, (HHV): *4,335* Btu/kWh Cycle #1

  4,267 Btu/kWhr Cycle #2
- Basis for plant performance:

  Circulating water temperature: 60 to 80 °F

  Generator terminal power factor: 0.85 Cycle #1

  0.90 Cycle #2

  Generator terminal frequency: 60 Hz.

2.3 Noise Emissions

Location	Parameter	Units	Value
Near Field	Indoor and outdoor plant equipment measured 3 ft horizontally and 5 ft above the machine baseline.	dB(A)	85
Far Field	Plant equipment measured at the 400 foot distance from the plant site.	dB(A)	45 (based on 30 to 40 ambient + 6)

2.4 Site Conditions

Design ambient dry bulb / relative humidity: 45 °F / 60%

Maximum ambient dry bulb / relative humidity: 87 °F / 46%

Minimum ambient dry bulb / relative humidity: -2 °F / 50%

Barometric pressure:	14.2 psia
Elevation above mean sea level	1,000 feet

3.0 CODES, STANDARDS, AND REFERENCES

The design and specification of all work will be in accordance with all applicable industry codes and standards. A summary of the codes and industry standards to be used in design and construction is listed below:

- Air Conditioning and Refrigeration Institute (ARI).
- Air Diffusion Council (ADC).
- Air Movement and Control Association International (AMCA).
- American Bearing Manufacturers Association (ABMA).
- American Boiler Manufacturers Association (ABMA).
- American Gear Manufacturers Association (AGMA).
- American Institute of Steel Construction (AISC).
- American National Standards Institute (ANSI).
- American Petroleum Institute (API).
- American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE).
- American Society of Mechanical Engineers (ASME).
- American Society for Nondestructive Testing (ASNT).
- American Society of Sanitary Engineers (ASSE).
- American Society for Testing and Materials (ASTM).
- American Welding Society (AWS).
- American Water Works Association (AWWA).
- Cast Iron Soil Pipe Institute (CISPI).

- Conference of Governmental Industrial, Hygienists - Industrial Ventilation, A Manual of Recommended Practice.
- Cooling Technology Institute (CTI).
- Ductile Iron Pipe Research Association (DIPRA).
- Expansion Joint Manufacturers Association (EJMA).
- Factory Mutual (FM).
- Fluid Sealing Association (FSA).
- Heat Exchange Institute (HEI).
- Hoist Manufacturers Institute (HMI).
- Hydraulic Institute (HI).
- International Organization for Standardization (ISO).
- Manufacturers Standardization Society of the Valve and Fitting Industry, Inc. (MSS).
- Mechanical Power Transmission Association (MPTA).
- National Fire Protection Association (NFPA).
- NSF International.
- Occupational Safety and Health Administration (OSHA).
- Pipe Fabrication Institute (PFI).
- Rubber Manufacturers Association (RMA).
- Sheet Metal and Air Conditioning Contractor's National Association (SMACNA).
- SSPC: The Society for Protective Coatings (SSPC).
- Tubular Exchanger Manufacturers Association (TEMA).
- Underwriter's Laboratories (UL).

Other recognized international standards will be used as required to serve as design, fabrication, and construction guidelines when not in conflict with the above-listed standards.

The codes and industry standards used for design, fabrication, and construction will be the codes and industry standards, including all addenda, in effect on the date as stated in equipment and construction purchase or contract documents.

4.0 EQUIPMENT SELECTION

4.1 General Requirements

This plant will be designed to be highly reliable. It is essential that the plant design and equipment selection be conservative and based upon proven and reliable designs. The plant will be designed to permit ease of access for operation, repair, and maintenance. All frequently operated, inspected or maintained items will be accessible by means of stairs, platforms, or ladders. All heavy motors, reducers, and wear elements not accessible by a fork lift or a mobile crane, will generally be accessible by an overhead crane or monorails.

Sizing of equipment will be based on the design flow rates, capacities, temperature, and pressure, as shown on the heat flow diagrams. Equipment will also be capable of sustained operating at normal flow rates, and occasionally, at minimum flow rates.

Manufacturer's information used during the design phase of the project will take into consideration possible clearance or interference problems resulting from final equipment selection.

Equipment selection will also take into consideration the environmental conditions of the project.

Equipment will be designed to operate on a continuous, 24-hour basis for the conditions specified, unless otherwise approved by the Owner.

This section is devoted to mechanical hardware and equipment including pumps, piping, valves, tanks, and insulation and lagging. In specifying this equipment, the system engineer will consider material selection carefully with corrosion mitigation/prevention in mind. This is critical when developing equipment specifications, piping line specifications, and technical specifications (i.e. bedding & backfilling, coatings, paint, etc). The system engineer will interface with corporate as well as external resources as needed to define these items.

Early project studies of soil conditions and raw water quality will determine buried pipe materials, coatings, fasteners and aboveground piping materials. Project-specific corrosion control recommendations for materials coatings, cathodic protection, and chemical treatment will be determined by the responsible system engineer in conjunction with corporate and external resources. Corrosion mitigation/prevention details will be enumerated in the following project-specific documents:

- Piping Materials Service Index listing piping recommended materials, design requirements, and associated Piping Line Specifications.
- Cathodic Protection Technical Specification in coordination with Electrical Engineering.
- Coatings/paint selections for piping, equipment, and tanks, in coordination with Structural Engineering.
- Materials, corrosion, coatings, and related recommendations will also be inserted into Equipment and Technical Specification documents within the project work scope.

4.2 Equipment Numbering

Equipment will be numbered in accordance with the project numbering system.

4.3 Pumps

4.3.1 General

Pumps will be selected with a shutoff head at least 115 to 125% above the design total head, where possible.

4.3.2 Pump Design Margin for Miscellaneous Pumps

The capacity margin should be 5 % rounded off to the next higher step as follows:

Capacity, gpm	Step, gpm
10,000 – 100,000	500
1.000 – 10,000	50
100 – 1,000	5

A total head margin of 5 % is normally adequate. After adding the 5 %, the total head should be rounded off to the next whole foot for less than 100 foot application and to the next 5 feet for more than 100 foot total head pumps.

The diameter of the impeller for the design flow point will not exceed 90 % of the diameter of the largest impeller than can be installed in the casing.

The pump motors will be sized to permit the pump to operate anywhere on the certified pump curve without overloading

4.4 Tanks

4.4.1 Field Erected Tanks

Field erected tanks will be designed to AWWA (typically water storage) and NFPA 22 (for fire fighting). Tanks will be specified using the WorleyParsons standard specification and any project-specific requirements.

Tank connections requiring expansion joints will be provided with block valves between the tank connection and the expansion joint to allow for repair or replacement of the expansion joint without draining the tank. Where the tanks are a suction source for a pump or pump manifold and the pumps are on a foundation independent from the tank foundation (non-monolithic), an expansion joint will be used at the tank nozzle (after valve) to allow for differential settlement.

The following features will be provided:

- Process, vent (may require a conservation vent depending on process fluid), overflow, and drain connections for startup, operation, and maintenance. Depending on the fluid stored, the tank vent may require a filter and the tank a vacuum breaker.
- Materials will be compatible with the fluid being handled. Carbon steel tanks will have a minimum interior corrosion allowance of 1/16-inch unless coated or lined.
- Personnel access opening(s) for maintenance or cleaning access. Add davit and hinge to manway opening to support manway during entry.
- Shop-installed insulation clips and insulation support rings for tanks requiring insulation (clips will not be spaced greater than 18-inches on center).
- Ladders, stairs and platforms as required for access and maintenance. Handrails and non-skid paint on roof.
- Depending on process fluid, a double wall tank or dike may be required. Multiple tanks inside a common dike may require a small separation dike in accordance with NFPA 30.
- Consideration will be given to welded or bolted construction depending on cost and client preference.
- The tanks provided with sloped bottom will have drains as close to the low point of the bottom as possible.
- Tanks will be provided with overflow sized to handle 1.5 times the total maximum design inflow to the tank.

4.4.2 Shop Fabricated Tanks

Consideration should be given to designing atmospheric tanks in accordance with the requirements of ASME B&PVC, Section VIII, Division 1 without the code stamp. Tanks will be specified using the WorleyParsons standard specification and any project-specific requirements. The following features will be provided:

- Process, vent, and drain connections for startup, operation, and maintenance.
- Materials will be compatible with the fluid being handled. Carbon steel tanks will have a minimum interior corrosion allowance of 1/16-inch unless coated or lined.
- A minimum of one personnel access opening and one air ventilation opening (e.g., handhole), where required for maintenance or cleaning access.
- Shop-installed insulation clips and insulation support rings for tanks requiring insulation (clips will not be spaced greater than 18 inches on center)
- Coating and cathodic protection design consideration for tank intemals and externals will be coordinated on a project-specific basis.

4.4.3 Pressure Vessels

Shop fabricated tanks will be designed in accordance with the requirements of ASME B&PVC, Section VIII, Division 1, and provided with a code stamp. Tanks will be specified using the WorleyParsons standard specification and any project-specific requirements. The following features will be provided:

- Pressure vessels will be designed in accordance with the requirements of ASME B&PVC, Section VIII, Division 1.
- Relief valves will be in accordance with the applicable codes.
- Process, vent, and drain connections for startup, operation, and maintenance.
- Materials compatible with the fluid being handled. Carbon steel tanks will have a minimum interior corrosion allowance of 1/16-inch unless coated or lined.
- A minimum of one personnel access opening and one air ventilation opening (e.g., handhole), where required for maintenance or cleaning access.
- Shop-installed insulation clips and insulation support rings for tanks requiring insulation (clips will not be spaced greater than 18-inches on center)

4.5 Combustion Turbine Generator and Accessories

The Cycle #2 combustion turbine generator will be provided with inlet air filtration system; inlet silencer; hydraulic control oil systems with cooling provisions; excitation starting systems; acoustical enclosures including heating and ventilation; control systems including supervisory; fire protection; and fuel systems. The combustion turbines will fire natural gas, and will use a dry, low NOx combustion system.

The generator will be provided with the combustion turbine package. The generator will be the manufacturer's standard, constructed to meet ANSI and NEMA standards for turbine-driven synchronous generators.

Significant features of the combustion turbine generator are as follows:

- Lubricating and hydraulic oil system.
- Oil-to-water lube oil coolers.
- Fuel gas system, including liquid separators, flow orifice meters, startup strainers, and pressure regulating valves.
- Inlet air filtration system.
- Exhaust system.
- Fire protection/detection system (utilizing FM200 or equal).
- Starting system.
- Turbine compartment vent fans.
- Generator compartment vent fans.
- Generator water/air heat exchangers.
- Turbine controls.
- Generator controls, protection, excitation, power system stabilizer, and automatic governor control.
- Neutral grounding and surge protection equipment.
- 125 V DC battery system for each unit.
- Online/offline water wash system.

- Piping, valves, piping specialties, and instrumentation.

4.6 Air Expander Generator and Accessories

The air expander generator will be provided with all auxiliary systems for a complete operating air expander generator.

The generator will be provided with the air expander turbine package. The generator will be the manufacturer's standard, constructed to meet ANSI and NEMA standards for turbine-driven synchronous generators.

Significant features of the air expander turbine generator are as follows:

- Cycle #1 will have LP and HP burners.
- High pressure inlet stop and control valves.
- Low pressure inlet stop and control valves (Cycle #1 only).
- Seal system.
- Exhaust casing blowout diaphragms.
- Lagging.
- Local gauge panel.
- Actuated drain valves.
- Lubrication system.
- Hydraulic power unit.
- AC motor-driven turning gear.
- Control system.
- Generator.
- Generator excitation system.

4.7 Recuperator

The recuperator is designed to recover heat from the air expander exhaust and transfer it to the compressed air feed for Cycle #1 or to recover heat from the combustion turbine exhaust and transfer it to the compressed air feed for Cycle #2. The recuperator is designed to be fully integrated into the heat cycle and includes required inlet/outlet ducts, structural supports, piping, and accessories.

The recuperator proper is designed, fabricated, and inspected in accordance with the requirement of Section I (Power Boilers) of the ASME Boiler and Pressure Vessel Code (B&PVC) for both technical and administrative jurisdiction.

The recuperator external piping is furnished in accordance with the requirements of ASME B31.1 Power Piping (for technical jurisdiction only) and ASME, Section I, B&PVC (for administrative jurisdiction only).

All valves, trim, and accessories necessary for the operation of the recuperator are provided.

A system of platforms, stairways, and ladders is provided for inspection and maintenance access to valves and instrumentation. Access lanes are provided within the recuperator for inspection. Each lane is equipped with an access door.

An Inlet duct system is provided to deliver the air expander exhaust for Cycle #1 or the combustion turbine exhaust for Cycle #2 to the recuperator inlet. The duct system includes an expansion joint and horizontal ducting. The duct is designed to meet pressure drip limitations and distribute the exhaust gas to the inlet.

An outlet duct system is provided to deliver recuperator exhast to the stack. The outlet transition duct is provided with personnel protection (expanded metal) to a height of 8 feet. Stand-offs are provided for attachment of the expanded metal.

The recuperator heat transfer sections, steam drum, inlet/outlet, duct systems, and interconnecting piping are supported by a support structure designed in accordance with the equipment data, the site conditions and the applicable structural codes and standards.

Stairways, ladders, and platforms are provided for operation and maintenance access to valves. Instrumentation, steam drums, emission test ports, and stack closure. All stairways and platforms are provided with handrails and kick plates. Platform grating and stair treads are open, hot dipped galvanized steel

Recuperator interconnecting piping is provided to transfer heat from the recuperator to the compressed air feed. The piping is supported from the recuperator support structure.

4.8 Process Air Compressors

The process air compressors will be supplying atmospheric air to three interconnected 5 million cubic feet caverns for storage at pressures ranging from 1,150 to 1,500 psig. The desired compression time is 8-10 hours. The desired efficiency will be greater than 80%.

The compressors will be provided with inlet air filtration system; inlet silencer; starting systems; inter stage and after coolers; acoustical enclosures including ventilation; control systems.

Significant features of the process air compressors are as follows:

- Inlet air filtration system.
- Inter stage and after air to water coolers.
- VFD starting system.
- Isolation and control valves.
- Water wash system.
- Lagging.
- Local controls and instruments.
- Actuated vent and drain valves.
- Lubrication system.
- Oil to water coolers.
- AC synchronous motor.
- Control system.

4.9 Piping

Review project piping specification CAES-0-TS-15062.

Piping will be designed, selected, and fabricated in accordance with the following criteria:

Design Temperature and Design Pressure

- The design temperature and design pressure for piping will be consistent with conditions established for the design of the associated system.

- The design temperature of a piping system generally will be based on the maximum sustained temperature that may act on the system plus 10 °F except where specific design guides or criteria stated herein dictate otherwise. The piping design temperature will be rounded up to the next 5 °F increment, unless otherwise noted.

- The design pressure of a piping system generally will be based on the maximum sustained pressure that may act on the system plus 25 psi, unless otherwise noted in the specific design parameters for the system. All design pressure values will be rounded up to the next 10 psi increment, unless otherwise noted.

Piping Design and Selection Criteria

- Piping will be designed in accordance with the requirements of ASME B31.1 Power Piping and other codes and standards referenced in Section 3.0, as applicable. WorleyParsons standard piping line specifications will be used; special wall piping applications will require project-specific line specifications.

- Piping that is 1-1/4-, 3-1/2-, 5-, or 7-inches in nominal diameter will not be used for general system design. However, it is recognized that short segments may be required at connections to equipment.

- Minimum wall thickness of straight pipe under internal pressure will be designed in accordance with Paragraph 104.1.2 and 104.1.4 of ASME B31.1, as applicable.

- Allowable Fluid Velocities

The recommended range of fluid velocities will be as follows:

SERVICE	**VELOCITY**	**RESULTANT ΔP** psi/100 ft (steel pipe)
STEAM		
LP saturated ≤ 30 psig	1,000 fpm/inch ID: 1,000 to 12,000 fpm	Calculate
MP saturated ≤ 200 psig	1,000 fpm/inch ID: 1,500 to 12,000 fpm	Calculate
WATER		
General service discharge 2” to 6” 8” and over	5 to 8 fps 5 to 12 fps	Calculate
Suction 2 to 6 inches Suction 8 inches & over Circulating Water 8” & over	2 to 4 fps 3 to 5 fps 6 to 12 fps	Calculate

SERVICE	VELOCITY	RESULTANT ΔP psi/100 ft (steel pipe)
AIR Compressed air (≤100 psig)	700 fpm/inch ID: 900 to 4,500 fpm	Calculate
Compressed air (>100 psig)	500 fpm/inch ID: 600 to 3,000 fpm	Calculate
GAS Fuel	3,000 fpm maximum(for noise consideration)	

- Allowance for variations from normal operation, consideration for local conditions, and transients will be in accordance with Paragraphs 102.2.4 and 102.2.5 of ASME B31.1.

- The calculated value of SE will not exceed that given in Appendix A of ASME B31.1 for the respective material at the design temperature. These values include the weld joint efficiency. For longitudinal welded or spiral welded pipe operating in the creep range, paragraph 104.1.4 will be complied with.

- The value of A must be selected to compensate for material removed in threading, corrosion, erosion, and to provide mechanical strength. The following minimum allowances should be applied:

  – Special wall piping 2-1/2-inches (65 mm) and larger – The value of A will be at least 0.01-inch (0.25 mm) on alloy steel pipe and 0.06-inch (1.52 mm) on carbon steel pipe.

  – Schedule wall piping 2-1/2-inches (65 mm) and larger (typically considered large bore pipe) – The value of A will generally be 0.01-inch (0.25 mm) on alloy steel pipe and 0.06 inch-(1.52 mm) on carbon steel pipe except when additional thickness is considered necessary for a specific service.

  – Schedule wall piping 2-inches (50 mm) and smaller (typically considered small bore pipe) – The value of A should be selected to provide adequate mechanical strength. The minimum A value of 0.01-inch (0.25 mm) on alloy steel pipe and 0.06-inch (1.52 mm) on carbon steel pipe is suggested, but is not mandatory.

  – Threaded piping – The value of A will not be less than the depth of thread. Threading of pipe will consider minimum wall thickness. For small bore pipe, this implies using at least schedule 80 material.

- The pressure-temperature ratings for seamless and ERW (welded with no filler) schedule wall pipe will be based on minimum wall values, which are 87-1/2 percent of

the nominal pipe wall thickness per ASME B31.1. This allows for the minus 12-1/2 percent manufacturing tolerance on wall thickness. For the design of ASME flow nozzles, the vendors must consider this allowance when detailing the OD of nozzles and the weld lip for insertion into steam lines.

- Material selection will generally be based on the design temperature and service conditions in accordance with the following:
  - All power cycle piping will be of metallic material.
  - The use of fibreglass-reinforced plastic (FRP), high-density polyethylene (HDPE), chlorinated polyvinyl chloride (CPVC), and polyvinyl chloride (PVC) piping will be limited as shown in Table 1.
  - Carbon steel piping materials will be used for design temperatures less than or equal to 800 °F (427 °C).
  - Chromium-molybdenum alloy steel or stainless steel piping materials will be used for design temperatures great then 800 °F (427 °C).
- Stainless steel piping materials will be used as follows:
  - Piping applications requiring a high degree of cleanliness generally including air compressor inlet piping, miscellaneous lubricating oil system piping, instrument air piping, and sampling piping after process isolation valves.
  - Piping generally subjected to corrosive service applications.
  - Material selection will be performed by the system engineer using corporate and external resources on a per system basis generally following the above and will be documented in a project-specific Piping Materials Service Index as follows:
    - The Piping Materials Service Index will be updated by the system engineer and the corrosion engineer throughout the project as design, operating, and shut-in conditions are determined / revised.
    - The Piping Materials Service Index serves as an input to all Piping Line Specifications and Piping and Instrumentation Diagrams.
    - Materials selection for water-wetted components will reference the project-specific Water Quality Analysis Report including raw and treated water, cycles of concentration, and chemical treatment considerations, as well as the chemical treatment plan.

- Materials selection may also consider the worst case of normal operation, peak load, partial load, and shut-down conditions.

Table 1
Application of PVC, CPVC, HDPE and FRP Piping

Application Chart

Application	HDPE	PVC/CPVC	FRP
Power Plant Thermal Cycle	None	None	None
Circulating Water System	X	None	X
Water Treatment System drains (above grade)	None	None	X
Water Treatment System drains (below grade)	X	X	None
Fire protection water, underground	X	None	None
Fire protection water, aboveground	None	None	None
Cast into concrete	X	None	X
Plant Equipment and Drains Piping	X	X	X
Overflow Drains on Chemical Solution Tanks	X	X	X
Wastewater	X	X	X
Roof Drains	X	X	X
Potable Water (aboveground)	None	None	None
Potable Water (belowground)	X	None	None
Sodium Hypochlorite	None	X	None

Additional application rules for plastic (CPVC, PVC, FRP, and HPDE) piping:

- Limited to low-pressure applications. Generally limited to 75 psig.
- Temperature for nonmetallic piping will be limited to the temperature listed in ASME B31.1, except where designed in accordance with governing plumbing codes (in these cases, use industry/manufacturer ratings as applicable)
- Detailed installation and fabrication specifications will be used.
- Certification of joiners will be specified.
- Flanged and threaded pipe will be avoided, when possible, in chemically aggressive applications.
- Underground fire protection loops using HDPE must employ FM 200 rated pipe. Also consider the use of cement-lined ductile iron.

Copper and/or stainless steel piping materials will be used for instrument air piping downstream of the air dryers. Carbon steel will be used for instrument air systems upstream of the air dryers and throughout service air systems.

Copper piping materials will be used for aboveground potable water piping, including safety showers and eyewashes. HDPE piping will be used for underground potable water systems. Copper may be used as an alternative to HDPE provided that the soil conditions are favourable (i.e. not elevated levels of sulphate or chlorides and not retaining significant moisture).

The Piping Materials Service Index will document above and below ground piping materials on a project-specific basis.

The above-listed materials will be used where required for special service to meet specific requirements.

Miscellaneous Piping Design and Selection Criteria

The minimum pipe size and wall thickness for miscellaneous piping, other than control and instrument piping, will generally be in accordance with the following criteria:

- The pipe size will be ¾-inch minimum, except for sample piping and cycle chemical feed piping. However, it is recognized that short segments of ½-inch pipe may be required at connections to equipment.
- Sample piping will be 1/4-inch, 3/8-inch, or 1/2-inch stainless steel tubing or piping to maintain proper velocities and response times.
- In general, all carbon steel, low alloy steel, and stainless steel will be specified for but welding or socket welding as appropriate. The use of flanges will be limited to connection to equipment or required for maintenance. A gas tungsten arc weld (GTAW) root pass will be specified where required for cleanliness. These systems will include all main power cycle systems such as steam, feedwater and condensate, oil systems, natural gas systems and stainless steel systems (both socket and butt welded joints).
- Cycle chemical feed piping will be ¼-inch and 3/8-inch stainless steel tubing.

Vent and Drain Piping Design Criteria

High point vent and low point drain piping will generally be in accordance with the following criteria:

- The recommendations of ASME TDP-1 will be followed for all power cycle steam piping drains.
- Vent and drain piping through the isolation valve or drain line termination will be as described for miscellaneous piping and will be consistent with the piping for the main piping system.
- Vent connections will be provided at all high points in water and oil piping, and all high points in other piping, including steam lines, which will be pressure tested.
- Drain connections will be provided at all non-drainable low points in steam, water, and oil piping, and all other piping, which will be pressure tested.
- Drain connections will be provided at all control valve stations. The drain will be located to drain the control valve as completely as possible.

- All vent and drain connections will be provided with manually operated isolation valves in accordance with the following table:

SYSTEM	VENT	DRAIN
Steam	Globe	Globe
Natural Gas	Ball	Ball
Compressed Air	Not Vented	Ball
Lube Oil	Globe or Ball	Globe or Ball
All Others	Gate or Ball	Gate or Ball

- Piping systems such as steam systems may have the high point vent valve omitted following pressure testing, with the vent connection plugged by welding a fitting in place of the vent valve. ASME B31.1, paragraph 137.8, will be consulted for re-hydro requirements when welds have been completed on the pressure boundary after the first hydro.

- Vent and drain connections that require frequent operation will be piped to a suitable drain. Vent or drain connections that normally require operation when hot fluids will be discharged will be piped to a safe termination point (drain funnel or floor area discharge). All other connections will terminate with the isolation valve.

- Valved vents: Piping highpoint vents will be 1-inch minimum size, capped, for piping sizes being vented that are equal to, or greater than, 1 inch. Use two valves in series for Class 900 systems and higher; one valve is used for Class 600 and lower.

- Valved drains: Piping low point drains will be 1-inch minimum size, valved, nippled, and capped for piping sizes being drained that are equal to, or greater than, 1 inch. Use two valves in series for Class 900 systems and higher; one valve is used for Class 600 and lower.

- Drain pot drains will be minimum 2-inch to accommodate cleaning of the piping by high pressure water blast.

Piping Materials

Piping materials will be in accordance with applicable ASME, AWWA, and ASTM standards. Materials to be incorporated in permanent systems will be new, unused, and undamaged. Piping materials will generally be in accordance with the following criteria and will be documented by system on a project-specific basis in the Piping Materials Service Index:

Ductile Iron Pipe

Ductile iron piping (sizes 3 to 16-inches) will be AWWA.

Carbon Steel Pipe

Carbon steel piping 2-inches nominal size and smaller will typically be ASTM A 106 or A53, Grade B minimum.

Carbon steel piping 2-1/2-inch through 24-inch nominal size will be ASTM A 53, Grade B seamless or A 106, Grade B Carbon steel piping larger than 24-inch nominal size will be ASTM A 672, Grade C70 seam welded Class 22 for steam service with an operating temperature less than 800°F, and ASTM A 672, Grade B60, Class 22, Grade B or A 106 Grade B for cold water service. API-5L, Grade B may be used as an alternate for cold water service and AWWA C200 may be used for circulating water.

The use of ASTM A 53 piping material will be limited to 2-1/2-inch nominal size and larger piping, with a design temperature of 200 °F or less and a maximum design pressure of 200 psig.

Electric Fusion welded steel pipe will be of the welded straight seam type.

Schedule numbers, sizes and dimensions of all carbon steel pipe will conform to ASME B36.10.

Stainless Steel Pipe

Stainless steel pipe will be ASTM A 312, Grades TP 304, TP 316, or TP 316L, seamless/welded piping. All stainless steel piping materials will be fully solution annealed before fabrication. Type 316 will be used for high resistance to corrosion. Type 316L will be used for handling solutions that are high in chlorides.

Steel plate piping will be of the welded straight-seam type.

Sizes and dimensions of stainless steel pipe designated as Schedule 5S, 10S, 40S, or 80S will conform to ASME B36.19. Schedule numbers, sizes, and dimensions of stainless steel pipe not designed as 5S, 10S, 40S, or 80S will conform to ASME B36.10.

Small bore fuel oil and lube oil piping will use socket-welded joints.

Copper Tubing

Copper tubing will conform to ASTM B 88 Seamless Copper Water Tube. For both aboveground and underground service, only type K is to be used; types L & M will not be used.

Polypropylene-Lined Pipe

Polypropylene-lined pipe will be ASTM A 53 Grade B steel pipe seamless/welded with an applied liner of polypropylene. The pipe will be the type as manufactured by Resistoflex Corporation or WorleyParsons approved equal.

Fiberglass-Reinforced Plastic Pipe

Fiberglass-reinforced plastic pipe will be chosen in accordance with the specific service requirements. When used for piping systems within the scope of ASME B31.1, the pipe will meet the requirements of ASME B31.1 non-mandatory Appendix III. WorleyParsons standard fittings/piping database uses RPS/ABCO. The use of another supplier dictates adjustments to the database for routing of pipe.

Polyvinyl Chloride Pipe

Polyvinyl chloride (PVC) pipe will conform to ASTM D 1785 or ASTM D 2241. When used for piping systems within the scope of ASME B31.1, the pipe will meet the requirements of ASME B31.1 non-mandatory Appendix III.

Chlorinated Polyvinyl Chloride Pipe

Chlorinated polyvinyl chloride (CPVC) pipe will conform to ASTM D 1784. When used for piping systems within the scope of ASME B31.1, the pipe will meet the requirements of ASME B31.1 non-mandatory Appendix III.

High Density Polyethylene Pipe

High density polyethylene pipe (HDPE) will conform to ASTM D 3350. When used for piping systems within the scope of ASME B31.1, the pipe will meet the requirements of ASME B31.1 non-mandatory Appendix III.

Alloy 20 Pipe (UNS N08020)

CR-Ni-Fe-Mo-Cu-Cb stabilized alloy piping (Carpenter Steel Alloy 20) will conform to ASTM B 464 or B 729.

Pipe Fittings

Cast Steel-Flanged Fittings

Cast Carbon steel-flanged fittings will conform to ASME B16.5 and be manufactured from materials conforming to ASTM A 216 Grade WCB and WCC.

Welded Steel Fittings

Reducing outlet tees or specially designed adapters will be used for branch piping 2-1/2 inches and larger. The type of branch connection will be determined as indicated in the WorleyParsons piping specifications. If not addressed in the piping specifications, Mechanical Engineering Standards DS-169-13 and DS-169-14 will be followed. Specially designed adapters will be postweld heat treated, when required by the material specification and the ASME Code requirements. Specially designed adapters will be Weldolets, Sweepolets or forged nozzles as manufactured by Bonney Forge Corporations, WFI International, Inc. or WorleyParsons approval equal. Welded steel fittings will conform to ASME B16.9 and B16.11 and materials conforming to ASTM A 105, A 182, and A 234 as applicable. Circulating water pipe fittings greater than 24-inch will conform to AWWA C208.

Branch connections 2-inches and smaller will be made with special reinforced welding adapters such as Bonney Forge Thredolets or Sockolets or WorleyParsons approved equal, or will be special welded and drilled pads.

Brass and Bronze Fittings

Screwed brass and bronze pipe fittings will be designed to match the pressure temperature ratings of the pipe. Molded fittings will be used where practical. Fabricated fittings will be produced with smaller SDR (i.e. thicker) piping as required to meet the ratings of the matching pipe.

High Density Polyethylene (HDPE) Fittings

High density polyethylene fittings will be designed to match the pressure temperature ratings of the pipe. Molded fittings will be used where practical. Fabricated fittings will be produced with smaller SDR (i.e. thicker) piping as required to meet the ratings of the matching pipe.

Polypropylene-Lined Ductile Iron Fittings

Flanged ductile iron fittings used with polypropylene-lined steel pipe will be ductile iron fittings conforming to ASME B16.42 and will be lined with the same material as the pipe with which they are used.

Fiberglass-Reinforced Plastic Fittings

Fittings and joints for use with fiberglass-reinforced plastic pipe will be compatible with and furnished by the same company as the fiberglass pipe.

Polyvinyl Chloride Fittings

Polyvinyl chloride pipe and fittings will be manufactured from PVC material of the same type as the pipe with which they are used. The fittings will have socket ends with internal shoulders designed for solvent cementing.

Chlorinated Polyvinyl Chloride Fittings

Chlorinated polyvinyl chloride fittings will be manufactured from CPVC material of the same type as the pipe with which they are used. The fittings will have socket ends with internal shoulders designed for solvent cementing.

Flanges, Gaskets, Bolting, and Unions

Flanged joints will be in accordance with the following requirements:

Flange Selection

Flanges mating with flanges on piping, valves, and equipment will be of sizes, drillings, and facings that match the connecting flanges of the piping, valves, and equipment.

Flange class ratings will be adequate to meet the design pressures and temperatures specified for the piping with which they are used.

Flanges will be constructed of materials equivalent to the pipe with which they are used.

Steel Flanges

Steel flanges will conform to ASME B16.5 for sizes through 24-inch (600 mm) and ASME B16.47 from 26-inch (650 mm) through 60-inch (1500 mm).

Low pressure circulating water system pipe flanges 26-inches (650 mm) or larger will conform to AWWA C207.

Steel flanges will have raised-face flange preparation. Flat-face flanges will be used to mate with cast iron, ductile iron (except class 250), high density polyethylene, fiberglass-reinforced plastic, polyvinyl chloride, or bronze flanges.

Carbon steel flanges will be of ASTM A 105 material. Carbon steel flanges will not be used for temperatures exceeding 800 °F (400 °C).

Chromium alloy steel and stainless steel flanges will conform to ASTM A 182.

Brass and Bronze Flanges

Brass and bronze screwed companion flanges will be plain forced and will conform to class 150 or class 300 classifications of ASME B16.24. Drilling will be in accordance with ASME class 125 or class 250 standards.

High Density Polyethylene Flanges

HDPE flanged connections will be made with HDPE flange adapters (stub end type) and metallic lap joint flanges (i.e. back-up rings). Flanges will be designed to be leak tight for hydrotest at 1.5 times the pipe ratings.

Gaskets

Non-metallic gaskets will be used with flat-face and raised-face flanges within the limitations of the gasket materials. Spiral-wound gaskets will be used with raised-face for steam, high temperature and flammable (fire-safe) service. No asbestos containing gaskets will be specified.

Gaskets will be suitable for the fluid design pressures and temperatures. Unconfined, non-metallic gaskets will not be used above 720 psig (4964 kPa) or 750 °F (399 °C) per ASME B31.1.

Non-metallic Gaskets

Non-metallic gaskets will be in accordance with ASME B16.21, and materials will be suitable for the system design conditions and be compatible with the system fluids. Gaskets will be dimensioned to suit the contact facing. Gaskets will be full faced for flat-face flanges and will extend to the inside edge of the bolt holes on raised-face flanges. Gaskets for plain-finished surfaces will be not less than 1/16-inch (1.6 mm) thick. Gaskets for serrated surfaces will be not less than 3/32-inch (2.4 mm) thick. The gasket will be selected for the service requirements in accordance with the recommendations of the manufacturer.

Spiral-Wound Gaskets

Spiral-wound gaskets will be in accordance with ASME B16.20 and be constructed of a continuous stainless steel ribbon wound into a spiral with non-asbestos filler between adjacent coils. The gasket will be inserted into a steel gauge ring whose outside diameter will fit inside the flange bolts properly positioning the gasket. The gauge ring will serve to limit the compression of the gasket to the proper value. Compressed gasket thickness will be 0.130-inch (3.3 mm) plus or minus 0.005-inch (0.13 mm). For temperatures to 800 °F the filler material will be Flexible Graphite, as manufactured by Flexitallic Gasket Company or WorleyParsons approved equal. For temperatures between 800 °F and 975 °F the filler material will be thermiculite as manufactured by Flexitallic or WorleyParsons approved equal. Flexicarb filler will be specified for fuel gas service. Inner ring gaskets, Flexitallic Style CGI

will be specified for vacuum service, erosive service, temperatures exceeding 950 °F (510 °C) and where winding failure can damage downstream rotating equipment. Style CGI is required for all ASME class 900 and higher flanges and for all flanges with a surface finish smoother than 125 rms. Style CG will be used for ASME class 600 and lower flanges.

Ring Joint Gaskets

Ring joint gaskets will be octagonal in cross section and will have dimensions conforming to ASME B16.20. Material will be suitable for the service conditions encountered and will be softer than the flange material.

Rubber Gasket

Rubber gasket materials will conform to ASME B16.21. They will be full face and 1/16-inch (1.6 mm) or 1/8-inch (3.2mm) thick as recommended by the vendor and industry standards.

Bolting and Unions

Alloy steel bolting will be used for joining all steel flanges, except for large diameter low pressure water pipe flanges and will conform to the following:

- Bolting will conform to the requirements of ASME B16.5.
- Bolting will consist of threaded studs and two nuts for each stud.
- Bolted joints are not permitted above 975 °F (524 °C).
- Material for studs will be ASTM A 193, Grade B16, for piping design temperatures between 800 °F (427 °C) and 975 °F (524 °C), and Grade B7 for piping design temperatures less than 800 °F (427 °C)
- Material for nuts will be ASTM A 194, Grade 3, for piping design temperatures between 800 °F (427 °C) and 975 °F 524 °C), and Grade 2H for piping design temperatures less than 800 °F (427 °C).
- Carbon steel bolting will be used for joining flanges on large diameter, low pressure water piping and will conform to the following:
- Bolting will conform to the requirements of ASME B16.1 and ASME B16.24.
- Bolting for bolt sizes 1-1/2-inches (40 mm) and larger will consist of threaded studs and two nuts. Bolting for bolt sizes less than 1-1/2-inches (40 mm) may be threaded studs and nuts or bolts and nuts.

- Bolts and nuts will be heavy hexagonal head conforming to ASME B18.2.1 and B18.2.2.

Buried bolting and bolting outdoors will be zinc plated in accordance with ASTM A 153. Fasteners may also be stainless steel. Buried bolting will be specified consistent with other Buried Piping corrosion recommendations.

Piping unions will be of the ground joint type constructed of materials equivalent in alloy composition and strength to other fittings in the piping systems in which they are installed. Union class ratings and end connections will be the same as the fittings in the piping systems in which they are installed.

Insulating Flanges

Where required, underground piping will be electronically isolated from aboveground piping and other steel components to allow the underground piping to be cathodically protected. Isolation will be by installation of isolation flanges with insulating gaskets, bolt tubes, and washers (Pikotek or approved equal)

Insulating kits will be fire tested when used in or in close proximity to flammable liquid or gas systems (Pikotek or approved equal).

Piping Fabrication

Piping fabrication will generally be in accordance with the requirements stated herein.

Dimensions

The dimensions indicated on the drawings will not make allowance for welding gaps or welding shrinkage. Allowances will be made for gaskets in the dimension indicated. Fabrication tolerances will be in accordance with PFI Standard ES-3, “Fabricating Tolerances.”

The wall thickness and outside pipe diameter of all special wall piping will be measured and recorded before fabrication. The spool weights of all special wall piping will be calculated based on the actual dimensions of the piping.

Fittings

Fitting such as tees, crosses, elbows, caps, and reducers will be used for all changes in direction, intersections, size changes, and end closures of piping, unless the use of fittings is impractical.

Couplings will be used for joining straight lengths of 2-inch (50 mm) and smaller piping.

Branch welds and mitered fittings will not be used except where specifically required. The radius of mitered fittings will be greater than or equal to the diameter of the pipe. Mitered segment angles will not exceed 15 degrees for aboveground piping and 11-1/2 degrees for below ground piping.

Welding adapters, drilled and welded pads, and branch weld connections will be reinforced to meet the requirements of paragraph 104.3 of ASME B31.1. Safety valve nozzles will be additionally reinforced, as required, to resist thrust due to valve operation and will be designed in accordance with ASME B31.1 Non-Mandatory Appendix II Rules the Design of Safety Valve Installations.

Backing Rings

Backing rings are not permitted.

Bends

Pipe bending will be used only when specifically designated on the piping drawings or where the use of elbows is impractical.

All bends will be smooth, without buckles, and truly circular. The allowable flattening, as determined by the difference between the minor and major axes, will not be greater than 5 percent of the nominal diameter.

Allowance will be made for thinning of the pipe wall in accordance with the requirements of paragraph 102.4.5 of ASME B31.1 to ensure that minimum wall thickness after bending is not less than the minimum wall thickness required.

Brazed Joints

Brazing will be accomplished in accordance with the requirements specified in ASME B31.1.

Brazing filler metals will be either silver or copper-phosphorus alloys. Filler metals containing phosphorus will not be used for brazing steel or nickel base materials.

High Density Polyethylene (HDPE) Pipe Joints

Joints in high-density polyethylene (HDPE) piping will be fusion welded in accordance with the pipe manufacturer's recommendations. Where physically impractical to use the fusion bonding machine, electro-fusion couplings and fittings may be used with prior approval.

Fiberglass-Reinforced Plastic Pipe Joints

Fiberglass-reinforced plastic piping will be in accordance with the pipe manufacturer's standards. The type of joint (bell/taper or butt-wrap) will be agreed upon by all parties prior to detailed design commencing.

Certified joiners will make all joints. Individual joiners will be trained and tested under a Bonding Procedure and program developed in accordance with ASME B31.1, Appendix III for the specific pipe brand, type of joint, and pipe sizes to be used.

The Bonding procedure will be submitted for review before beginning the work. The certification program will provide training and examination of persons who will assemble the pipe joints. The certification program will include as a minimum, equipment training, joint preparation, fitting, bonding, curing, repair, and testing by written examination and by testing of a joined pipe.

A copy of the current certification for each joiner will be submitted before starting the work by any particular joiner.

PVC and CPVC Pipe Joints

Joints in polyvinyl chloride (PVC) and chlorinated polyvinyl chloride (CPVC) piping will be the solvent-cemented type using methods recommended by the pipe manufacturer.

Solder Joints

Soldering will be in accordance with requirements specified in ASME B31.1.

Solder filler metals will be 94 Tim – 6 Silver accordance with ASTM B 32 Grade Sn94.

<u>Buried Piping:</u>

Corrosion control of buried piping will be determined by the responsible System Engineer using corporate as well as external resources. Designed considerations and deliverables will include:

- Coatings will be specified based upon review of the project-specific Geotechnical Engineering Soil Test Report, the P&ID's, and the system design and operating requirements.
- Cathodic protection for buried piping must be coordinated through the Electrical Engineer on a project, system, material, and segment/location-specific basis.
- Flange insulation kits are required on al buried piping systems that are cathodically-protected or in close proximity to other cathodically-protected piping.

- Buried piping above 180 °F may require special coatings and backfill requirements. Piping above 240 °F will not be buried.

- Buried piping will also consider design requirements for pigging and/or other non-destructive testing methods.

4.10 Valves

Valve pressure classes, sizes, types, body materials, and end preparations will generally be as described herein. Special features and special application valves will be used where required.

Valves specified to have flange, socket welded, or screwed connections will have ends prepared in accordance with the applicable ASME standards. Steel flanges will be raised-face type, unless otherwise required. Cast iron and bronze flanges will be flat-faced type. Butt-welding ends will be prepared for GTAW root-pass in accordance with ASME B16.25 Figures 4, 5B, or 6B as appropriate.

Steel body gate, globe, angle, ball, and check valves will be specified and constructed in accordance with ASME B16.34, as applicable. Valve bodies and bonnets will be specified to suppose the valve operators (handwheel, gear, piston, diaphragm, or motor) with the valve in any position without external support.

Steel Body Gate, Globe, and Check Valves 2-inches and Smaller

Steel body valves 2-inches (50 mm) and smaller will have forged steel bodies. Forged steel valves complying with the standards and specifications listed in Table 126.1 of ASME B31.1 will be used within the manufacturer's specified pressure temperature ratings with the following limitations. The use of ASME class 600, 1500, 2500, and 4500 forged steel valves will be limited in accordance with the pressure temperature ratings specified in ASME B16.34. API class 800 valves may be substituted for class 600 valves.

Class 600, 800, 1500, 2500, and 4500 forged steel valves will be constructed as follows:

Class 600 and 800 valves will be specified with bolted bonnet joints. Class 1500, 2500, and 4500 valves will have pressure seal, welded bonnet or bolted bonnet joints (limit is Class 1500); valves may be used with integral bonnets. Gate, globe, and angle valves will have outside screw and yoke construction.

All valves, except gate valves, will have seats specified as hardened cobalt alloy (stellite or equal), integral type. Gate valves may have renewable or integral seats.

Class 1500, 2500, and 4500 globe valves will be of the Y-pattern type with removable – loose or threaded-in – back seat design.

Valve ends will be socket weld type, unless otherwise required.

Except as otherwise required, check valves will be of the guided piston or swing disk type. All check valves except guided piston will be designed for installation in either horizontal piping or vertical piping with upward flow. Guided piston check valves must be installed in horizontal piping.

Steel Body Gate, Globe, and Check Valves 2-1/2-Inches and Larger

Steel body gate, globe, and check valves 2-1/2-inches (65 mm) and larger will have either cast steel or forged bodies. The face-to-face and end-to-end dimensions will conform to ASME B16.10. The use of these valves will be in accordance with the pressure temperature ratings specified in ASME B16.34, as applicable.

Gate, globe, and angle valves will be provided with back seating construction. Gate, globe, and angle valves will be of outside screw and yoke construction. Gate valves 4 inches (100 mm) and larger will have flexible wedge disks. Valves will have full-size ports, except where venturi ports are specifically permitted. The use of valves with venturi ports will be limited to selected large diameter, high-pressure valve applications.

Class 150, 300, and 600 valves 2-1/2-inches (65 mm) and larger will be specified as follows:

Bonnet joints will be of the bolted flanged type having flat-face flange facing for class 150 valves and male and female facings for class 300 and 600 valves.

Body ends will be butt weld type, unless otherwise required.

Class 600, 900, 1500, 2500, and 4500 valves 2-1/2-inches (65 mm) and larger will be constructed as follows:

Bonnet joints will be of the pressure seal type.

All Class 600, 900, 1500, 2500, and 4500 valves will have grease-lubricated, anti-friction-bearing yoke sleeves.

Body ends will be butt weld type, unless otherwise required.

Check valves used on multiple pump discharge installations, and on other applications in which the valves may be subjected to significant reverse flow water hammer or fluid surges, will generally be the non-slam, tilting-disk or double disk water type. All other check valves will be of the guided piston, swing disk, or double-disk spring check type. All check valves except guided piston will be designed for installation in either horizontal piping or vertical piping with upward flow. Guided piston check valves must be installed in horizontal piping. The use of double-disk wafer spring check valves will be limited to 4-inch and larger cold

water services. Stop check valves, where specified, will be Y-pattern globe type or angle pattern.

Iron Body Valves

Iron body gate, globe, and check valves will have iron bodies and will be bronze mounted. The face-to-face dimensions will be in accordance with ASME B16.10 or appropriate AWWA standards. These valves will have flanged bonnet joints. Gate and globe valves installed aboveground will be of the outside screw and yoke construction. Body seats will be of the renewable type. Gate valves will be of the wedge disk type.

Butterfly Valves

Resilient-seated butterfly valves will be in accordance with MSS SP-67 or AWWA C504. Valves of the wafer or lug-wafer type will be designed for installation between two ASME flanges. Valves with flanged ends will be faced and drilled in accordance with ASME B16.5, B16.47 or AWWA C207 as required to match the piping system into which it is installed. The selected use of butterfly valves will be in accordance with the pressure and temperature ratings specified in industry standards, the pressure and temperature ratings specified by the manufacturer, and as specified in the following criteria:

Resilient/rubber-seated single and double offset butterfly valves will generally be used for 4-inch (100 mm) and larger cold water services only.

Consideration should be given to removing a section of pipe and having the ability to dead-end the upstream or downstream section of piping remaining. This is achieved with a lug style body butterfly valve.

Butterfly valves for buried service will be of cast or ductile iron body materials and will be equipped with flanged ends.

Cast iron butterfly valves will have pressure classes selected, based on the piping design pressure as follows:

Piping Design Pressure	Valve Class
25 psig (172.4 kPa) and below	Class 25
Above 25 psig (172.4 kPa) to 75 psig (517.1 kPa)	Class 75
Above 75 psig (517.1 kPa) to 150 psig (1034.2 kPa)	Class 150

Cast iron butterfly valves will be limited to use with piping systems having a design temperature of 125 °F (52 °C) or less.

Butterfly valves for other than buried service will be carbon steel or cast iron body material, depending on the service application. Valves 26-inches (650 mm) and larger will have flanged ends. Valves 24-inches (600 mm) and small will be the wafer type, or lug-wafer type, if used with steel or alloy steel piping, and will be flanged if used with other piping materials (cast iron, ductile iron, FRP, PVC, CPVC, etc.).

Resilient/rubber seated carbon steel butterfly valves will be limited to use with piping systems having designed temperature of 400 °F (204 °C) or less and will be specified in accordance with manufacturers limitations for the resilient seating material specified.

High performance single and double offset butterfly valves for special service applications will be the wafer or lug-water type and will be designed for installation between ASME flanges – Class 150 and 300. These valves will be fabricated from either carbon or stainless steel with either PTFE or RTFE seats recessed in the body and the disc will be 316 SS. These valves are position-seated, bi-directional and rated for dead-end service. These valves will be in accordance with MSS-SP-68 and API-609. The use of these valves will be in accordance with the pressure temperature ratings specified by the manufacturer.

High performance triple offset metal torque seated butterfly valves designed in accordance with MSS SP-68, API-609 and inherently fire-safe per API-607 will be used where applicable in main power cycle systems. These valves will be ASME Class 150, 300, or 600. These will be specified for use between ASME flanges (specified as narrow, double flanged) or as butt weld end connection.

Bronze Body Valves

Bronze gate and globe valves 2-inches (50 mm) and smaller will have union bonnet joints and screwed ends. Gate valves will be inside screw, rising stem type with solid wedge disks. Globe valves will have renewable seats and disks.

Bronze check valves 2-inches (50 mm) and small will be Y-pattern, swing disk type, or guided piston type will be designed for satisfactory operation on both horizontal piping and vertical piping with upward flow. Guided piston check valves must be installed in horizontal piping.

The use of these valves will be in accordance with the pressure temperature ratings specified by the manufacturer and in accordance with the criteria established in MSS SP-80. Bronze valves will generally be class 200 and will be limited to service with piping systems having design pressures of 200 psig (1379 kPa) or less, and design temperatures of 150 °F (66 °C) or less.

Bronze valves will generally be limited to a size of 3 inches (800 mm) or less.

Plug Valves

Plug valves will be of the eccentric, or PTFE sleeve plug type, as required by the service. Lubricated plug valves are not permitted. Plug valve bodies will conform to the requirements of ASME for dimensions, material thickness, and material specifications. Bonnets will be of the bolted flange type. Body ends will be flanged, faced, and drilled for installation between ASME flanges. The use of these valves will be in accordance with pressure temperature ratings specified by the manufacturer.

Ball Valves

Ball valves bodies 2-inches (50 mm) and smaller will have threaded or socket weld end connections. Ball valves 2-1/2-inches (65 mm) and larger will have flanged or butt weld ends.

The valves will not require lubrication. The use of these valves will be in accordance with the pressure temperature ratings specified by the manufacturer.

Valves specified for use in cold water, instrument air, service air, gas, oil and chemical service will be use PTFE seats. In addition, ball valves specified for natural gas, hydrogen, and compressed air service will be specified for fire safe service and conform to the latest version of API-607. Ball valves specified for use in steam service will be metal seated. Ball valves will normally be specified with a regular port unless a full ported valve is required.

Ball Valves specified in steam service will be metal seated and in accordance with ASME TDP-1 2006. The Hard Coatings on the Metal Seated Ball and Seat will either be HVOF Chrome Carbide with a bond strength of 10,000 psi minimum or Chromium Carbide Spray & Fused with a bond strength of 70,000 psi minimum. For Actuated/High Cycle Chrome Body F11/F22/F91 Metal Seated Ball Valves above 580 °F a Chromium Carbide Spray & Fused or approved equal is recommended. Metal Seated Ball Valves will have bore sizes in accordance with ASME TDP-1 2006 paragraph 3.7.13.

Diaphragm Valves

Diaphragm valves will be straight-away or weir bodies with flanged ends faced and drilled for installation between ASME flanges. The use of these valves will be in accordance with the pressure temperature ratings specified by the manufacturer.

Polyvinyl Chloride (PVC) and Chlorinated Polyvinyl Chloride (CPVC) Valves

PVC and CPVC valves will be constructed entirely from polyvinyl chloride, chlorinated polyvinyl chloride, and PTFE. Bodies will be double-entry flanged or true union screwed type. The use of these valves will be in accordance with the pressure temperature ratings specified by the manufacturer.

Valve Materials

Valve bodies will generally be constructed of materials equivalent to the pipe with which they are used. Valve body and trim materials of construction will be in accordance with applicable ASTM and ASME standards.

The main cycle system valves will be free of copper materials to allow the cycle to be treated at the optimum pH for corrosion protection of carbon steel components.

Valve Operators

Valves will be provided with manual or automatic operators, as required, for the service application and system control philosophy. Automatic operators will be motor, piston, or diaphragm type.

Manual operators will be lever, handwheel, or gear type, with the use of lever operators to be limited to valves requiring a maximum of 90 °F stem rotation from full open to full closed position on valve sizes 6-inches (150 mm) and smaller. All operators will be sized to operate the valve with the valve exposed to maximum differential pressure (maximum system pressure minus atmospheric). Rim pull will be limited to 80 lbs.

The use of gearing for manually operated valves will generally be as follows. Some service applications, seats and valve types may require that gear operators be used on valves smaller than as indicated in the following.

Class	Gate, Globe	Butterfly	Ball
150	≥ 8”	≥ 8”	≥ 8”
300	≥ 8”	≥ 8”	≥ 6”
400 and 600	≥ 6”		≥ 4”
900	≥ 4”		≥ 4”

Valve Special Features

Valves will be provided with locking devices, handwheel extensions, vacuum service packing, limit switches, and other special features, as required. Locking devices, when furnished, will allow the valve to be locked either open or closed with a standard padlock. Limit switches, when furnished, will be provided for the open and closed position of the valve.

All valve bonnets for valves potentially exposed to high temperatures over 150 °F (66 °C) will be provided with internal drains. The drains will prevent the bonnets from being exposed to excessive pressure when the bonnet is full of water and the valve is exposed to elevated temperatures.

Valves will not be equipped with bypass, unless specifically required.

4.11 Insulation and Lagging

The insulation and lagging to be applied to piping, equipment, and ductwork for reducing heat loss, reducing sweating, and providing personnel protection will be in accordance with the following criteria:

Insulation Materials

Insulation materials will be specified to contain no asbestos, chlorides, or halogens.

All piping operating from 140 °F to 850 °F will be insulated for heat conservation or personnel protection with mineral fiber insulation in accordance with ASTM C 547 and as stated in the project-specific insulation thickness table.

All piping operating above 850 °F will be insulated for heat conservation or personnel protection with calcium silicate molded insulation in accordance with ASTM C 533 and as stated in the project-specific insulation thickness table. Piping operating above 140 °F and subject to foot traffic or other compressive loads will use calcium silicate.

All outdoor piping and equipment will be designed to have a surface temperature that does not exceed 140 °F with an outdoor ambient temperature and a wind speed based on project-specific site design conditions.

All indoor piping and equipment will be designed to have a surface temperature that does not exceed 140 °F with an indoor ambient temperature based on project-specific site design conditions.

All piping and equipment not insulated for economic reasons in excess of 140 °F surface temperature that is personnel accessible will be insulated, covered, or guarded for personnel protection. Personnel accessible is defined as 7 feet from floor and 15 inches from handrail.

Equipment and ducts operating at elevated temperature will be insulated with fibreglass or mineral fiber blanket insulation.

Mineral fiber blanket insulation will be in accordance with ASTM C 592, Class II.

Insulating cements will be mineral fiber thermal insulating cements and will conform to ASTM C 195.

Anti-sweat insulation will be flexible elastomeric cellular thermal insulation, ASTM C552. Outdoor anti-sweat insulation will be protected with paint or lagging in accordance with the manufacturer's recommendations.

Piping and small-diameter cylindrical equipment installation will be hollow cylindrical shapes, split in half lengthwise, or curved segments. Large-diameter cylindrical equipment and other items of equipment will be insulated with block or scored block insulation, as required, to obtain a close fit to the contour. Pipe fittings and accessories will be insulated, using either molded insulation or by insulation fabrication from straight pipe insulation segments.

Ducts will be insulated where required for thermal conservation or personnel protection. Ducts with external stiffeners will have the insulation installed over the stiffeners so that the stiffeners are insulated and a level surface achieved.

Lagging Materials

All insulated surfaces of equipment, ductwork, piping, and valves will be lagged using aluminum lagging 0.016-inches thick up to 72-inches in diameter. Use 0.024-inch lagging over 72-inches in diameter.

All aluminium lagging will be in accordance with ASTM B209. Aluminum lagging will be stucco embossed and painted or anodized to obtain a minimum outer surface emissivity of 0.80.

Insulation Classes for Piping and Equipment

Piping and equipment insulation thickness are calculated for project-specific design conditions using the WorleyParsons standard calculation spreadsheet for insulation thickness (PPSD Insulation.xls). The insulation classes for piping systems will be designated by letters, which will be indicated in the pipeline listing.

Minimum insulation thickness is based on 140 °F surface temperatures, which is derived from ASTM C 1055, “Heated System Surface Conditions That Produce Contact Burn Injuries.” Jacketing will be stucco embossed aluminum painted or anodized to obtain a minimum outer surface emissivity of 0.8.

The insulation for piping accessories will be of the same type as indicated for the piping. Insulation materials for miscellaneous piping and equipment will be suitable for the actual operating temperatures and will, whenever possible, be of the same insulation type as insulated main piping and equipment operating under similar temperatures.

Anti-sweat Insulation

All indoor aboveground cold water piping will be provided with anti-sweat insulation with the exception of piping in which fluid flow is not normally expected.

Heat Tracing

Heat trace and insulate stagnant water lines per site-specific datasheet. Also, heat trace and insulate stand-by water lines per system operating philosophy.

4.12 Cycle Makeup System

4.12.1 General

The cycle makeup system produces demineralized water for plant makeup. It also stores and transports demineralized water. Uses of demineralized water include air expander low NOx burners and combustion turbine cleaning.

The water treatment portion of the system is done using a reverse osmosis and electrodeionization system for water pretreatment and demineralization.

Makeup water is taken from the demineralized water storage tank and sent to the plant when necessary.

4.12.2 Demineralized Water Storage Tank

Quantity:	One.
Location:	Outdoors on foundation at grade.
Construction:	Design in accordance with AWWA D100.
Material:	Stainless steel.
Design Pressure:	Atmospheric.
Design Temperature:	Use range of minimum to maximum ambient temperatures.

4.12.3 Cycle Makeup Pumps

Design Temperature:	Equal to maximum ambient temperature.
Design Pressure:	Cold water shutoff head of the cycle makeup pumps plus a design margin of 25 psi rounded to the next highest 10 psi.
Material:	ASTM A 312 Grade 316 stainless steel.

Capacity:	Based on the total feedwater flow to the air expander low NOx burners.
Total Head:	Calculated based on system requirements with 5% margin on total head rounded to the next highest 5 feet.
Type:	Horizontal, centrifugal, motor driven.

4.13 Ammonia Storage and Forwarding System

4.13.1 General

The ammonia storage and forwarding system provides for the safe unloading, storage, and forwarding of ammonia solution to the selective catalytic reduction modules in the recuperator.

4.13.2 Ammonia Storage Tank

Design Pressure:	50 psig and full vacuum.
Design Temperature:	120 °F.

4.13.3 Ammonia Pumps

Design Temperature:	Equal to maximum ambient temperature.
Design Pressure:	Shutoff head of the cycle makeup pumps plus a design margin of 25 psi rounded to the next highest 10 psi.
Material:	ASTM A 312 Grade 316 stainless steel.
Capacity:	Based on the total flow to the recuperator selective catalytic reduction system need.
Total Head:	Calculated based on system requirements with 5% margin on total head rounded to the next highest 5 feet.
Type:	Horizontal, centrifugal, motor driven.

4.14 Circulating Water System

4.14.1 General

The circulating water system will consist of a cooling tower, circulating water pumps, and interconnecting piping. The heated circulating water from the compressors will be cooled by a counterflow, mechanical draft cooling tower with single speed fans. Circulating water will be treated to control corrosion, biological growth, and pH.

4.14.2 Design Parameters

Main Circulating Water System:

Design Pressure:	Based on the shutoff head of the circulating water pumps.
Velocity:	In accordance with Section 4.8

4.14.3 Special Requirements

Pumps will have motor operated butterfly valves on discharge, interlocked with pump start-up operation. Expansion joints at the pump discharge will be specified with control rods.

4.14.4 Pump Trash Screens

Each circulating water pump suction bay is protected by a trash screen to remove large debris at the inlet to the circulating water pump basin.

Design Flow:	Equal to circulating water pump flow.
Maximum ΔP with 50% clean screens:	1 foot of water.

4.15 Circulating Water Chemical Feed System

4.15.1 General

The circulating water chemical feed system consists of the sodium hypochlorite feed system, the acid feed system, and the corrosion/scale inhibitor feed system.

Biological fouling of the circulating water system is controlled by periodic injection of sodium hypochlorite.

The corrosion/scale inhibitor feed system transfers corrosion/scale inhibitor to the cooling tower basin based on cooling tower make-up flow.

For pH control of the circulating water 66 degree Baume' sulfuric acid is pumped into the cooling tower basin using a metering pump.

4.15.2 Sodium Hypochlorite

Design Parameters

Chemical:	Sodium hypochlorite.
Pressure at the diffuser:	50 psig.

Storage Tank

Size:	Tote bin.
Pressure:	Atmospheric.
Material:	Polyethylene.

Chemical Feed Pumps

Quantity:	Two 100% capacity.
Location:	On skid with accessories.
Type:	Positive displacement, diaphragm type metering pump.
Materials:	PTFE diaphragms and PVC wetted parts.
Piping Material:	CPVC.

4.15.3 Acid Design

Parameters

Chemical:	Sulfuric acid.

Storage Tank

Size:	Tote bin.
Pressure:	Atmospheric.

Chemical Feed Pumps

Quantity:	Two 100% capacity.
Location:	On skid with accessories.
Type:	Positive displacement, diaphragm type metering pump.
Materials:	PTFE diaphragms and Alloy 20 wetted parts.

4.15.4 Corrosion Inhibitor

Design Parameters

Chemical:	Corrosion/scale inhibitor.

Storage Tank

Size:	Tote bin.
Pressure:	Atmospheric.

Chemical Feed Pumps

Quantity:	Two 100% capacity each.
Location:	On skid with accessories.
Type:	Positive displacement, diaphragm type metering pump.
Materials:	PTFE diaphragms and 316 stainless steel wetted parts.

4.16 Wastewater Collection and Treatment System

4.16.1 General

The wastewater collection and treatment system receives, segregates, and transfers all plant liquid waste streams.

The wastewater collection and treatment system consists of an oil / water separator, sumps, and sump pumps to collect the plant wastes and transport them.

Chemical spills for the chemical feed areas are contained locally to the spill area by curbs and are removed from the site by a special waste truck.

4.16.2 Oil / Water Separator

The oil water separator ensures conformance to the following oil and grease values for the effluent water:

Item	Units	mg/l	Limit Value
Oil and Grease			15 or less based on removal of all free droplets equal to or greater than 60 microns in diameter.
pH:	6 to 9		
Temperature:	180 °F maximum.		

4.16.3 Oil / Water Separator Water Effluent Pumps

Quantity:	Two 100% capacity pumps.
Capacity:	Total required system flow plus 10% margin.
Total Head:	System pressure drop at total required system flow plus margin.
Type:	Submersible, centrifugal, motor driven.
Materials:	Ductile iron or cast iron casing, stainless impeller, stainless steel shaft and sleeve.

4.16.4 Miscellaneous Area Sumps

Drains from throughout the plant, as needed, are pumped to the oil / water separator. All drains will be controlled by an administrative isolation valve for the release of storm water to the oil / water separator which handles trace oil only. If an oil or chemical spill occurs, then a waste disposal vendor should be used to remove the oil or chemical.

4.16.5 Miscellaneous Area Sump Pumps

Quantity:	Two 100% capacity pumps.
Capacity:	Total required system flow plus 10% margin.

Total Head:	System pressure drop at total required system flow plus margin.
Type:	Submersible, centrifugal, motor driven.
Materials:	Ductile iron or cast iron casing, stainless impeller, stainless steel shaft and sleeve.

4.17 Compressed Air System

4.17.1 General

The plant will process compressed air to supply the instrument air and service air needs. The compressed air system will be provided with two heatless, desiccant-type air dryer, which will be equipped with dual prefilters and after-filters.

4.17.2 Air Receiver

Type:	Vertical, with safety valve, support legs, automatic drain valves.
Quantity:	One.
Capacity:	90 ft^3
Construction:	Per ASME B&PVC Section VIII. Code stamp required.
Materials:	Carbon steel.
Design Pressure:	150 psig.
Design Temperature:	150 °F.

4.17.3 Air Dryer

Quantity:	Two 100 % capacity dryers (two drying towers each)
Type:	Heatless, automatic regenerative with two 100% capacity coalescing pre-filters and two 100% capacity after-filters, complete with integral control valves, regeneration controls, and automatic moisture sensing control. ASME B&PV Code Section VIII, code stamp

	required. Purge air values will be limited to between 10 and 15% of total air flow.
Inlet Air Temperature:	125 °F.
Exit Air Dew Point:	Minus 40 °F at 125 psig.
Pressure Drop:	5 psi, maximum.
Design Pressure:	150 psig.
Design Temperature:	150 °F.

4.17.4 Piping

Materials:	Copper or stainless steel.
Design Pressure:	150 psig.
Design Temperature:	150 °F.
Piping:	Including low-point condensate traps to remove accumulated water.

4.18 Compressed Gas System

4.18.1 Nitrogen

A nitrogen blanketing system provides for shutdown corrosion protection of the internal surfaces of the recuperator. The nitrogen system consists of a manifold with valves and instrumentation for regulating the supply of nitrogen to the recuperator. The system maintains a nitrogen pressure of 5 psig in each recuperator. The nitrogen bulk storage is either bottles or a tube trailer.

4.19 Fire Protection System

See separate project Fire Protection Plan

4.20 Raw Water and Filtered Water System

4.20.1 General

The raw water will be routed to the filtered water/fire water storage tank after passing through a pretreatment filter system if necessary. The fire water section of the tank will be sized based upon two hours of continuous fire pump operation at maximum pump output, plus eight hours of storage of filtered water plus general plant service water and evaporative cooler make-up water (if required).

4.21 Fuel Gas System

4.21.1 General

Natural gas is used as the primary fuel for the Cycle #2 combustion turbine and the Cycle #1 air expander burners.

4.21.2 Fuel gas Compressor

A natural gas compressor is supplied for the Cycle #1 air expander HP burners.

4.21.3 Piping

All piping upstream of the fuel gas separator is ASTM A106B, seamless carbon steel. Piping downstream of the fuel gas separator is stainless steel. Although not a code requirement, consideration will be given to x-ray examination of all welds.

4.21.4 Fuel Gas Cleanliness / Filtration

Final filtration of the fuel gas system is required to meet the contaminant limitation requirements of the combustion turbine and the air expander burners. The fuel gas final filters are included as part of the scope of supply of the combustion turbines. These final filters are to be located in consideration of the hazardous classification of this equipment.

Solids removal capability	Particle Size	Removal Efficiency
By CT Vendor	By CT Vendor	By CT Vendor
Liquids removal capability	**Particle Size**	**Removal Efficiency**
By CT Vendor	By CT Vendor	By CT Vendor

4.21.5 Fuel Gas Dew Point Heater

Heating Water Source: Fuel gas.

Type:	Shell and tube, TEMA Class R, in accordance with TEMA, and ASME B&PVC Section VIII.

4.22 Bridge Crane

4.22.1 General

Cranes are provided for use in equipment maintenance and lifting heavy pieces. All hoists will be designed for true vertical fit.

4.22.2 Air Expander Turbine And Compressor Crane

Type:	Double girder-top running bridge crane.
Span (column to column):	66 2/3 feet Cycle #1
	99 1/6 feet Cycle #2
Bridge Travel Distance:	389 feet Cycle #1
	420 feet Cycle #2
CMAA Class:	A1.
<u>Main Hoist</u>	
Capacity:	35 tons Cycle #1
	80 tons Cycle #2
Type:	Wire Rope (anti-twist designed for true vertical lift).
Speed:	10 ft./min.
Lift:	35 ½ feet Cycle #1
	59 feet Cycle #2
<u>Auxiliary Hoist</u>	
Capacity:	15 tons.

Type:	Wire Rope (anti-twist designed for true vertical lift).
Speed:	10 ft./min.
Lift:	35 ½ feet Cycle #1
	59 feet Cycle #2

Miscellaneous Hoists and Trolleys

4.22.3 General

Hoists and trolleys are provided for use in equipment maintenance and lifting heavy pieces. Hoists may also be needed for SCR catalyst exchange and in a mechanical equipment building housing the main mechanical auxiliaries.

4.22.4 Hoist and Trolleys

Quantity:	
Capacity:	*Later*
Type:	Manual chain hoist and manual trolley
Lift Height:	*Later*

4.23 Heating, Ventilating, and Air Conditioning Systems

4.23.1 General

Special consideration will be given to projects located where extreme ambient conditions exist (cold or hot) and where environmental issues (i.e. sand, dirt, salt) may impact equipment design.

The HVAC systems provide an environment within the buildings suitable for personnel and/or equipment operation, with consideration given to maintaining acceptable conditions of temperature, humidity, filtration, fresh air supply, air movement, and exhaust removal of poor quality air or contaminated air.

The HVAC system is interlocked with the plant fire protection and detection systems. Smoke evacuation and purge provisions are incorporated into the HVAC design as required by the applicable codes and regulations. Duct penetrations through firewalls are protected with fire dampers protecting the fire resistance integrity of the wall.

4.23.2 Air Conditioning and Ventilation System Design Conditions

Ambient Design Conditions:

- Summer: 87 °F dry bulb and 71 °F wet bulb.
- Winter: -2 °F dry bulb.

Indoor Design Conditions:

Administration offices

- PDC Building
- Control Room
- Cooling Tower Electrical Building
- PDC Enclosures
- Battery Room
- Mechanical Equipment Building
- Cooling Tower Chemical Feed Building
- Fire Water Pumps Building

Humidity control will be provided only in those areas having electrical, electronic, computer or other type equipment having specific humidity conditions imposed by the equipment manufacturer. In which case, a written statement of the vendor's requirements will be obtained for timely review and approval of the related criteria.

4.23.3 Ventilation Requirements

The intake and exhaust capacity for ventilation systems is designed to maintain the inside design temperature.

For general ventilation, powered exhaust fans and/or powered supply fans and/or intake louvers or gravity ventilation are used as required. Areas subject to general ventilation are the turbine building, mechanical equipment building, pump houses, cooling tower electrical equipment building, cooling tower chemical feed building, miscellaneous storage facilities, and fire water pumps building. When dictated by building noise conditions, acoustical louvers will be necessary. These louvers have less free area and may impact building design.

Off/on/auto switches are located in the immediate area of the exhaust and supply fans. In the auto mode a thermostat controls the fans. Make-up air enters the buildings through wall louvers.

4.23.4 System Requirements

All design and construction will comply with the International Building Code (IBC) and all other codes having local jurisdiction. The most stringent code will apply.

All HVAC systems will meet the latest safety considerations of the Occupational Safety and Health Act. Noise contribution from HVAC equipment to the air-conditioned spaces will be limited to the RC method recommended by ASHRAE Fundamentals (current edition). All other HVAC noise contribution will comply with OSHA Standard 1910.95 for 8 hours per day occupancy.

All design and installation of HVAC equipment will comply with the NFPA codes and standards.

Design of the air distribution and duct system will be based on ASHRAE Fundamentals, current edition. Duct sizes and velocities are based on the “Recommended Velocities – Industrial Buildings.” Air diffusers, registers, and grilles will be certified as conforming to ADC Standards.

Duct construction will be based on the applicable SMACNA Standards.

Drainable blade intake louvers will provide the make-up air. Ventilation and exhaust systems will be designed so the building negative pressure does not exceed 0.15 inches w.g.

For general air-conditioned spaces such as a control room, self-contained packaged air conditioning units or split systems will be used.

Heating in conditioned spaces will be by electric resistance heaters in the air distribution system supplemented as required by electric baseboard, panel, or unit heaters or heat pump application if economically feasible. General area heating will be provided by electric unit heaters. Heaters in water treating area and other non hazardous areas subject to wash down will have water-tight construction and be suitable for use in these areas.

All make up and recirculation air in air-conditioned areas will be filtered by dry-disposable type filters. Supply air to general ventilation areas will in general not be filtered except where required for equipment protection.

Air flows will be based upon the calculated cooling loads, heating loads, or ventilation requirements whichever is greater. Design of the air distribution and duct systems will be based upon the latest copy of the ASHRAE "Handbook of Fundamentals." Duct size and related velocities will be based upon the "Recommended Velocities - Industrial Buildings", for

air conditioning systems and "Maximum Velocities - Industrial Buildings" for all others, except for outside air intakes and as approved otherwise. All outside air intakes will be sized to limit the face velocity not to exceed the manufacturer's recommendations. Pressure drop will not exceed 0.10 in. w.g. and velocities will be below the point of water penetration (intake louvers to have a minimum of 50 percent free area).

All ductwork handling outside air, and air-conditioned supply and return air will be insulated. All chilled water, steam, and condensate piping will be insulated to minimize heat transfer.

Acoustical lining will be used instead of or in addition to duct insulation where required for sound attenuation. All rotating equipment will be isolated from duct and/or piping distribution systems.

Equipment will be arranged to allow easy removal of components as well as full access for inspection and maintenance.

HVAC equipment and ductwork will be equipped with controls and fire dampers in accordance with NFPA No. 90-A.

4.23.5 Materials

Duct material may by carbon steel per ASTM A 1011, galvanized carbon steel per ASTM A 653, aluminum per ASTM B 209 Commercial Designation 3003 Temper H14, or stainless steel per ASTM A 480 Type 304 for the duct sheeting material. Reinforcing angles and flanges will be of compatible metals.

All materials provided, such as flexible connections, insulation, hardware, ductwork, etc., will be fire resistant and will be classified to have a flame spread rating of less than 25, as listed and defined by the UL Fire Resistance Index.

Electric motor and equipment constructions, rating enclosures, electrical characteristics, accessories, etc., will be in accordance with the Project Electrical Design Criteria.

Refrigeration equipment, refrigeration piping, and water pumps and piping will be in conformance with applicable portions of ASME, ARI, and HI pressure codes and ANSI piping standards.

4.23.6 HVAC Calculations

All heat gain and heat loss calculations will comply with the latest ASHRAE Standards. All air distribution system pressure drop calculations will also conform to ASHRAE Standards and recommendations.

4.24 Plumbing

4.24.1 General

For drainage systems, the system engineer will consider the following. There are two types of systems discussed below – one is sanitary and the other is plant equipment/floor/roof drains. The former is designed for half-full pipe flow with traps and vents and the latter is designed for full pipe flow with no traps and vents. Piping materials and connections are different for each as noted below.

The plumbing systems provide an adequate system of in-plant drainage and potable water supply to satisfy the plant needs and fixture requirements within the buildings. Water conserving fixtures will be used in accordance with governing codes.

4.24.2 Design Conditions

Equipment, Floor and Roof Drains

Equipment/floor/roof drainage systems will be designed in conformance with the governing codes and as required by local authorities. Equipment and floor drains will be sized on the basis of the greater of the expected normal drainage rate of equipment to be drained or to take the run-off of the greatest water deluge from the fire protection system in that area. In lieu of specific equipment drainage rates, the lines will be sized on the basis of two equipment floor drains flowing simultaneously at 50 gpm each.

Where combustible fluids are present, area drains will be sized to drain the expected "spill" of combustible liquids plus the fire protection water flow in a manner to prevent flushing the combustible liquids beyond the area protected by sprinklers. All combustible fluids will be collected in a closed drainage tank (vented to outdoors) and/or conveyed outside the building into a safe area. Floor drains in sprinkled areas will be sized on the basis of sprinkler water applied at the rate of 0.50 gpm per square foot of sprinklered floor area. The gravity drainage piping from the drain hub to the first valve (administrative) will be steel, not plastic.

Chemical process wastes will be neutralized before combining with ordinary floor and equipment drains. Drainage from areas containing oil will be processed through oil separators before discharge.

Internal roof drain systems will be designed in conformance with the governing plumbing codes. External roof drain systems consist of gutters and downspouts. These may spill on concrete splash pads at the bottom of the vertical leaders or connect to an underground storm drainage system. Roof drain systems will be designed based on a 60 minute storm duration and a 100 year return or on other rainfall rates determined from approved local weather data. Secondary (emergency) roof drainage systems will be provided as required by code. Secondary systems will have piping and point of discharge separate from primary system. Storm drains will be designed for full flow conditions.

Sanitary Drains

Sanitary drains will be kept separate from all other drains to permit their being routed to separate disposal facilities or connected to the municipal sewer system.

4.24.3 System Requirements

Potable water supply and sanitary drainage facilities will be provided as required by the architectural plans for lavatories, water closets, urinals, service sinks, showers, drinking water coolers, and emergency showers. The emergency shower system design should include delivered water temperature and ANSI/ISEA Z358.1 requirements.

Sanitary floor drains will be provided in toilet rooms, washrooms, and showers, and be connected to the sanitary drainage system.

Cleanouts will be provided on all drainage systems (sanitary and storm) for maintenance and located in accordance with governing plumbing codes.

All connections to the sanitary drainage system will be trapped after each fixture.

A backflow preventer (BFP) will be provided on all connections from the potable water supply system to any and all process or non-potable services in the plant. The BFP will be a factory built assembly specifically intended for use as a device to prevent contamination of potable water systems by backflow from a potentially contaminated system under all conditions of pressure deviations from normal. Type is dependent on the degree of hazard. Ordinary check valves are not acceptable. BFPs will be certified as conforming to ASSE Standard 1013 and AWWA Standard C-506.

Hose bibs will be provided indoors, as required, for equipment and building maintenance. All hose bibs will be provided with vacuum breakers.

All piping will be installed with adequate provisions for pipe expansion and support. All roof drains will be provided with integral expansion joints.

All water supply lines at fixtures will be provided with water hammer arresters.

Where gravity drainage is not feasible to the final connection point, a duplex type electric motor driven pumping station will be provided with alternator type controls. The pumps will be sized to permit either pump of a duplex set to carry the normal design drainage flow. Pump basins may be fiberglass or field poured concrete.

Equipment drains will be provided for all equipment with continuous drips or that are subject to frequent flushing. "Over-the-floor" piping will be avoided. Equipment drains are typically connected to the plant drainage system and not part of the sanitary drainage system due to traces of oil.

The potable water system will be cleaned, disinfected/chlorinated and leak tested in conformance with governing plumbing codes. Drainage systems will be cleaned and pressure tested in accordance with governing plumbing codes.

The design will provide for functional testing of all operating equipment with appropriate documentation.

4.24.4 Materials

Potable Water Supply

Potable water supply piping, valves and fittings 2-inches and smaller for above ground use will be copper or copper alloy tubing with 94 Tin – 6 Silver solder conforming with ASTM B 32 Grade Sn94 for all joints, including those at all valves except those furnished with the fixtures. Brazed joints will be used in concealed areas. Tubing will be hard drawn Type K copper conforming to ASTM B 88. Victaulic PermaLynx may be used as an alternate for lines 1 – 1/2 inch or smaller. Fittings will be wrought copper conforming to ASME B16.22. Fittings may also be cast bronze per ASME B16.18 when permitted by local plumbing codes. Electrolytic couplings or unions will be provided at all copper to ferrous connections.

Potable water piping 3-inches and larger for above ground use will be hard drawn Type K copper conforming to ASTM B 88 with grooved copper couplings and fittings as manufactured by Victaulic.

Potable water piping for below grade use will be HDPE SDR 11 or cement-lined ductile iron. Copper may be considered as an alternate provided that soil conditions are favorable as noted earlier.

Sanitary Drains

Sanitary drain piping will be cast iron hub and spigot, with compression joints using neoprene gaskets for all buried or concealed work. Materials will conform to ASTM A 74. Sanitary drain piping above the floor will be hubless cast iron with neoprene gaskets and stainless steel clamps and sleeves per CISPI Standard 301.

Equipment/Floor/Roof Drains

Internal roof drain piping will be galvanized ASTM A53 Grade B steel pipe with grooved end mechanical couplings. Equipment and floor drain piping will be ductile iron with push-on (preferred) or mechanical joints for all buried or concealed work. Piping above floor level will be schedule 40, ASTM A 120 Grade A or B steel pipe. Joints will be either welded or by means of grooved end mechanical couplings.

NEW YORK STATE ELECTRIC & GAS

Civil Engineering Design Criteria for Seneca CAES Project

Document: CAES-1-DB-024-0002-RA

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NEW YORK STATE ELECTRIC & GAS
CIVIL ENGINEERING DESIGN CRITERIA FOR SENECA CAES PROJECT

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PROJECT - CAES-DB-024-0002CIVIL ENGINEERING DESIGN CRITERIA FOR SENECA CAES PROJECT

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1.0 INTRODUCTION

This document presents the Civil Design Criteria for the facility's civil sitework (grading, drainage, roadways). All geotechnical and civil site development shall be designed and constructed in accordance with the most current edition in effect at time of the start of engineering, unless otherwise noted herein, of the applicable codes, industry standards, and local, state, and federal regulations and as otherwise noted in this section and the contract documents. All required local building permits and government agency inspections will be obtained and/or arranged for by the Owner or Contractor. The Engineer will prepare site development and erosion and sedimentation control calculations and plans that are required as part of the permit applications.

If any conflict arises between this guideline and the applicable standards or codes, this shall be resolved either by application of the most stringent design conditions or resolution by the Civil/Geotechnical Engineer.

2.0 CODES, STANDARDS, AND REFERENCES

The design and specification of all work will be in accordance with all applicable industry codes and standards. A summary of the codes and industry standards to be used in design and construction is listed below:

- U.S. Department of Labor, Occupational Safety and Health Administration (OSHA).
- American Concrete Institute (ACI).
- American Society for Testing and Materials (ASTM).
- American Association of State Highway and Transportation Officials (AASHTO).
- Asphalt Institute (AI).
- Code of Federal Regulations, Americans with Disabilities Act (ADA).
- U.S. General Services Administration, Federal Specifications (FS).
- American National Standards Institute (ANSI).
- National Pollutant Discharge Elimination System (NPDES) Permit for Discharges of Stormwater Associated with Construction Activity Water
- New York State Codes, Rules and Regulations (NYCRR).
- New York State Department of Environmental Conservation, SPDES General Permit for Stormwater Discharge from Construction Activity.
- New York State Stormwater Management Design Manual.
- New York Standards and Specifications for Erosion and Sediment Controls.
- New York State Department of Transportation Standard Specifications

3.0 DESIGN LOADS

3.1 Earth Loads

Soil Bearing Capacity shall be based on the results of the geotechnical investigation.

3.2 Highway Loads

Road Traffic - AASHTO HS20-44 or special heavy transport vehicle as information is provided.

3.3 Geotechnical Properties for Foundation Design

Soil properties used in the design of foundations and slab-On-grade floor design shall be based on the results of the geotechnical investigation. The allowable bearing pressure, lateral earth pressures and other soil parameters shall be taken from the Geotechnical Investigation report or approved by the project engineer. The maximum soil bearing pressure shall not exceed the allowable bearing pressure. Bearing pressures may need to be considerably less than the allowable bearing pressure for settlement sensitive structures.

4.0 CIVIL DESIGN DETAIL

Site preparation, excavation, backfill and grading shall be performed as required to construct the facility and achieve finished site grades as described in this section.

The site shall be left properly graded with no construction debris or soil stock piles. Consideration shall be given to drainage to ensure no low lying areas remain that may accumulate water other than those defined on the drawings. All drainage shall be away from the buildings to a collection system.

Engineer will design the plant to maintain major plant systems above 100 year flood elevation.

4.1 Surveying

A plant boundary and topographic survey referenced to the plant horizontal (coordinate grid) and vertical (elevation) datum will be provided by Owner. The Contractor shall maintain the primary control points and provide all detail measurement and layout for the project with qualified survey personnel and certified equipment.

4.2 Site Preparation

Contractor shall be responsible for clearing all plant life, trees, and shrubs to the extent necessary to construct the facility, for rough grading of the site, and for disposal of all waste materials resulting from the site preparation work.

The Owner shall re-locate known in-service utilities in support of Contractor's schedule. Any underground debris or utility encountered during the course of the work should be brought to the attention of the Owner for disposition. If considered an in-service utility, the relocation and removal will be by the Owner. If considered miscellaneous debris, the removal will be performed by the Contractor.

4.3 Excavation

Excavation work shall consist of the removal of fill, soil, vegetation, organic matter, rock, boulders, and debris, etc. to the lines and grades necessary for construction of foundations and underground facilities included in the project. Materials suitable for backfill shall be stockpiled at designated locations using proper erosion protection, moisture control, and safety methods. Disposition of any excess uncontaminated backfill material shall be the Contractor's responsibility. If contaminated materials are encountered, the Owner shall be notified immediately.

Contractor shall provide dewatering of excavations necessitated by flows from surface runoff as required to support the construction activities.

4.4 Backfilling

Backfilling shall be done in uniform layers of specified thickness following the criteria specified by the Engineer as based on the Geotechnical Report. Soil in each layer shall be properly moistened or dried to obtain its specified density. To verify compaction, representative field density and moisture-content tests shall be taken during placement and compaction of each layer.

Structural fill and general site fill shall be compacted following the criteria specified by the Engineer as based on the Geotechnical Report. Contractor shall provide all structural fill specified on the drawings and technical specifications.

Earthwork compaction requirements shall be as specified in the Geotechnical Report. In general, fills and sub-grades under roads and structures shall be compacted to a minimum of 98 percent of the maximum standard proctor density and yard area fills and sub-grades shall be compacted to a minimum 92 percent of the maximum standard proctor density.

4.5 Site Grading

The design of the site grading will take into account the finished geometry of the facilities, roads, parking, and other facilities to be constructed. The design will consider long term slope stability and erosion control. Based on the existing topography, grading the site to balance the cut and fill quantities shall be performed, if it is possible.

The site shall be graded to convey storm water runoff away from permanent facilities. Graded areas shall be smooth, compacted, free from irregular surface changes, and sloped to drain. Final grade adjacent to equipment and buildings shall be below finished floor slab and shall be sloped away from foundations as necessary to maintain positive drainage. Minimum slopes shall be based on surface type. In the main plant complex area, grade shall be sloped away from the building walls and equipment at a minimum of one half percent (0.5%) to provide surface drainage to collection points, however, where possible a slope of one percent (1.0%) shall be used.

4.6 Stormwater Drainage and Management

4.6.1 Stormwater Quantity and Quality Requirements

A stormwater management system will be implemented at the site to regulate the water quality and quantity from storm runoff generated from the site development. The Engineer shall design the stormwater management system and erosion and sediment control plan in accordance with regulatory requirement to support the submittal by the Owner.

The proposed site shall preserve the existing site drainage patterns to the maximum extent feasible, and to promote the protection of groundwater, surface water, adjacent properties, and any wetlands encountered. As a minimum the system shall consist of on-site sediment filtering facilities, perimeter silt fences, ditches/swales, catch basins, manholes, and piping, and must conform to all permit requirements.

- Stormwater management control design criteria: control peak discharge flows from post-development to pre-development flow rates at the following events: 1-year, 2 – year, 10-year, and 100-year storm.

- Implement the Best Management Practices wherever possible to minimize the impact due to land development.

4.6.2 Stormwater Drainage System

Site stormwater drainage system will only collect clean, uncontaminated site surface drainage. Drains or sumps that collect contaminated fluids will be handled by other systems described in the mechanical engineering design criteria document.

The runoff from offsite areas will be collected and conveyed offsite to natural drainage courses. The offsite runoff maybe controlled by diversion systems independent of the plant drains, or, alternately, maybe combined with site runoff and conveyed offsite to natural drainage courses.

Sizing criteria for the plant site drainage system are as following:

- Closed Conveyance System: 25-year Storm

- Open Channels, Outfalls: 10-year Storm

Main plant loop road (Primary Roads) will be crowned to provide surface drainage with a minimum transverse slope of 2 percent. Secondary Roads will be either crowned or sloped to provide surface drainage with a minimum transverse slope of 2 percent. Catch basins will be constructed along the side of the roads to collect the stormwater runoff.

Where site space allows, open drainage ditches will be designed to collect and convey stormwater runoff. The ditch will be vegetated with perennial grasses or gravel lined to provide infiltration if possible, or rip rap lined to prevent erosion where ever is needed.

Stormwater pipes to be used are reinforced concrete pipe (RCP), smooth lined corrugated polyethylene (SLPE), or corrugated steel pipe (CSP).

Drainage inlets and manholes shall be precast reinforced concrete structures. With approval by the Owner, cast-in-place reinforced concrete structures may be utilized.

4.7 Roads and Parking

Site roads and parking areas shall be provided for access, operation and maintenance as shown on the general arrangement drawing. Permanent roads shown on the general arrangement drawings shall be paved with asphalt (bituminous concrete) paving. Shoulders will be dense graded aggregate. Engineer shall design the roadway pavement section following the recommendations provided in the Final Geotechnical Report. The design of the flexible pavement will consider the predicted wheel load applications over the plant life.

Plant yards inside the main perimeter road will be surfaced with dense graded aggregate with geotechnical fabric beneath to provide erosion protection and provide access for maintenance vehicles. Areas outside the perimeter road will be planted with perennial grasses.

4.8 Fencing and Gate

Fencing and security gate will be provided around the facility perimeter.

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NEW YORK STATE ELECTRIC & GAS
COMPRESSED AIR ENERGY STORAGE PROJECT

Electrical Engineering
Design Criteria

Document: CAES-1-DB-023-0001

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COMPRESSED AIR ENERGY STORAGE PROJECT
ELECTRICAL ENGINEERING
DESIGN CRITERIA

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1. ELECTRICAL DESIGN CRITERIA

1.1 INTRODUCTION

This design criteria establishes the guidelines for the engineering and design work required for the electrical discipline for the compressed air energy storage facility. The criteria include design basis and equipment and material selection. Design criteria are presented for each major piece of electrical equipment or system.

1.2 CODES AND STANDARDS

The latest edition and published addenda of the following publications are applicable to the extent indicated by the specific reference. All equipment furnished and work performed under this Section will comply with the approved standards, specifications, and regulations, codes, and tests of the following:

A. American Electrical Association (AEA)

B. Association of Edison Illuminating Companies (AEIC)

C. American National Standards Institute (ANSI)

D. Institute of Electrical and Electronics Engineers (IEEE)

E. American Society for Testing and Materials (ASTM)

F. Electronic Industries Association (EIA)

G. Illuminating Engineering Society (IES)

H. National Electric Manufacturers Association (NEMA)

I. National Electric Safety Code (NESC)

J. National Fire Protection Association (NFPA)

K. Underwriters Laboratories (UL)

1.3 115kV HIGH VOLTAGE INTERFACE

A. The primary distribution system within the facility will be 3-phase, 3-wire consisting of the following equipment:

1. One (1)13.8kV-115kV generator step-up transformer (GSU) fed from the plant switchyard.

2. Two (2) 115kV-13.8 compressor transformers fed from the plant switchyard.

3. One (1) 115kV-13.8kV auxiliary supply transformer (UAT) fed from the plant switchyard.

4. 115kV generator breakers, disconnects and associated plant switchyard equipment (Refer to CAES-1-DB-023-0003).

5. Current transformers and potential transformers for the 115kV system to meet all performance testing, protective relaying, metering, synchronizing, substation and/or utility requirements. (Refer to CAES-1-DB-023-0003)

1.4 ISOLATED PHASE BUS DUCT (IPB) or NON-SEGREGATED PHASE BUS DUCT (NPD)

A. One (1) lot of 13.8kV isolated phase bus duct or non-segregated bus duct of appropriate ampacity including all necessary fittings, connections, and supports. Bus duct will, as a minimum, be provided between the generator line terminals and the step-up transformer (as applicable) and between other medium voltage transformers and their secondary load switchgear. Metal enclosed bus duct will be designed, manufactured, and tested in accordance with all the applicable ANSI, IEEE, and NEMA standards.

B. The IPB and NPD will have the following parameters:

1. Nominal Voltage: 13.8kV, 3-phase, 60 Hertz

2. Cooling: Self-cooled

3. Continuous Current: Refer to oneline diagrams for preliminary information

4. Momentary Fault Current: TBD

5. Bus Insulation Level: 150kV BIL

C. The continuous current rating will be determined based on the guaranteed maximum generator current at five-percent under voltage. The momentary withstand fault current rating of the main bus will be determined by assuming a three-phase bolted fault at the generator terminals or on the step-up transformer low voltage terminals, whichever is higher. The momentary withstand fault current rating of the bus taps sections will be determined by assuming a three phase bolted fault at the main bus tap. Outdoor sections of the bus will be supported independently of transformer foundations to permit differential settling.

D. The generator neutral grounding transformer and resistor will be located in a metal cubicle and connected to the generator neutral bus by an insulated conductor internal to the cubicle. Grounding equipment will be sized to limit over voltages during arcing ground faults and to limit ground fault currents to a value, which will significantly limit damage to the bus at the point of the fault. The generator will be tripped expeditiously upon sensing a ground fault.

E. All bus supports, mounting hardware, erection details, notes, and drawings will be provided by the supplier. Coordination of the bus duct with the generator terminals, step-up transformer and main plant layout will be provided by the Engineer. The bus duct is an engineered system that is not suitable for field modifications. Layout details must be finalized prior to release for manufacture.

F. The turbine generator VT'S, surge protection equipment, and neutral grounding equipment are provided by the generator supplier in individual cubicles or in the generator terminal enclosure.

G. IPB and NPD construction features will include:

1. Weather tight, dust-tight;

2. Connections to equipment will be such as to maintain weather tight and dust-tight integrity;

3. Bolt-on, removable covers with re-useable gaskets at all terminations, at all bolted bus joints and at all supporting insulators;

4. Weatherproof seals at structure penetrations;

5. Thermostatically controlled and individually monitored space heaters or a pressurized air system for protection against condensation;

6. Screened drain holes;

7. Expansion joints as required;

8. Steel structures to support the Isolated Phase Bus Duct and Non-segregated Bus Duct;

9. Flexible connections to terminal equipment connecting means will be provided at generator line terminals to permit dielectric testing of this equipment;

1.5 MEDIUM VOLTAGE NON-SEGREGATED PHASE BUS DUCT OR CABLE BUS

A. Non-segregated phase bus ducts or cable bus will be used for all incoming connections to the medium voltage switchgear. The short circuit withstand capability of all bus ducts or cable bus will be determined based on comprehensive fault duty calculations. The bus ducts' or cable bus continuous current ratings will be based on carrying the transformer secondary windings' full rated current and the continuous current ratings of the medium voltage switchgear busses that they feed. The medium voltage bus ducts or cable bus will be rated 4.16 kV, three phase, 60 kV BIL.

1.6 STEP-UP TRANSFORMERS

A. The step-up transformers will transform power generated at 13.8kV from the turbine generator to 115kV high-voltage for transmission to the transmission system. The transformers will be located outdoor in the transformer yard. The layout will accommodate offsite access, as well as a simplified bus arrangement. Final transformer parameters will be defined by the generating equipment purchased and may change from those defined below.

B. The step-up transformers will have the following parameters:

1. MVA Rating: TBD (Refer to oneline diagrams for preliminary information)

2. High Voltage Winding: 115kV

3.	High Voltage Connection:	Wye Grounded
4.	High Voltage Winding Taps:	+/-2 @ 2.5%, and 0% CRT Tap
5.	Lightning Arresters:	Provided
6.	Low Voltage Winding:	13.8kV
7.	Low Voltage Connection:	Delta
8.	Cooling:	ONAN/ONAF
9.	Temperature Rise:	55/65 Degrees C
10.	Impedance:	TBD (Refer to oneline diagrams for preliminary information)
11.	Noise Level:	1 dBA below NEMA Standard
12.	Windings Material:	Copper
13.	Current Transformers	Bushing type, quantities and ratios as required

1.7 UNIT AUXILIARY TRANSFORMERS (Including Compressor Transformers)

A. The unit auxiliary transformers and the compressor transformers will be two-winding transformers that transform power at 115kV to 13.8kV.

B. The unit auxiliary transformers will have the following parameters:

1.	Rating:	TBD (Refer to oneline diagrams for preliminary information)
2.	High Voltage Winding:	115kV
3.	High Voltage Connection:	Delta
4.	High Voltage Winding Taps:	+/-2 @ 2.5%, and 0% CRT Tap

5.	Lightning Arresters:	Provided
6.	Low Voltage Winding:	13.8kV
7.	Low Voltage Connection:	Wye Grounded (low Resistance)
8.	Cooling:	ONAN/ONAF
9.	Temperature Rise:	55/65 Degrees C
10.	Impedance:	TBD (Refer to oneline diagrams for preliminary information)
11.	Noise Level:	1dBA below NEMA Standard
12.	Windings Material:	Copper
13.	Current Transformers	Bushing type, quantities and ratios as required

1.8 BOP STATION SERVICE TRANSFORMERS

A. The station service transformers will be two-winding transformers that transform power at 13.8kV to 480V or 34.5kV to 480V for the pumphouse area.

B. The station service transformers will have the following parameters:

1.	Rating:	TBD (Refer to oneline diagrams for preliminary information)
2.	High Voltage Winding:	13.8kV or 34.5kV
3.	High Voltage Connection:	Delta
4.	High Voltage Winding Taps:	+/-2 @ 2.5%, and 0% CRT Tap
5.	Low Voltage Winding:	480V
6.	Low Voltage Connection:	Wye Grounded (high Resistance)
7.	Cooling:	AA/FA

8.	Temperature Rise:	150 Degrees C
9.	Impedance: information)	TBD (Refer to oneline diagrams for preliminary
10.	Noise Level:	1dB below NEMA Standard
11.	Winding Material:	Copper
12.	Current Transformers	Quantities and ratios as required

C. Transformer capacity will be sufficient to allow across the line starting of the largest 460 volt motor, simultaneously with all other motors required for full unit capability running in full load condition, without objectionable voltage drop at any bus in the plant. Consideration will be made to accommodate future load growth. Transformer impedance will be high enough to limit interrupting fault duty on the switchgear, yet low enough to ensure that the voltage dip on starting the largest motor will remain above 80 percent of the motor voltage rating. The voltage profile of the plant under full load conditions will be examined to determine that with the utility system voltage at 115kV, the running voltage at all motors is at least 90 percent of the motor rated voltage. 13,800V-480V or 34,500V-480V transformers may be either oil filled or dry type.

1.9 MEDIUM VOLTAGE SWITCHGEAR

A. The secondary power distribution system will consist of 13.8kV and 4.16kV, 3-phase, 3-wire, resistance grounded neutral equipment described herein.

B. Medium voltage switchgear will be provided to distribute power to the medium voltage loads. Circuit breakers will be vacuum type, draw-out power circuit breakers. Layout of the medium-voltage bus will require compilation of the plant electrical load list. Bus bars will be insulated copper. Auxiliary system calculations will be performed to verify the adequacy of the medium-voltage system, as well as required fault interrupting capacities. A minimum of one spare breaker compartment and one breaker space will be provided on each bus for Owner's future use. Breaker control voltage will be 125 volts dc.

C. The secondary power distribution system will consist of the following main electrical equipment:

1. Cable runs, cable bus, or NPD connecting the new auxiliary power transformers to the medium voltage switchgear breakers.

2. Metering and protective relays for the medium voltage switchgear.

3. Medium voltage switchgear equipped with all the required draw-out switchgear breakers.

4. The required relays for motor protection will be Multilin 369+; switchgear mains/ties will be Basler BE1-51 phase and ground overcurrent; non-motor feeders will be Basler BE1-51 phase and ground overcurrent. Exact model numbers will be approved by the Owner.

5. Circuit breakers will be remote racking capable, remote racking devices will be provided in such a manner that adequate space is available to allow the worker to maneuver around the equipment at a safe distance. That safe distance will be consistent with findings of the arc flash calculations.

6. A viewing window that is infrared transparent will be provided; the exact size and location to be engineered to ensure the maximum viewing area unless it invalidates the safety margin provided by the structure. The viewing window will allow thermography inspection without opening the front/rear doors.

7. The medium voltage switchgear will include the following protection:

    a. Ground fault protection

    b. Parallel transformer operation

    c. Inter-phase fault protection

    d. Motor and feeder protection

8. The main balance of plant switchgear will have the following parameters:

    a. Voltage: 13.8kV or 4.16kV

    b. BIL: 150kV for (13.8kV) and 60kV for (4.16kV)

    c. Bus Current Rating: TBD (Refer to oneline diagrams for preliminary information)

d. Short Circuit Rating: 50kA symmetrical short circuit interrupting rating (Refer to oneline diagrams for preliminary information)

e. Incoming Main Breaker: TBD (Refer to oneline diagrams for preliminary information)

f. Feeder Breakers: TBD (Refer to oneline diagrams for preliminary information)

g. Tie Breakers: TBD (Refer to oneline diagrams for preliminary information)

1.10 VARIABLE FREQUENCY DRIVES

A. Medium voltage variable frequency drive (VFD) systems or soft start equipment will be used for starting the compressors.

B. Each VFD system will consist of all system components required to meet the performance, protection, safety, testing, and certification criteria of applicable specifications. These components may include incoming harmonic filter / power factor correction unit, input isolation transformer, VFD converter/DC-link/inverter, output filter and bypass contactor.

C. The VFD system will represent a fully integrated package and include all material necessary to interconnect any provided VFD system elements.

1.11 LOW VOLTAGE SWITCHGEAR

A. Secondary Unit Substation Transformers will be provided to distribute 480-volt power to the low voltage Station Service Switchgear. 480-volt switchgear will be provided to distribute power to the 480-volt loads. The exact configuration, single ended versus double ended, will be determined by the Engineer. It may be fed via non-segregated bus duct from the oil-filled or dry-type (for outdoor use) station service transformers, or close coupled via indoor dry type station service transformers. Each station service transformer will be sized to carry the entire busload with the other transformer out of service if a double ended tiebreaker configuration is used. The incoming main switchgear circuit breaker and tiebreaker will be electrically operated. Feeder breakers will be electrically operated. Breakers will be draw-out air magnetic units. 460 volt motors and other loads will be powered from 480-volt motor control centers (MCC's) that are fed from a secondary unit transformer or the 480-volt switchgear. Auxiliary system

calculations will be performed to verify the adequacy of the 480-volt system, as well as required fault interrupting capacities. A minimum of one spare breaker compartment and one compartment space will be provided on each bus for the Owner's future use. Breaker control voltage will be 125 volts dc. Final kVA size of transformers will be determined by the Engineer.

B. The 480V, 3-phase, 3-wire, high-resistance grounded distribution system will consist of the following main electrical equipment:

1. Station service transformers; 480V secondary with a 4.16kV primary.

2. 480V switchgear line-up, equipped with the required main breakers, tie breaker, and feeder circuit breakers.

3. Metering and protection.

4. A spare breaker of each current rating will be provided. Spare breakers for main or tie breaker service will be an uninstalled warehouse spare breaker.

5. The required static trip units are MicroVersaTrip Plus PM.

6. Circuit breakers will be remote racking capable, remote racking devices will be provided in such a manner that adequate space is available to allow the worker to maneuver around the equipment at a safe distance. That safe distance will be consistent with findings of the arc flash calculations.

7. A viewing window that is infrared transparent will be provided, the exact size and location to be engineered to ensure the maximum viewing area unless it invalidates the safety margin provide by the structure. The viewing window will allow thermography inspection without opening the front/rear doors.

8. 480V motor control centers.

C. The low voltage switchgear will include the following protection:

1. Bus or Cable under voltage protection.

2. Motor feeder protection.

3. Motor control center feeder protection.

D. The 480V switchgear parameters are as follows:

1.	Voltage:	480V, 3-phase, 3-wire, 60 Hertz
2.	Bus Current Rating:	TBD, copper bus bar (Refer to oneline diagrams for preliminary information)
3.	Incoming Breaker Continuous Amps:	TBD (Refer to oneline diagrams for preliminary information)
4.	Incoming Breaker Interrupting Amps:	65kA (Refer to oneline diagrams for preliminary information)
5.	Tie Breaker Continuous Amps:	TBD
6.	Tie Breaker Interrupting Amps:	TBD
7.	All Feeders Continuous Amps:	TBD
8.	All Feeders Interrupting Amps:	TBD

1.12 BLACK START GENERATOR

A. A black start natural gas powered generator will be provided to connect at the 480-volt system level. The black start generator will energize the 480V switchgear in order to support starting of the facility. All required switchgear, controls and synchronizing capability will be included in the system.

1.13 480V MOTOR CONTROL CENTERS (MCC'S)

A. 480 volt motor control centers will be provided with combination starters and molded case circuit breakers. These MCC's will serve low voltage motors and feeders required for plant operations. 480-volt power panels may be used to feed some loads and motor-operated valves. 480-volt MCC's will be provided to control 460-volt, 3-phase, 60 Hz, single speed induction motors and other miscellaneous 480-volt loads. Layout of the MCC's will require compilation of the plant electrical load list. MCC layouts will utilize front access construction. MCC placement will be against a wall, or stand-alone. Auxiliary system calculations will be performed to verify the adequacy of the 480-volt system, as well as required fault interrupting capacities. The equivalent of one vertical

stack of compartment spaces will also be provided in each MCC lineup for Owner's future use. Layout will facilitate future expansion of each lineup.

B. 480-volt MCC's will have the following parameters:

1.	Voltage:	480V, 3-phase, 3-wire, 60 Hertz
2.	Horizontal Bus Current Rating:	TBD, copper bar
3.	Feeders:	Molded Case Thermal Magnetic Circuit Breakers
4.	Motor Starters:	NEMA Size 1 and larger motor controllers with solid state overloads.
5.	Enclosure:	NEMA 1 gasketed, or NEMA 3R walk-in

1.14 LOW VOLTAGE SYSTEM

A. Power distribution at ac voltages below 480-volt will utilize 120/208 volt 3-phase, 4- wire, solidly grounded transformers and panels fed from the 480-volt MCC's. These transformers and panels may be located within the MCC's as long as the MCC is designed for outdoor installation or within an appropriate structure internal to the plant, depending upon the design circumstances. Allocation of these panels will be made after the load list provides load concentration details. Motor space heaters, equipment space heaters, equipment lights and power receptacles and equipment miscellaneous power feeds will be fed from power panels.

1.15 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. A UPS system will be provided to power all the instrumentation, control and monitoring circuits required for startup, operation, normal and emergency shutdown and offline housekeeping of the new equipment. In addition to static switch transfers, the UPS will provide filtered and regulated power.

B. The UPS will interface with the plant DCS and provide information to the operator in the control room on status, line up, bus voltages, operation, trouble, etc.

C. The UPS system capacity will be sized for 125% of the Control Systems for the turbine generators and the distributed control system and 100% of the remaining loads.

D. UPS expected loads:

1. Control System for the Turbine
2. Distributed Control System
3. Fire Detection System if required (the fire detection system may include individual batteries located in the main fire panel and/or the steam turbine generator valve house)
4. CEM System
5. Communication System
6. Generator Protection/Control System
7. Electrical Field Transmitters
8. Other loads as required by Vendor's supplied equipment (such as PLC's that cannot tolerate loss of power)

E. Normal power supply to the UPS will be from the 125 Vdc bus (normally fed from the ac rectifier and alternately fed from the dc battery) and through the inverter and load transfer switch to the uninterruptible bus. If the output of the inverter fails, the uninterruptible bus will be transferred to the alternate ac supply by means of the load transfer switch and fed through the regulated bypass ac power supply. The load transfer switch will also transfer the uninterruptible bus to the bypass ac supply whenever the current demand by the uninterruptible bus exceeds the capability of the inverter, such as during inrush periods following load energization and for external short circuits. UPS architecture will consist of an inverter section, a static transfer switch, an alternate source regulating transformer, a 120-volt or 120/240-volt ac distribution panel board and a maintenance bypass switch. The emergency source of power to the inverter will be the 125 Vdc systems.

F. The UPS system will have the following parameters:

1. Input Voltage: 480-volt, + 10, -15%; 3-phase; 60 Hertz power for regulated bypass transformer (alternate source);, 125 volts dc, 105 -140 volt dc range power for UPS inverter

2. Output Voltage: 120 volts: plus or minus 1% for all load conditions, 1-phase, 60 Hertz +/- 0.5Hertz

3. Inverter Overcurrent Output: Sufficient to allow use of molded case, circuit breaker distribution panels for feeder short circuit protection

4. Static Switch Transfer Time: 4 milliseconds

5. Enclosure: NEMA 1

6. Noise Level: <85dBA

1.16 DC SYSTEM

A. The dc systems will be designed to provide adequate 125-volt dc power to safely shut down the plant or protect equipment with minimal risk to people or equipment. Typical dc plant loads include turbine expander, generator emergency lube oil pump, UPS, fire protection, control room emergency lighting and switchgear and protective relays control. Assessment of the plant dc loads will be made to determine the appropriate quantities and locations for plant dc systems. Each dc system will include a battery, redundant battery chargers, battery ground detection, and dc distribution panels. Electrical calculations will be performed to verify dc system ratings and interrupting capacities.

1.17 STATION BATTERIES

A. The station battery will be lead-acid flooded cell type. Valve regulated types are not acceptable. Batteries will be manufactured for filtered full voltage float service with a high discharge rate, low deterioration rate, and low maintenance. Batteries will be supplied complete with all accessories (e.g. battery racks, inter-cell connectors). Racks will be in a single-tier of two step configuration such that no part of any cell resides directly above any part of another cell. All batteries will have a full discharge test. Battery sizing will be based on IEEE 485.

B. Electrical calculations will be performed to verify station battery sizing meets the dc load profile. The calculation shall be approved by the Owner.

C. One (1) station 125V dc battery system sized for three (3) hour back-up will be provided. The battery will supply the generator protection panel, switchgear and protective relay control power, emergency pumps, and uninterruptible power supply (UPS) loads.

D. The station batteries will have the following parameters:

1.	Voltage: (maximum)	125Vdc (nominal) 105 Volt (minimum) 140 Volt
2.	Number of Cells:	60
3.	Floating Charging Voltage:	2.25Vdc per cell/ 135 Vdc
4.	Equalizing Charging Voltage:	2.33Vdc per cell/ 139.8 Vdc
5.	Final Discharge Voltage:	1.75V per cell/ 105 Vdc
6.	Design Temperature:	77F plus or minus 2 degrees
7.	Design Margin:	10%
8.	Aging Factor:	1.25
9.	Discharge Duration:	2 hours (3 hours for UPS loads)

1.18 BATTERY AREA

A. The battery area will be independently ventilated, heated and cooled and designed in accordance with IEEE 484, "Recommended Practice for Installation, Design, and Installation of Large Lead Storage Batteries for Generating Stations and Substations", with the following exceptions:

1. An emergency shower and eyewash, in accordance with OSHA 29CFR1910.124(g), will be provided within the battery room. Storage for testing and monitoring equipment for the batteries will be provided.

2. Hydrogen detector with an alarm contact wired to the DCS.

1.19 BATTERY CHARGERS

A. Two battery chargers (100% redundant and with load sharing capability) will be connected to the dc bus and will supply the dc load power requirements during normal operation. Momentary loads in excess of the capacities of the battery chargers will be supplied by the battery connected to the dc bus. Upon loss of the battery chargers, the

battery will supply dc power in accordance with its discharge cycle. Upon re-energization, the battery chargers will pick up the normal dc load and recharge the battery in 12 hours. Battery charging equipment will not be installed in same room with the batteries. Normally the steady state dc loads and the battery float and equalizing charge will be supplied by one charger. The second charger will be on standby.

B. Battery chargers will also have a battery equalizing charge mode. Battery chargers will be self-regulating after charging levels are manually selected.

C. Battery chargers will be manufactured in NEMA 1 enclosures suitable for placement in an indoor, environmentally controlled atmosphere. The battery chargers will require only front access, and will allow either top or bottom conduit/cable entry.

D. Battery chargers will use 480V, 3-phase, 60 Hz power to convert to DC power.

1.20 AUXILIARY MOTORS

A. In general, electrical motors will be supplied with the driven equipment and will be premium efficiency grade motor. Motors will be supplied in accordance with motor attachment specifications appended to the driven equipment specification. Motors used for variable frequency drive service will be designed for acceptable operation due to harmonic related or other concerns.

B. Acceptable nameplate voltages for ac induction motors are:

1. 13,200-volt, 3-phase
2. 4000-volt, 3-phase
3. 460-volt, 3-phase
4. 208-volt, 3-phase (HVAC motors rated at 1hp or less)
5. 115-volt, 1-phase

C. In general, motors under 1/3 hp will be single phase; 1/3 hp and larger will be three phase. In general, all motors greater than 250 hp will be 13,200V, 3-phase or 4000V, 3-phase.

D. Acceptable nameplate voltage for dc motors is 115-Vdc.

E. Dc motors will be capable of starting, accelerating and running without damage within the range of 102 to 140 volts for 115V motors.

F. 460-volt, 4000-volt and 13,200-volt 3-phase ac motors will operate satisfactorily over a ±10% range from their rated voltage. Motors will start satisfactorily over a + 10%, -20% voltage range where required by the electrical system related calculations.

G. Motor Frames will be grounded and grounding surfaces cleaned in accordance with the National Electric Code, Article 250. Electrical system calculations will be done to verify the auxiliary power system performance and motor starting capabilities. Compilation of the electrical load list and the electrical calculations will confirm the system requirements.

H. Motors will be sized to at least a 10% capacity margin above that of the maximum horsepower requirement of the driven equipment. The motor's horsepower rating will be determined without taking advantage of the service factor, over 1.0, even for short duration overloads. All motors will have a service factor of 1.15. Motor heaters will be fed from a separate power source than the motor. Mechanical anti-rotation devices will be included on 4000V or 13,200V critical service motors such as circulating water and condensate pumps.

I. Motors, NEMA frame size 180 and larger, will include motor space heaters rated 115 volts, single phase, sized to maintain motor internal temperature above the dew point when motor is at rest. Engineer may take exception if application or environment of motor requires heaters for smaller motors.

J. All motors 4000V and higher will have sleeve-type bearings. Anti-friction bearings may only be used on motors 4000V and higher when technically required or advised and must be approved by Owner. All 4000V and higher motors will have externally lubricated anti-friction bearings, except for motors that drive equipment with forced lube oil bearings. Those motor bearings will share the forced lube oil system of the driven equipment.

K. All 460V and smaller motors will have externally lubricated anti-friction bearings, except for motors that drive equipment with forced lube oil bearings. Those motor bearings will share the forced lube oil system of the driven equipment.

L. 460V motor enclosures will be as follows:

1. Hazardous Areas: As specified in the driven equipment specifications

2. Indoor: Drip proof guarded enclosures, unless totally enclosed fan- cooled (TEFC) specified in the driven equipment specification, or unless TEFC enclosures are supplied as standard

3. Outdoor: TEFC

4. Lubricating Oil, Seal Oil: Totally enclosed

M. 4000V and 13,200V motor enclosures will be as follows:

1. Hazardous Areas: As specified in the driven equipment specifications

2. Indoor: Drip proof guarded enclosures

3. Outdoor: WP II

N. Each 4000-volt and 13,200-volt, 3-phase motor will be provided with a minimum of six (3 spares) 3-wire 100 ohm platinum RTD's, embedded in the stator winding at locations where highest temperatures are expected. Motor bearings will be equipped with dual-element, Type E chromel-constantan thermocouples.

O. For motors 3,000 hp and larger, both ends of each winding will be brought out for application of differential relay protection.

P. All motors will be supplied with connection boxes of sufficient size to accommodate the power lead terminations. Separate connection boxes will be supplied for RTD’s and heaters.

Q. All motors will have a nameplate containing information in accordance with NEMA MG1 as well as the motor service factor.

1.21 RELAY PROTECTION SYSTEMS

A. Protective relay Systems for the Work will be designed or specified by the Engineer in accordance with all applicable ANSI/IEEE standards, Owner standards, and the Engineer's engineering standards relay systems. The Engineer will calculate and provide all relay settings and current transformer ratios for all relays not provided by suppliers or

the Owner. Owner will review settings and associated calculations prior to implementation.

B. All relays will be solid state or microprocessor based. All voltage relays will have sufficient thermal capacity for continuous energization. Test device switches (ABB type FT -1) will be provided in all Transmission relay current, metering current, potential, and relay trip output contact circuits.

1.22 GENERATOR PROTECTION

A. Primary and backup generator protection will be provided by the generator vendor.

1.23 GENERATOR STEP-UP TRANSFORMER PROTECTION

A. The following is a list of the devices: *Note: Suffixes (X) on relay protection devices will match with transformer designation.*

1. Low and High Voltage Winding, Phase to Phase and Three-Phase Faults, Protected by Differential Relay and Sudden Pressure Relay if Used for Tripping (87/X, 63FP/X).

2. Phase to Phase or Three-Phase Faults in High Voltage Winding by Over-Current Relays, High Voltage Winding Neutral Ground (50/51X).

3. Relay for Line Ground Fault (51N/X).

4. Oil Level Alarm (71Q/X).

5. Pressure Relief alarm if used for Tripping (63PR/X).

6. Thermal Overload Protection (49/X).

1.24 AUXILIARY TRANSFORMER PROTECTION

A. The following is a list of the devices: *Note: Suffixes (X) on relay protection devices will match with transformer designation.*

1. Relay for Differential Protection (87/X).

2. Sudden Pressure Relay if used for Tripping (63FP/X).

3. Phase to Phase or Three-Phase Faults in Either Winding by Over-current Relays (50/51/X).

4. Thermal Overload Protection (49/X).

5. Oil Level Alarm (71Q/X).

6. Relay or Line Ground Fault (51N/X).

1.25 MEDIUM VOLTAGE SYSTEM PROTECTION

A. The medium-voltage, 3-phase systems will be low resistance grounded systems and will be protected by relays, which will trip the medium-voltage circuit breakers. The switchgear bus will be protected against three-phase and phase-to-phase faults by time over-current relays (50/51), which will trip the switchgear main circuit breaker. Motors will be protected against three phase faults, phase-to-phase faults, thermal overload and ground faults by a multifunction motor protective relay.

1.26 480 VOLT SYSTEM PROTECTION

A. The 480-volt system will be a high-resistance grounded neutral system with ground fault detection.

B. The 480-volt switchgear main and feeder circuit breakers will be equipped with solid-state trip devices.

C. The 480-volt motor control centers will be equipped with a molded case breaker and contactor starter for each motor. The breaker will provide short circuit protection for the motor and its feeder. The magnetic contactor will be equipped with a solid-state overload element in each phase which will protect the motor and circuit conductors against excessive heating due to prolonged motor over-current.

1.27 LIGHTNING PROTECTION

A. Lightning protection will be provided where necessary in accordance with NFPA No. 780, UL 96, UL 96A, and Lightning Protection Institute Standards 175, 176 and 177 and per manufacturer's recommendations. Air terminal, conductors and other related accessories will be UL listed and labeled.

B. Transient Voltage Surge Suppression (TVSS) will be provided on 480 volt distribution centers including 480 volt panel boards, and motor control centers.

C. Air terminals will be installed on top of the exhaust stack with the necessary electrical connections to the plant grounding grid.

D. In addition, outdoor instrumentation should have surge protection. These should be sized in accordance with the above and prevent surge propagation into the DCS cabinets.

1.28 METERING

A. Current Transformers

1. Rating: The primary windings of current transformers will have a continuous rating of at least 120 percent, and approximately no higher than 150 percent of the motor or transformer full-load current. IEEE Standard C57.13 lists the available current transformer ratings. The short-time thermal and mechanical rating of each ratio of current transformer and connecting relays will be specified to successfully withstand the available short-circuit current. These short-time ratings will be obtained from manufacturers' information. Reference IEEE C57.13 for definition of these ratings. The ratings will be given for one, one-second duration of short circuit time and will be equal to I^2t, where t = 1 second.

2. Accuracy Classification: The burden on the current transformer affects the accuracy classification. Therefore, the various burdens will be added to obtain the total burden. In most cases, it is sufficiently accurate to add arithmetically the impedance burden. Current transformers used in differential protective schemes will have a minimum accuracy class of C800. IEEE Standard C57.13 will be used for the accuracy classes, standard burdens for all other current transformers for metering, and relaying and accuracy calculations. The turbine generator suppliers will be responsible for providing an integrated system of CT's, meters, and relays for their equipment.

3. Grounding Methods: Secondary circuits of current transformers will be grounded in accordance with NEC Article 250.

B. Potential Transformers

1. Rating: IEEE C57.13 lists the primary voltage ratings, insulation classes, etc. for potential transformers. Potential transformer standard burdens are based on 120 volts and 69.3 volts. The generator potential transformers will be Y-Y connected with the secondary neutral grounded.

2. Accuracy Classification: Similar to current transformer circuits, the burdens will be added for the potential transformer circuits. IEEE C57.13 will be used for the standard burdens, accuracy classes, and accuracy calculations for potential transformers. The turbine generator suppliers will be responsible for providing an integrated system of PT's, meters, and relays for their equipment.

3. Grounding Methods: The grounding of potential transformer circuits will be done in accordance with NEC Article 250.

C. Instrumentation

1. Voltmeters: Voltmeters reading secondary voltage of potential transformers will have a 150-volt full-scale value with scale markings in primary volts.

2. Watt/Watt-hour Meters: The current transformer and potential transformer ratios multiplied together and then multiplied by a constant K = 1 for three-phase, three-wire circuits will result in an approximate scale. The exact scale will be determined from the manufacturer's scale selector. For example, 400/5 and 7,200/120 multiplied by 1 equals 4,800 kW. Therefore, a 5,000 kW full-scale meter will be specified. Watt-hour meter pulse contacts will be selected for even kWh/pulse values, i.e.100 kWh/P.

3. Ammeters: Ammeters will have a full-scale value equal to the current transformer primary rating and be rated for 5 amps input current. For auxiliary loads, current transformer ratios will be selected to give an approximately two-thirds full scale reading at rated loads.

4. Varmeters: The varmeter will have the same scale as the wattmeter, except it will be a zero center meter. The sum of the left-hand scale and the right-hand scale will equal the wattmeter full scale.

5. Plant Control System: All analog meter inputs to the Plant Control System will be 4-20 mA or datalink. Totalizing meters will provide digital inputs to the Plant Control System. Overall accuracy will be 0.2% or better.

1.29 CABLE RACEWAY

A. Cable raceways will primarily consist of cable tray and conduit. Cable raceway center-to-center separation will be determined during design based on equipment requirements.

1.30 CABLE TRAYS

A. The cable tray system will utilize multiple classes of tray, and cable tray separation will be determined during design based on equipment requirements. This separation isolates power and control cables from instrument cables for safety and electrical noise purposes. The cable trays will be continuous with straight lengths interconnected with horizontal and vertical fittings. Where required, cable trays will totally enclose the cables they transport.

B. The cable tray classification also indicates the sequence of cable tray placement in a vertical array, with medium-voltage tray at the top and instrumentation at the bottom. The separation between the low voltage (600V) and control can be 0" if both cables are insulated at 600V.

C. Medium-voltage cable trays will be ladder style with ventilated covers to prevent accidental contact with the medium-voltage cables while avoiding additional cable derating for heat affects. All other trays will be ladder type, except instrumentation, which will be solid bottom. Covers will be installed on the top tray of all outdoor trays, horizontal runs under grating, and on vertical runs, which penetrate platforms and floors (to a height of eight feet).

D. Cable trays and covers installed indoors will be aluminum. Cable trays and covers for normal outdoor atmosphere will be aluminum. Instrument trays, both indoor and outdoor will be ladder style. Solid covers will be provided on all outdoor and on indoor horizontal trays exposed to falling objects or subject to the accumulation of debris. Cable trays, which run under floor gratings or access platforms, or parallel to walkways and in close proximity thereto, will be provided with covers. Trays under gratings and walkways will have these covers extended 5 feet beyond the extremity of the walkway or grating. On multiple cable tray installations, the foregoing requirement applies only to the top tray. Tray covers will be provided for trays where contained cables are exposed to direct sunlight and in areas where cables may be damaged from falling objects.

E. All metallic cable tray runs will be electrically continuous. Where breaks occur, stranded copper ground straps will be installed as bonding jumpers to maintain continuity.

F. Where possible, cable trays will avoid all fire hazard locations, such as turbine oil tanks, main turbine lube oil reservoir, etc. Cable trays will also be routed to avoid maintenance access areas for equipment.

G. Nominal cable fill for random lay trays will be according to NEC.

1.31 CABLE TRAY SUPPORTS

A. Cable tray supports will be field installed. The basic material and structures will be "Unistrut" type or galvanized threaded rod type trapeze hangers. Typical tray support designs and installation criteria will be provided on the drawings. Cable tray support spacing criteria will be in accordance with tray manufacturer requirements. Cable trays will not be supported from piping.

1.32 CONDUIT

A. All exposed conduits, except for flexible connections, will be rigid galvanized steel. Conduit embedded in a concrete floor will be PVC with galvanized steel risers.

B. Liquid-tight flexible conduits will connect the conduit to all loads subject to vibration, thermal movement or requiring flexibility to be moved aside during maintenance.

C. All above ground conduits will be schedule Rigid Galvanized Steel. No direct bury conduit will be used.

D. Cables will be routed in the conduit system using computer database software. Nominal cable fill for conduits will be according to NEC (NFPA 70, chapter 9, Table 4). Conduit voltage class separation will be the same as for cable tray.

E. There will be a maximum of four 90 degree bends or the equivalent thereof in one conduit run. Pull boxes or pull sleeves will be used when necessary to comply with this requirement.

F. Straight runs of conduit over 100 feet in length will have expansion fittings if there are no pull boxes.

G. Conduit connection points located outdoors or exposed to conditions that result in frequent wetting will not enter from the top. Bottom entry is preferred; under certain conditions, side entry is permissible. Weep holes or bug screws will be provided at low points for removal of water that does get into the conduit. Weep holes will be large enough that small debris will not plug the weep hole, but small enough to protect the cable from damage. When possible, conduits can be arranged to drain to pull boxes and panels with provisions for drains in the bottom.

H. Conduits containing Data Highway Cables (Fiber, CAT 5e, etc.) will be clearly identified as such and identify between Primary and Secondary runs.

1.33 CONDUIT SUPPORTS

A. Conduits will be supported by hangers spaced in accordance with the National Electric Code (NEC), Section 344 for rigid metal conduit. Piping will not be utilized for conduit support.

B. Conduit supports will be field installed. The basic materials will be "Unistrut" type.

1.34 UNDERGROUND DUCTBANKS AND MANHOLES

A. Underground duct banks will consist of concrete encased PVC conduit (Heavy wall PVC in accordance with NEMA TC2). The underground duct bank system will be designed with enough manholes that cable installation can be performed without damaging cables due to excessive pulling tension. The encased conduit will be sloped so that water will drain out of the conduit. Where undrained conduits are completely unavoidable, the conduits will be sealed with sealing compound after the cables have been installed.

B. Underground concrete duct banks will be marked with red dye in the concrete on the top of the bank.

C. Manholes will have sump areas.

D. Where ducts pass under roadways or in areas subject to movement of heavy equipment, they must be encased in a concrete envelope structurally adequate for the loads imposed.

E. As much as practical, when equipment is served by below-grade conduit, embedded conduits will be employed to reduce the above grade conduit runs and keep them out of walking spaces.

F. Main underground ductbank trunk runs will have approximately 20% spare ducts upon initial design.

1.35 PRECAST CONCRETE TRENCH

A. A pre-cast concrete cable trench system may be used for the distribution of medium voltage power, and low voltage power and control cables, where practical.

1.36 CABLE

A. Cables will be specified in accordance with the Engineer's, NEMA and ICEA standards. Cable outside diameters used for design purposes will be a composite of standard industry values.

B. Voltage Rating

1. The following table gives the voltage rating and service voltage of cables:

POWER				
Service	Nominal Cable Voltage Rating	Insulation	Jacket	Shield
13,800-Volt ac	15,000	133% EPR	CPE or CSP (Hypalon)	Shielded
4,160-Volt ac	5,000	133% EPR	CPE or CSP (Hypalon)	Shielded
480-Volt ac 120/208-Volt ac (Power Feeders)	600	FR-XLPE, FR-EPR, XHHW-2	CPE or CSP (Hypalon)	Unshielded
120/208-Volt ac (Lighting and Receptacles)	600	FR-XLPE, XHHW-2	N/A	Unshielded

125-Volt dc	600	FR-XLPE, FR-EPR	CPE or CSP (Hypalon)	Unshielded
24 or 48-Volt dc	300 or 600	FR-XLPE, FR-EPR	CPE, CSP (Hypalon), or LSZH-XLPO	Twisted/ Shielded

CONTROL				
Service	Nominal Cable Voltage Rating	Insulation	Jacket	Shield
125-Volt dc & 120-Volt ac	600	FR-XLPE, FR-EPR	CPE or CSP (Hypalon)	Unshielded or Shielded

INSTRUMENTATION				
Service	Nominal Cable Voltage Rating	Insulation	Jacket	Shield
Analog	300 or 600	FR-XLPE, FR-EPR	CPE, CSP (Hypalon), or LSZH-XLPO	Shielded, twisted pairs or triads
24- Volt dc Digital	300 or 600	FR-XLPE, FR-EPR	CPE, CSP (Hypalon), or LSZH-XLPO	Twisted/ Shielded
48- Volt dc Digital	300 or 600	FR-XLPE, FR-EPR	CPE, CSP (Hypalon), or LSZH-XLPO	Twisted/ Shielded

C. Cable Sizing

1. Cable sizing will be in accordance with the NEC, ICEA Publications and IEEE Standards.

D. Cable Terminations

1. Medium-voltage power cables will be terminated with prefabricated 3M Cold Shrink QT-H terminal kits. Lugs will be long barrel copper compression type. Unless otherwise noted, cable shields will be grounded at both ends.

2. Compression type, double indent, two-hole copper lugs will be used for all power cables larger than #6 AWG and where designed for use.

3. Medium voltage auxiliary motors will be terminated with 3M 5380 Series Re-moveable/Re-useable Motor Lead Splicing kits.

4. Solid insulated ring type connections will be used on all control, instrumentation, CT and PT connections.

5. Grounding cables will be color-coded for identification. Where phase leads are color- coded, tagging is required at feeder end only.

1.37 LIGHTING AND RECEPTACLES

A. Light Intensities

1. Illuminating Society of America (IES) recommendations, Owner standards, and the Engineer' s Engineering standards will be followed for light intensities and light sources. Minimum plant lighting levels are defined as follows:

a.	Roadways	1 foot-candle
b.	Platforms & Stairways	2 foot-candles
c.	Power Block	5 foot-candles
d.	Generator Enclosure	10 foot-candles
e.	Transformer Yard	3 foot-candles

B. Lighting Calculations

1. Lighting calculations will be performed to determine the required number of lighting fixtures and fixture geometry to produce the recommended lighting levels.

C. Lighting Systems

1. Normal ac, emergency ac, and dc lighting systems will be provided to ensure the availability of necessary illumination during normal and emergency operations. Each system will have its own separate supply source and lighting fixtures. Outdoor fixtures will be weatherproof.

2. In general, exterior lighting systems will be directed downward to diminish visual disturbances to surrounding properties.

3. In general, the normal ac systems will be supplied power from 480-volt or 120/208-volt Lighting or Power Panels (for 60 Hertz systems only). The lighting system power will be distributed to the fixture circuits by circuit breaker panel boards.

4. Electric power to light fixtures will be switched with locally mounted light switches in areas where the light can be "off" when the area is not occupied. Electric power to light fixtures located outdoors that are required to be on for safety purposes will be switched with photoelectric controllers.

5. The dc Emergency lighting will be supplied from the plant dc distribution system, or from individual battery powered lights. Emergency lighting will be employed wherever personnel egress lighting must be available per safety and code regulations. Typically, remote areas needing emergency lighting will utilize the individual battery powered lights. Special consideration will be given to matching fixture types to the environmental conditions.

6. Emergency ac Lighting will be designated as required.

7. Lighting fixtures and material will be in accordance with IES standards. The Engineer will perform basic and detailed lighting design.

8. Normal AC Lighting System: The normal ac lighting system will provide illumination for the plant when the unit auxiliary power system is available. The

lighting transformers and panels will be located in the general vicinity of the lighting fixtures, which are being supplied and controlled from these panels. The operating voltages for these fixtures will be 120/208-volts. Street Lights may use 480 Vac fixtures. Each single-phase feeder circuit in the lighting panels will be loaded so that all three phases in the panel have as balanced loading as practical. In general, a group of lighting fixtures will be controlled from a single circuit breaker located at the lighting panel. Where offices or infrequently accessed areas are involved, local switching of the lights will be provided. Outdoor areas requiring nightly access will have the lighting controlled from a photocell/contactor arrangement.

9. Dc Lighting System: Dc lights fed from the station batteries will remain operational for at least 3 hours after loss of ac power. The batteries for the individually powered emergency lanterns will be nickel cadmium and have sufficient power to keep the lanterns energized for at least 90 minutes after the 120-volt single phase supply has been de-energized. Self-contained battery operated exit lights will be provided as required by governing codes.

10. Security Lighting System: Security lighting will be limited to outdoor areas to be monitored by plant security which otherwise would not require lighting.

D. Convenience Receptacles

1. 120-volt duplex, specification grade convenience receptacles will be provided in general plant areas where periodic maintenance is performed. Frequency of receptacles will be based on the use of 100-foot extension cords. In areas where heavier maintenance work than normal is expected, the quantity of receptacles will be increased. Ground fault receptacles or ground fault branch circuit breakers will be used for outdoor receptacles and in areas required by the NEC.

2. Receptacles will be powered from the 120/208-volt lighting transformers and panel boards. All transformers will include a minimum of 20% capacity reserved for future use.

3. 480-volt, 3-phase, 3 wire, plus ground, 60 ampere with safety switch, welding receptacles will be installed in those areas where periodic maintenance welding is anticipated. These receptacles will be Siemens ITE Enclosed Switch Vacu-Break Clampmatic with Crouse Hinds 4 prong receptacle, catalog

HNF362SCH, Series A, 60 AMP 600 Volt, 3 Phase 277V/480V, Type 4/4X enclosure.

1.38 ELECTRICAL HEAT TRACING

A. Self-regulating parallel type heat tracing will be used to provide both freeze protection and process heat tracing. Self limiting heat tape is also required on the supply line from the water heater to the emergency showers to maintain a 60 degree temperature. Systems requiring heat tracing will be annotated as such on the P&IDs. Heat tracing calculations will utilize plant specific values for temperatures and insulation values. Individual freeze protection and process heat tracing circuits will use individual thermostats for control. Where large quantities of freeze protection circuits exist in the same area, a thermostat/contactor arrangement to switch an entire distribution panel will be used. Power for heat tracing will come from 120/208- volt distribution panels designated for heat tracing use. Open circuit indication will be provided from each panel to the DCS. Electrical heat tracing systems will be covered by a performance specification prepared by the Engineer. Heat tracing will be designed, installed and tested in accordance with IEEE 515.

B. Heat tracing will be designed per the minimum ambient temperature provided in this design criteria and will be provided as generally identified on the P&IDs. Heat tracing electrical circuits will be shown in isometric format.

1.39 CATHODIC PROTECTION

A. Cathodic protection systems will be provided in accordance with the Piping Line Specs. Systems will primarily be sacrificial anode systems based on a 20-year anode life. Should larger systems be required, a rectifier powered anode system will be used.

B. Care will be taken to coordinate the cathodic protection system with the ground grid system to preclude destructive interaction of these two systems.

C. Soil resistivity studies will be performed as needed to support design of the cathodic protection system.

D. Appropriate test stations for the cathodic protection systems will be provided with segregated test terminal points for each separate cathodic circuit. Test Stations will be located away from traffic areas, not in roadways or maintenance areas where they could be damaged.

1.40 GROUNDING SYSTEM

A. System Design

1. The grounding system will be designed to provide personnel safety and to provide protection to electrical equipment. The design of the grounding system will be in accordance with-the requirements of the current revision of IEEE 80, 81, 81.2, 142, 665-and 1050, NESC and the NEC. Soil resistivity will be measured as described in IEEE 80.

2. After the ground grid potential profile analysis has been determined, the tolerable step and touch potential will be checked in accordance with IEEE 80 procedures.

3. The ground grid will be designed such that, after it has been installed, its resistance to remote earth is measured as described in IEEE 80. The entire station resistance to remote earth will be less than 3.0 OHMS. The resistance to ground of different ground grid sections will be verified prior to permanent connection together. Remote areas within the main plant and outside the main plant fence will have a minimum of two connections to the main plant ground grid. New units or power blocks will be connected to the existing ground grid in multiple locations at no less than four locations. Ground grid perimeter will extend 3' outside all fencing and buried at a minimum of 18" deep.

4. All connections, except for those made to equipment, will be exothermic welded. Equipment connections will be bolted to facilitate equipment removal. All electrical equipment, including main generators, transformers, breakers, motors and other components will share a common grounding grid.

5. Fence grounding will also meet IEEE 80 and will be continuously connected to the common grounding grid, even the section of fence under transmission circuits at the switchyard and GSUs.

6. The isolated (i.e. floating) instrument ground from the Control System will be connected to the intersection of the ground grid cables, unless this point is in close proximity to a lightning post ground connection. If a lightning post ground connection is nearby, the instrument ground cable will not exceed twenty-five feet in length and will be located as far as possible from the lightning pole ground connection. The instrument ground cable will be an insulated 4/0 AWG cable.

7. Instrument cable shields will be grounded at the DCS cabinet end only to prevent circulating currents. Care will be taken to extend the continuity of the cable pair shields in all field terminal boxes. At points of termination, pair shields, and drain wires will remain on the pair as close to the termination point as is practical. Shields will be permanently taped to prevent unraveling and the drain wires will have insulating sleeves installed up to the point of termination.

8. All ground stringers through concrete will be insulated or run through PVC.

B. Main Plant Design

1. The main plant ground grid will consist of bare copper cable buried in earth or embedded in concrete as shown on the drawings. In the vicinity of the main power block, the parallel grid lines will be continuous under the foundation. Where resistance to ground measurements indicates greater than 3-ohm, additional copper-weld ground rods will be driven into earth and exothermically welded to the grid. The addition of ground rods will continue until the 3-ohm measurement is obtained.

2. Electrical equipment at grade or on the first floor of the power block will be directly connected to the ground grid via riser cables. Steel columns will be directly connected to the ground grid via riser cables. Column structural splices will be made electrically continuous. Equipment located above the first floor will have their grounds connected to building steel provided the structural steel splices have been made electrically continuous.

3. The generators will be grounded in accordance with the Supplier's requirements, and the Engineer's and NEMA Engineering standards. The generator frame will be grounded at four points by cable directly to the main ground grid.

4. Underground duct banks will include bare 4/0 AWG cables that will be run on top of the ductbank for connection of the ground grids at each end of the duct bank. In manholes, these ground cables will be extended around opposite sides of the manhole.

C. Transformer Yard Fence

1. The transformer yard fence will be grounded by tying it to the plant ground grid if located over the plant grid or by using a separate grid tied to the plant grid. If

a separate grid is used, one 4/0 AWG bare copper cable will be buried 3 feet outside the fence at a depth of 18 inches and will be connected to every other fence post with #2 AWG bare copper cable. The 4/0 AWG cable will be tied to the main plant or switchyard ground grid at four distinct points (i.e. each side of the transformer fence). Ground rods will be provided in accordance with the requirements of the ground grid design. Ground fittings for fence connection will be cast copper alloy with silicone bronze hardware. Copper-strap ground connectors and ferrous hardware will not be used. All gate hinges, and/or moveable connections, will be jumpered using flexible #2 AWG cable, such that all sections of the fence are hardwired to the ground grid. All connections between the transformer yard fence, the transformer ground grid, and the plant ground grid will be by exothermic connections, compression type connectors are only allowed for the connection to the fence itself.

D. Remote Areas Outside Plant Boundaries

1. A 4/0 AWG ground grid will be installed in the vicinity of all the remote plant structures, which contain electrical equipment. Each ground grid will be interconnected to the main plant ground grid in at least one place with minimum 4/0 AWG cable. The three (3) ohm resistance to ground requirement is valid at each of these locations.

1.41 HAZARDOUS AREAS

A. Hazardous areas will be determined in accordance with the NFPA. Areas of the plant will receive classifications as follows:

1. Non-hazardous; Class I, Division 2; Class I, Division 1

2. Known hazardous material is natural gas and fuel oil.

B. A plot plan will be developed for the plant and remote areas showing the hazardous area classifications.

C. Electrical equipment and construction specifications will require all electrical equipment, materials, and installation practices to adhere to the NEC hazardous area requirements for the area in which the equipment is located. The Engineer's design will minimize the impacts of hazardous areas by reducing the amount of equipment located within classified areas as much as possible.

1.42 COMMUNICATIONS SYSTEM

A. The communication system will include a plant wide paging system, and communication ports/data links in the remote buildings. Handsets, paging amplifiers and loudspeakers will be located as required to provide adequate plant coverage. Power supply for the communication system will be from the UPS system.

B. The system will be designed to produce a sound intensity of at least 6 dB above a possible 100 dB background from the turbine generator or other noise producing equipment. The loud speakers will have a frequency range of 85 to 7500 hertz.

C. System will include alarm capability that will be activated from the main control room.

D. The system will contain spare capacity for future addition of a minimum of 25% additional communication instruments and alarm conditions without procuring new or supplementary system hardware or software.

E. Communication equipment will have weatherproof ratings so that installation prior to building enclosure will not degrade the equipment.

F. Handsets will be of the desk or wall-mounted type as required for a particular location. Where required, sound-attenuating enclosures may be required plus enclosures will be highly visible and well marked.

G. Required vendor is GAI-Tronics.

1.43 PLANT SECURITY SYSTEM

A. A plant security system will be required.

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NEW YORK STATE ELECTRIC & GAS
COMPRESSED AIR ENERGY STORAGE PROJECT

I&C Engineering
Design Criteria

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COMPRESSED AIR ENERGY STORAGE PROJECT
I&C ENGINEERING
DESIGN CRITERIA

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1. INSTRUMENTATION AND CONTROLS DESIGN CRITERIA

1.1 Introduction

The instrumentation and controls design criteria provides the basis for the plant control philosophy, the control systems, the instrumentation design, and the instrument installation design. The intent of this criteria document is to provide the design criteria for engineered systems, as well as to provide the design basis to which vendor-supplied systems are specified and reviewed.

1.2 Codes and Standards

The latest edition and published addenda of the following publications are applicable to the extent indicated by the specific reference. All equipment furnished and work performed under this Section shall comply with the approved standards, specifications, and regulations, codes, and tests of the following:

A. ASME:

1. B16.5, "Pipe Flanges and Flanged Fittings."
2. B16.34, “Valves - Flanged, Threaded, and Welding End”
3. B16.10, “Face-to-Face and End-to-End Dimensions of Valves”
4. B31.1, "Power Piping."
5. MFC-3M, “Measurement of Fluid Flow in Pipes using Orifices, Nozzles, and Venturi”
6. PTC 19.3, “Temperature Measurement Instruments and Apparatus”
7. PTC 19.5, “Flow Measurement”

B. Institute of Electrical and Electronics Engineers (IEEE):

1. 1050, “Guide for Instrumentation and Control Equipment Grounding in Generating Stations”

2. 1100, “Recommend Practice for Powering and Grounding Electronic Equipment”

3. C 37.90.1, "Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus."

C. National Fire Protection Association (NFPA):

1. 70, “National Electrical Code.”

2. 85, "Boiler and Combustion Systems Hazards Code.”

D. National Electrical Manufacturers Association (NEMA).

1. ICS 1, “Industrial Controls and Systems General Requirements”

2. 250, “Enclosures for Electrical Equipment (1000 Volts Maximum)”

E. The International Society of Automation (ISA):

1. 5.1, “Instrumentation Symbols and Identification.”

2. 5.2, "Binary Logic Diagrams for Process Operations."

3. 51.1, “Process Instrumentation Terminology.”

4. 75.01.01, “Flow Equations for Sizing Control Valves.”

5. 75.02.01, “Control Valve Capacity Test Procedure.”

6. MC 96.1, “Temperature Measurement Thermocouples.”

F. The Measurement, Control, and Automation Association (MCAA)

1. Functional Diagramming of Instrument and Control Systems

1.3 General

A. Unit and Scale

1. The following units of measure shall be the standard for this project:

a. Positive gauge pressure: psi, inH2O
b. Vacuum: mmHg, inH2O
c. Temperature: °F
d. Flow:

i. Liquid: GPM
ii. Steam: lb/hr
iii. Air and Gas: lb/hr, SCFM
iv. Solids and slurry: lb/hr

e. Level: inches, feet – as appropriate for the application

2. Scales shall be designed to read directly in engineering units, unless otherwise specified.

B. Symbols and Legends

1. In general, instrument and control symbols and identifications shall be as indicated in ISA and The Measurement, Control, and Automation Association standards or approved equivalent.

2. All documents, instructions, legends, charts, scales, and nameplates shall be in the English language.

3. All tag numbers for equipment and instrumentations shall be as indicated in the project specific tagging structure.

C. Control Signal

1. Electrical control signal: 4 – 20mA DC

2. Pneumatic signal: 3 - 15 psig

D. Control shall utilize Distributed Control System (DCS) technology by using fully redundant microprocessor technology with redundant, high speed, fault tolerant communications and multiple screen operator interfaces.

E. Controls shall include safety logic that shall automatically alarm and execute preprogrammed actions in cases where unsafe situations are likely or imminent.

F. The general design of control room operator interface criteria shall be for a soft display-based control and monitoring system with minimal "hard" devices.

G. The control system shall be designed so that the entire plant process and ancillary plant systems can be safely operated through the unit control room DCS display console. These displays will provide a single, integrated, cohesive, interface to all plant equipment and processes.

H. All alarms that jeopardize plant operation shall be collected by the DCS, evaluated and sorted according to process system groups and alarm severity.

I. Control facilities shall be designed so that major operation of Combustion Turbine (CT) Generator, Recuperator and plant auxiliaries can be accomplished from the control room.

J. "Hard" manual-automatic control stations will not be provided.

K. The use of local pneumatic controls shall be minimized.

L. PLC's or vendor standard controls shall be provided for the following:

1. Air Compressor Control Systems Local Control Panels
2. Domestic Water Treatment System PLC Control Stations
3. Industrial Sewage Water Treatment
4. Auxiliary Boiler (aux boiler enclosure)
5. Ammonia storage, forwarding and feed systems
6. CEMS Operator Stations (CEMS enclosure at chimney, and in the unit control room)

Datalinks shall be provided between all PLCs and DCS.

M. Instrument Air Systems

1. The instrument air supply shall be distributed at 80 to 125 psig with design dew point of minus 40 ºF. It shall be oil and solid free (no particulate greater than 10 microns) and shall consist of atmospheric air compressed by a non-lubricated

pump. Surge capacity shall be provided by over-sizing sections of the distribution header throughout the plant.

2. If automatic emergency provisions are included for devices for backup from Service Air, design shall not permit loss of pressure of the Instrument Air header on a catastrophic failure of the Service Air header.

3. A dual tower air dryer system shall be supplied. Transfer to the back-up air dryer shall occur on low instrument air pressure or high moisture.

N. Motor Control

1. Most motors are controlled from the DCS. Local control, in lieu of DCS control, is provided in instances where DCS control is not warranted due to limited need for control room operator interface, or due to the infrequent use of the equipment.

2. Standby Starts - Components in a system (such as 2 x 100% pumps) that are redundant will have a standby mode included in the control logic. If the redundant pump is in the standby mode when the operating pump is tripped, or a process parameter indicates that the operating pump has failed, the standby pump will standby-start. An alarm will alert the operator that the pump has standby-started.

3. Medium voltage motor switchgear feeder breakers will have the following I/O for control and monitoring from the DCS:

   a. One digital output for start, momentary closed contact to start

   b. One digital output for stop, momentary closed contact to stop

   c. One digital input for motor status

   d. One digital input for trouble alarm from the multifunction motor protection relay. Any alarm condition detected by the relay will initiate this alarm, including loss of control power. Three RTDs for motor winding temperature where provided will be wired to the multifunction relay. A high temperature on any of these RTDs will initiate this trouble alarm.

e. One digital input to indicate that DCS control is enabled. This contact indicates that the breaker is racked in and the local control switch is in the “Remote” position indicating that it is ready for remote control.

4. Low voltage motor starters in motor control centers will have the following I/O for control and monitoring from the DCS:

   a. One digital output for start/stop, maintained closed to run (normally open contact)

   b. One digital input for motor status

   c. One digital input for control power available

5. All motor operated valves will have local starters and local control stations on the valves. Motor operated valves in open/close service will have the following I/O for control and monitoring from the DCS:

   a. One digital output for valve open (forward) command (normally open contact)

   b. One digital output for valve closed (reverse) command (normally open contact)

   c. Two digital inputs for valve position (full opened and full closed)

   d. One digital input for Local/Remote switch feedback (Remote = 1)

   e. One digital input for trouble alarm (includes control power available)

6. Motor operated valves in jogging service will have the following I/O for control and monitoring from the DCS:

   a. One maintained digital output for valve open (forward) command (normally open contact)

   b. One maintained digital output for valve closed (reverse) command (normally open contact)

   c. Two digital inputs for valve position (full opened and full closed)

d. One digital input for Local/Remote switch feedback (Remote = 1)

e. One digital input for trouble alarm (includes control power available)

f. One analog input for valve position

O. Breaker Control

1. Medium voltage switchgear main breakers will have the following I/O for control and monitoring from the DCS:

a. Digital output for breaker close command

b. Digital output for breaker open command

c. Digital input for breaker closed status

d. Digital input for breaker common trouble alarm

e. Digital input for breaker racked in

2. Medium voltage switchgear tie breakers will have the following I/O for control and monitoring from the DCS:

a. Digital output for breaker close command

b. Digital output for breaker open command

c. Digital input for breaker closed status

d. Digital input for breaker common trouble alarm

e. Digital input for breaker racked in

3. Medium voltage switchgear feeder breaker will have the following I/O for control and monitoring from the DCS:

a. Digital output for breaker close command

b. Digital output for breaker open command

c. Digital input for breaker closed status

d. Digital input for breaker common trouble alarm

e. Digital input for breaker racked in

4. Low voltage switchgear main breakers will have the following I/O for control and monitoring from the DCS:

a. Digital output for breaker close command

b. Digital output for breaker open command

c. Digital input for breaker closed status

d. Digital input for breaker common trouble alarm

e. Digital input for breaker racked in

f. Digital input for bus ground fault

5. Low voltage switchgear tie breakers will have the following I/O for control and monitoring from the DCS:

a. Digital output for breaker close command

b. Digital output for breaker open command

c. Digital input for breaker closed status

d. Digital input for breaker common trouble alarm

e. Digital input for breaker racked in

6. Low voltage switchgear feeder breakers will have the following I/O for control and monitoring from the DCS:

a. Digital output for breaker close command

b. Digital output for breaker open command

c. Digital input for breaker closed status

d. Digital input for breaker common trouble alarm

e. Digital input for breaker racked in

f. Digital input for bus ground fault

P. Control Valves and Drives

1. The fail-safe position of the valve or damper will be when the signal or electric power or pneumatic power is not present.

2. Pneumatic modulating control valves will receive a 24 VDC-powered, 4-20 mA DC control signal. Limit switches and air failure lockup devices will not be used unless needed for special control or monitoring.

3. Pneumatic on-off control valves or drives will have the following I/O for control and monitoring from the DCS:

   a. One or two digital outputs, depending of failure position, of a 120 VAC signal from the control system to power a three way solenoid.

      i. Fail Open or Closed: one digital output

      ii. Fail in Place: two digital outputs

   b. Two digital inputs for valve or drive position (full opened and full closed)

4. Electric modulating control drives will have the following I/O for control and monitoring from the DCS:

   a. One 24 VDC-powered 4-20 mA DC analog for drive position demand

   b. Drive position feedback via HART protocol

5. Pneumatic modulating control drives will have the following I/O for control and monitoring from the DCS:

   a. One 24 VDC-powered 4-20 mA DC analog for drive position demand

b. Drive position feedback via HART protocol except for critical valve position feedback which will be hardwired

6. Electric on-off control drives will have the following I/O for control and monitoring from the DCS:

a. One digital output for drive open (forward) command (normally open contact)

b. One digital output for drive closed (reverse) command (normally open contact)

c. Two digital inputs for drive position (full opened and full closed)

d. One digital input for Local/Remote switch feedback (Remote = 1)

Q. Trips and Interlocks

1. Trips and interlocks will be implemented in the DCS to the maximum extent possible except in the following instances:

a. Code required direct hardwired means of tripping

b. Required response time for the interlock is faster than can be implemented through the DCS.

2. All required equipment interlocks shall be shown on equipment vendor logic diagrams. Interlocks implemented in the DCS shall be shown on DCS control system logic diagrams. Hardwired interlocks will be shown on wiring diagrams.

1.4 Control Room and Electronics Room

A. Control Room

1. Normal temperature of central control room shall be 72 - 78 °F and allowable temperature shall be 68 - 82 °F.

2. Relative humidity of the central control room shall be 40 - 60% (minimum 20%).

3. Lighting in the control room shall be designed with the ability of the operator to adjust the level for optimum reading of displays.

4. All control room panels and consoles shall be designed to prevent the operator from being subjected to objectionable noise from fans, printers, and any other background noise source, including equipment external to the Control Room. Background noise levels should be less than 65 dBA.

B. Operator's Control Console Layout

1. Control console design will be for a soft DCS display-based operator interface.

2. The control console shall be arranged to accommodate one or two operators.

3. Console items shall be placed for ease of operation and in logical relationships with respect to each other.

4. The control console shall accommodate page system and phone system handsets.

C. The following equipment shall be located in the control room:

1. Operator's Control Console

a. Three dual screen DCS operator workstations

b. One CTG control system workstation

c. Operator work surface to accommodate phone and page sets, and drawing/document laydown area

d. CEMS operator interface display.

e. Water Treatment operator interface display.

f. Auxiliary Boiler display

g. Air compressor display

2. One (1) ceiling-mounted large flat panel overview displays

3. Auxiliary Benchboard Control Panel

   a. Hardwired trip pushbuttons for the CT and the Auxiliary Boiler.

4. Vibration monitoring system and analysis workstation

5. One (1) DCS historical data storage system workstation

6. One (1) DCS alarm printer

7. Fire alarm panel

D. The following equipment shall be located in the electronics room:

1. Power Distribution panels

2. DCS control processor cabinets

3. DCS I/O cabinets (if required)

4. DCS Network Cabinets

5. One (1) DCS engineering workstation

6. One (1) DCS engineering workstation printers

7. Tables, files, and other miscellaneous furniture

8. Telephone and paging communication cabinet

9. Fiber Optic Termination Cabinet(s) (if required)

E. All instruments located in the control room or electronics room, susceptible to EMI, shall be designed in accordance with applicable standards.

1.5 Distributed Control System (DCS)

A. The DCS will be used to control and protect the main plant equipment and systems and will serve as the central interface for the operators. This system will be connected to the various instrumentation and control devices throughout the plant.

B. The DCS will be a hierarchical, microprocessor-based control system. All DCS control and monitoring functions will be implemented in control processors. All processors will be a minimum of 32-bit, multi-speed standard software design, with self-checking features to allow detection of processor malfunctions.

C. Each control processor shall be equipped with capacity required to perform its functions plus a spare capacity of 40 percent of all control processors memory, control processor utilization, addressable points, and any other factor that affects control processor utilization. Each distributed controller shall have at least 25 percent spare duty cycle under worst case conditions.

D. The DCS equipment will be designed such that a system component failure or a DCS power source failure will not disrupt control system functions. Each control processor cabinet will provide redundant control processors, power supplies, and data highway interfaces. Each I/O cabinet will provide redundant power supplies, and data highway interfaces. If the system detects a control processor failure, a power supply failure, or a communications failure, the failed equipment will automatically transfer to its back-up. In the case of a processor failure, if the back-up is unavailable, the processor outputs will fail to their fail-safe position and allow a manual shut-down of the equipment affected. Upon a back-up power supply failure, the affected equipment will fail in its de-energized position.

E. The DCS shall be the primary means of controlling most of the plant for all operating conditions. It shall implement analog and digital (logic) functions to bring the plant from start, up to the desired operating conditions, and back to complete shutdown. It shall also include all interlock and control functions to sustain any postulated transient condition. The DCS shall provide for automatic control, however the operator shall always have the capability to intercept the auto mode and to control the unit manually (subject to safety and protection restraints). Primary operator interface shall be provided though DCS operator displays in control room consoles.

F. Elements of both functional and geographic distribution shall be used in locating the hardware and assigning tasks to the control processors of the DCS. Where concentrations of field devices can be identified in the plant, geographic distribution shall be applied. Where extreme speed of response is essential, or where data communications are not sufficiently secure, functional distribution shall be applied. When functional distribution is applied, care should be exercised to ensure that failure of a single station has minimal effect on plant operation. To the greatest extent possible, a single data station shall serve process segments that are interdependent.

G. Control Functions

1. The primary purpose of the DCS is to maintain control over the plant processes. The objective is to obtain maximum efficiency, longest equipment life, and minimum environmental effects.

2. The system shall be readily configurable and capable of on-line configuration and maintenance. It shall be self-documenting, fault tolerant, highly dependable, and reliable.

3. The response time of the control actions shall be sufficient to maintain control over the process under all operating scenarios. This response time shall include consideration of delay and dead times, both internal and external to the DCS and shall be selected based on the process requirements.

4. The control system shall transfer to manual control and alarm upon loss of valid process data.

H. Safety and Protection Functions

1. Protective functions shall be designed to be very dependable and be designed to prevent failure to trip and false trips. Protective actions may be initiated based on an event, a threshold value, operator intervention, or an analysis of the plant status. The applicable safety codes governing each application shall be followed.

2. Failure or loss of a single component shall not cause a protective function to be disabled.

3. Protection functions require periodic testing and calibration. The DCS shall recognize and accommodate this requirement.

4. The interlocking and protecting functions that are applied in the DCS shall be implemented in a very careful, conservative, and fault tolerant structure, with assurances that the response time is adequate for each situation.

I. Data Highway Communications Network Design

1. The data highway shall be redundant. The data highway inside the control room and electronics rooms will utilize an Ethernet, twisted shielded pair, or fiber optic cable. The data highway outside these rooms will use fiber optic cables.

2. Redundant data highway cables shall be routed in separate conduits above ground. Under ground, redundant data highway cables may be routed in a single conduit.

3. The fiber optic cables used for DCS communication links will be a 12-fiber cable. All communication fiber will terminate in fiber optic patch panels at both ends, with all fiber strands terminated in the panel. Connection to the final termination point will be via 2-fiber patch cables.

4. Datalinks shall be provided between the DCS and the following:

    a. PLCs

    b. Medium Voltage Switchgear

    c. Motor Control Centers

J. Input and Output (I/O)

1. The following I/O signal types and I/O cards shall be used:

    a. 4-20 mA DC system powered analog output

    b. 4-20 mA DC system or field powered analog input

    c. Thermocouple analog input (Type K typical)

    d. RTD analog input (3 or 4-Wire 100 ohm platinum typical)

    e. 24 or 48 VDC system powered digital input

    f. 24 or 48 VDC system powered SOE input

    g. 125 VDC or 120VAC externally powered digital input

    h. Dry contact rated 120 VAC or 125 VDC digital output

i. Internally-powered 120 VAC digital output

2. The as-shipped control systems shall have twenty percent (20%) spare wired I/O provided for each I/O type in each cabinet and twenty percent (20%) spare slots and unwired terminations in each I/O cabinet.

3. I/O modules shall be available to accept all required signals and all analog I/O modules shall reject the common mode voltages that might appear between sensor ground and A-D converter ground.

4. A single component failure including a blown fuse shall not result in the loss of more than one I/O signal. The DCS shall monitor the status and alarm on the loss of any fuse.

5. As with all printed circuit cards in the system, the I/O modules shall be capable of installation or removal with the backplane energized, and without disturbing adjacent cards or field wiring. The modules shall be designed in such a manner that will prevent damage or misoperation if they are installed in the wrong slot.

6. The I/O system shall evaluate the quality of the incoming signals from the transmitters and sensing devices. They shall:

   a. Verify that the signal is within the valid sensor range for the variable.

   b. Detect open or shorted field wiring, without adversely affecting the function of the field device.

   c. Take immediate corrective action to avoid any upset to the controlled process on detection of a failed control input, and notify the operator of the failure.

7. I/O cards shall support Hart communication with all Hart enabled field equipment through the 4-20 mA analog input and analog output cards.

8. Communications links between I/O cards and control processors shall be redundant.

K. Power Supply Considerations

1. The DCS shall include all power supply conditioning necessary to accommodate normal variations in electrical supply to the system. The system shall accept a primary 120 VAC UPS power feed and a secondary 125 VDC power feed for all stations. Redundancy shall be provided in the DCS's power conditioning circuits.

2. DCS I/O cabinets which contain internally-powered 120 VAC digital output cards, shall have separate redundant 120 VAC UPS power feeds to provide the motive force. In addition, a relay shall be provided to automatically switch to the backup power feed in the event the primary feed is lost. Alarm shall be provided for loss of either power feed.

3. Field wiring for contact interrogation and device control shall be protected such that a fault in these cables does not cause a loss of more than one signal.

L. Control cabinets

1. Control processor cabinets shall be free standing and rated NEMA 12. These cabinets shall contain communication cards, processor cards, and power supplies. Control processor cabinets will be located in an environmentally controlled area; e.g. an electronic equipment room or a prefabricated room. Cabinets shall have front and rear access. Cable entry is through the top and bottom of the cabinet.

2. I/O cabinets located in an indoor controlled environment shall be NEMA 12 free standing. These cabinets shall contain communication cards, I/O cards, power supplies, and I/O terminations.

3. I/O cabinets located outdoor or in an uncontrolled environment shall be NEMA 4 free standing. These cabinets shall contain communication cards, I/O cards, power supplies, and I/O terminations. Outdoor cabinets shall be provided with the proper environmental controls (i.e. air conditioning)

M. Operator Interface

1. The control room operator console shall include three dual screen operator stations with twenty-two inch (22”) flat panel LCD displays, QWERTY keyboard and mouse. The control console will be arranged in a horseshoe, with wedge sections used to provide operator workspace and accommodate telephone and page system interface.

2. One (1) forty-two inch (42") flat panel LCD displays will be mounted from the control room ceiling above the operator console for display of overviews.

3. One (1) color laser printer is provided in the main control room for printing alarms, reports, and graphics.

4. The operator interfaces shall provide for the functions of control, monitoring, fault detection, reporting, system diagnosis, self-diagnosis, and testing.

N. Operator Display Techniques

1. The user shall have the capability to configure graphics on-line, while the process in running.

2. The operator interface shall be the same for all control and monitoring functions. The location, layout, and orientation of data and objects on the operator displays must be consistent and logical such that the operator will instinctively know where on the display to find the needed information.

3. Picture content shall be structured to contain only vital and essential information. The most important information shall be the data, not the precise physical layout of the plant equipment.

4. Data required for the evaluation of the operating status of the plant systems shall be complete and provided quickly to the operator.

5. Dynamic permissive and interlock lists shall be provided for each device to allow the operator to quickly determine why the device does not have an operational permissive. First-out trip indication shall be provided for all devices with multiple interlocks where the cause of trip may not be apparent to the operator.

6. Standardized rules regarding color usage, operating status, picture area arrangement, data display, graphic programming, and symbols shall be defined and observed for all graphics.

7. Display hierarchy techniques shall be incorporated to enable an operator to proceed from overviews to group/subsystem displays and back to obtain process detail.

8. The design should be such that minimum actions are necessary to move through displays.

O. Engineering Interface

1. One (1) dual screen engineering workstation (EWS) shall be provided for the distributed control system.

2. The EWS will be capable of control function manipulation to execute all binary and analog logic.

3. The engineering workstation and printer are powered from an uninterruptable power source (UPS).

4. Engineering tasks need not be performed in real time, but shall be performed with the control system in service - i.e. on-line. They include tasks for:

   a. Control system optimization

   b. Control system diagnostics and maintenance

   c. Historical performance analysis

   d. Data logging, trending, and storage

P. Alarm Requirements

1. Visual and audible alarms shall be provided to alert the operator to off-normal operating conditions and to provide a record of operations events.

2. Analog inputs shall be compared with high or low alarm limits to determine alarm conditions and initiation of an alarm. The return to normal of analog inputs shall be governed by separate alarm limits to provide a deadband limit for all high and low alarm limits. Digital inputs status shall be compared with previous status and changes shall initiate an alarm or return to normal signal.

3. Self-diagnostic alarming shall be provided to guide service personnel to quickly identify faulty modules of the DCS. Details concerning the self and system diagnostics shall be specific enough to enable the service personnel to find and exchange a faulty module within an hour at most.

4. Alarms shall be displayed or presented in the order of occurrence. The resolution between alarmed events shall be less than one second. Resolution to the millisecond shall be provided for sequence-of-events logging.

5. Alarm suppression techniques shall be utilized to avoid overloading and confusing the operators during an emergency operation.

6. The alarm list or history shall be provided on an operator display. It shall consist of all alarm operations, incremental limits, and return to normal, with time occurrence, in chronological order.

7. All alarms shall be recorded in the unit data historian for later evaluation.

8. Alarm messages shall be complete with the following minimum information:

    a. Time: The time of day using a 24 hour clock, using typical one (1) second resolution. SOE resolution shall be in milliseconds.

    b. Date: The day of the month, month, and year.

    c. Description: The equipment involved shall be described along with the problem.

    d. Point identification: The specific point name shall be identified

    e. Alarm status: Identify the condition that caused the alarm. Use terms such as HIGH, HIGH-HIGH, LOW, LOW-LOW, ALARM, NORM, OPEN, DEV, etc.

    f. Value: The measured dynamic value shall be used. e.g. IN, OUT, CLOSED, etc.

    g. Engineering units: These shall be specified. e.g. psi, ºF, etc.

    h. Limit: Identify the set point or limit value.

    i. Alarm summary access: A separate historical alarm summary shall be available and accessible to the operator. This summary shall show the alarm messages in the time order that they were received.

Q. Historical Data Storage

1. The DCS will have data historical storage and retrieval capabilities in order to facilitate long-term monitoring of plant equipment and performance. This system shall provide the ability to generate reports and trends of the stored historical data including the following:

   a. Periodic Logging. At hourly intervals analog inputs and integrated pulse inputs shall be printed on the periodic log reports. Alternatively, the hourly logs may be saved until midnight and then printed at one time per day.

   b. Group Review Logging. Selected groups of points may be called up and a printout made on the utility printer.

   c. Sequence of Events Logging.

   d. Historical Trending. Operator selectable analog points in data storage shall be trended over an operator selected time period.

R. Time Synchronization

1. A GPS time synchronization system will be supplied with the DCS. IRIG B signals from this system shall be used to synchronize time in all DCS equipment as well as align other control systems such as the CT control system

2. This will enable historical data and events to be precisely correlated.

S. Diagnostic Functions

1. Diagnostic functions shall be provided to identify faulty or failed equipment. The resulting output of diagnostic functions shall be the identification and documentation of faulty or failed control and monitoring equipment or process equipment to the highest level of detail possible.

2. Maintenance functions shall be provided to identify maintenance requirements, schedule, and provide guidance for all identified plant maintenance activities. The resulting output of maintenance functions shall be the identification and documentation of plant maintenance status, needs, and procedures consistent with the objective of maximum plant availability.

3. The DCS shall include a full set of on-line self-diagnostics using real time measurements. These shall include but not be limited to: hardware card voltages over/under range, A/D converter offset over range, microprocessor stall (failure), memory check sums/parity validation, communication failures, processor loading excessive, and a set of power-up diagnostics.

1.6 PLC and Other Control Systems

A. All BOP systems are controlled and monitored through the DCS unless specifically noted otherwise. Programmable logic controllers (PLC) and other control systems will only be used for the systems and equipment listed below:

1. Air Compressor Control Systems
2. Domestic Water Treatment Control System
3. Industrial Sewage Treatment Control System
4. Auxiliary Boiler Control System
5. Ammonia storage, forwarding and feed systems
6. Continuous Emissions Monitoring System (CEMS)

B. In general, all PLC control systems shall be Allen-Bradley ControlLogix with 1756 series I/O or SLC series control processors with 1746 series I/O. Standalone Equipment such as the Air compressor may utilize Equipment Suppliers standard controller as approved by the Owner/Engineer.

C. Local PC-based operator interface shall be implemented using a Panelmate LCD flat panel display for small systems or Wonderware Intouch HMI software and a Microsoft XP-based operating system.

D. Datalink shall be provided between PLCs and DCS.

1.7 System Controls

A. Load Control

1. The CT controls shall provide adjustments and control functions for:

a. The establishment of desired generation (either manually or by an automatic load control system).

b. The introduction of frequency bias to accommodate the inherent regulation of the turbine governor.

c. The establishment of appropriate maximum and minimum generation limits and maximum rate of change of unit output.

B. Fuel Systems

1. Control of the fuel gas system will be implemented through the DCS and coordinated with the CT control system.

C. Circulating Water System

1. Manual control for the circulating water pumps shall be provided in the control room through DCS. Pump discharge valves shall be interlocked with the pump motors and staged as per pump manufacturer's requirements.

2. Cooling tower fans operation and cooling tower basin level shall also be controlled and monitored through the DCS.

D. Domestic Water Treatment System

1. Control of the water treatment system will be through a PLC-based control system provided by the equipment supplier in a local control panel. A local PC-based operator interface shall be provided with the PLC at the same location.

2. A remote operator interface shall also be provided with the PLC to be incorporated into the control console in the control room.

3. Control of any periodic backflush or regeneration cycles will require local operator control and monitoring.

E. Industrial Sewage Treatment System

1. Control of the industrial water treatment system will be through a PLC-based control system provided by the equipment supplier in a local control panel. A

local PC-based operator interface shall be provided with the PLC at the same location.

2. A remote operator interface shall also be provided with the PLC to be incorporated into the control console in the control room.

F. Auxiliary Boiler

1. Control of the auxiliary boiler control system will be through a PLC-based burner management system provided by the manufacturer with the equipment. A local operator interface shall be provided with the PLC at the same local control panel.

2. A remote operator interface shall also be provided with the PLC to be incorporated into the control console in the control room.

G. Ammonia storage, forwarding and feed systems

1. Control of the ammonia system will be through a PLC-based control system provided by the manufacturer with the equipment. A local operator interface shall be provided with the PLC at the same local control panel.

2. A remote operator interface shall also be provided with the PLC to be incorporated into the control console in the control room.

H. Sump Pump Control

1. Sumps and sump pumps are located throughout the plant. Under Normal operation conditions the controls will be in automatic mode and require no operator action and will be controlled from a local control panel.

1.8 Instrumentation

A. General Instrumentation Design Requirements

1. Analog output signals from field instrumentation to the control systems shall be 4-20 mA DC signals. Instrumentation can be self-powered or loop powered from the control systems. Self-powered analog signals will be true “isolated from ground” signals.

2. All instruments and analyzers will employ RF protection in the system design.

3. Instrument tags will be permanently attached to the devices. If this is not possible, the instrument tag will be fastened to the instrument with stainless steel wire. The wired instrument tag will be supplied as 1 inch by 3 inch, stainless steel instrument tags. Tag thickness is 1/16 inch and stamped with instrument tag number. Tag number characters are 3/8 inch in height.

4. All instrumentation mounted inside, away from direct exposure to the elements, will be as a minimum NEMA 12 construction unless it is in an environmentally controlled environment (e.g., the control room). If the instrument is mounted in an environmentally controlled environment, the instrument will be as a minimum NEMA 1 construction.

5. All instrumentation mounted outside, exposed to the elements, in non-corrosive environments, will be as a minimum NEMA 4 construction.

6. All instrumentation mounted outside, exposed to the elements, in corrosive environments, will be as a minimum NEMA 4X construction.

7. Switches will generally be snap-acting type, DPDT action, with individual “on” and “off” points to be on a calibrated scale or dial. Where switches are not available in DPDT, switches shall be of the snap action type and shall have a minimum of two SPDT contacts unless the application requires types furnished only as SPDT because of deadband requirement. If additional contacts are required, contracts shall be multiplied by relays.

B. Transmitters

1. Transmitters shall be electronic, 2-wire, with isolated 4-20 ma dc output signals and with an appropriate valve manifold to allow on-line calibration.

2. Transmitters will be capable of driving a load up to 600 ohm at 24 VDC, and will be generally powered from the control system I/O cards.

3. Pressure, flow, differential pressure, level, and other miscellaneous transmitters’ accuracy will be within 0.1% of calibrated span.

4. Local LCD indicators shall be provided.

5. Transmitters shall generally be "smart" and shall also communicate via "Hart" communications protocol.

6. The transmitters are needed to interface with the DCS, providing process signals throughout the plant, and shall include the following types:

   a. Pressure transmitters.

   b. Temperature transmitters will typically not be utilized since thermocouples and RTDs shall be read by DCS directly.

   c. Ultrasonic or Radar transmitters will be used to measure level in atmospheric tanks. Differential pressure transmitters will be used in tanks at saturated pressure using a liquid-filled reference leg.

   d. Generally, flow signals shall be transmitted by means of d/p cell transmitters, with square root extraction in the DCS.

7. Gage and absolute pressure transmitters will be supplied with integral mounted two-valve manifolds directly mounted to the transmitter.

8. Differential pressure transmitters (flow, level, dP, etc.,) will be supplied with integral mounted three valve manifolds directly mounted to the transmitter.

C. Switches

1. All level switches shall be of the packless type (i.e., Magnetrol or equal). Contact requirements shall be the same as for pressure and temperature applications.

D. Flow Instrumentation

1. Flow nozzles shall be used, in general, for flow measurements. Consideration shall be given to the use of low-loss flow tubes where unrecovered head loss must be kept at a minimum. Calibrated flow nozzles shall be used for main feedwater or condensate flow.

2. Orifice plates will be used if accuracy requirements are minimized by application. Local indicating rotometers will be as per the instrument list.

3. Flow elements will conform to requirements of ASME 19.5, "Application, Part II of Fluid Meters: Interim Supplement on Instruments and Apparatus."

4. Flow nozzles will be of the weld-in holding ring type ASME long radius, with dual wall taps. Depending on the piping line specification, the nozzle material will either match the piping material or will be made of stainless steel. Metered pipe run and nozzle will match the pipe material and size in which the metered section is to be installed.

5. Orifice plates will be 316 SS, sharp square edge thin plate, paddle type suitable for installation between raised face orifice flanges. Orifice flanges, gaskets, and jacking screws will be furnished by the piping Contractor. Paddle will be stamped with the orifice ID bore diameter on the upstream side. Orifice flanges will be of the raised-face, weld-neck type with dual sets of taps.

6. Complete design data, sizing calculations, installation drawings, and installation procedures will be provided by the supplier with each nozzle and orifice. Beta ratios will generally be between 0.4 and 0.75.

7. Square root extraction shall be performed in the DCS. Transmitters will be configured to provide a local flow indication.

E. Pressure Instrumentation

1. All pressure transmitters will be capable of withstanding their body rating conditions without permanent damage or loss of calibration.

2. Differential pressure transmitters of the force balance low displacement type, regardless of the applied service, will be capable of withstanding a differential pressure equal to full process pressure on either side of the measurement element without damage or loss of calibration. Minimum accuracy will be 0.1% of calibrated span.

3. Local pressure gauges shall have 4-1/2 inch round dials, solid front safety case type with blowout back, 1/2 inch NPT bottom connection, phenol or drawn stainless steel case, with black figures on white face. Bourdon tube types shall be used for pressures of 10 psi and above and bellows for pressures below 10 psi and vacuum service. Movements are to be of nylon and stainless steel except for corrosive service where Monel shall be used. Pigtail syphons are to be used for steam service, snubbers for pulsating flows, chemical seals for acid and caustic service.

4. Pressure test points shall be supplied on all piping to permit pressure determination in the future without removing sensing lines for remote gauges. In general, test points shall be supplied before and after each major piece of equipment which can affect pressure such as pumps, control valves, flow measurement devices, filters, and heat exchangers. All tanks shall have pressure test points.

5. Pressure test points will not be supplied adjacent to pressure gauge or transmitter taps. Test instrumentation can be connected through the two valve manifold of a pressure transmitter or the pressure gauge connection, if necessary.

6. In general, pressure points shall be valved so that local gauges can be isolated without affecting remote equipment.

F. Temperature Instrumentation

1. Temperature measurements for control and monitoring shall be made with RTDs or thermocouples.

2. RTDs furnished by equipment suppliers will be of the dual-element, four-wire type made with 100 ohm platinum resistance elements. The RTDs will be contained in an insulated material and a sheath or sleeve of stainless steel, and will be so mounted that they can withstand the greatest shocks and vibrations that can be imposed upon them in the system piping without deterioration.

3. Thermocouples will be dual element with ungrounded measuring junction, manufactured in accordance with the ISA Standard MC96.1, “Temperature Measurement Thermocouples.” All thermocouples will be Type K. Local cold junctions shall not be used. Cold junctions shall be located at the receiving end with automatic reference junction compensation provided (i.e., at the monitor input cabinets). All thermocouple and low level d-c wiring shall be shielded.

4. Thermocouples will have dual elements and will be of swaged construction. The sheath or sleeve will be spring-loaded to maintain thermal and electrical contact with the bottom of the protecting well. Ungrounded multiple-element thermocouples will have electrically isolated measuring junctions.

5. Bimetallic dial type thermometers with minimum 4-1/2 inch dial, every angle form, hermetically sealed with external recalibration adjustment, 3/8 inch OD SS stem,

1/2 inch NPT connection, and SS case shall be used wherever possible. Where the point of measurement is not easily available for viewing, the filled-bulb type with long capillary tube may be used.

6. All RTDs, thermocouples, thermometers, and remote temperature sensing elements installed in pipelines or ducts shall have thermowells or protection tubes. Temperature elements for surface temperature measurement shall be directly welded directly to the surface.

7. Test thermowells shall be provided to permit testing of systems. Test thermowells and/or thermometers shall be provided before and after each piece of equipment that affects temperature, i.e., large pumps, heat exchangers, and coolers. If local thermometers are provided, test wells may be omitted except for those wells required for performance tests.

8. Thermowells shall generally be tapered type with welded or screwed pipe connection depending on the system. Thermowell lagging extensions shall extend beyond the pipe insulation so insulation will not drop into the thermowell when the temperature element is removed. Test thermowells will be furnished with a plug and chain to seal the thermowell when not in use.

9. An extension nipple or union nipple will be furnished for each thermocouple or RTD assembly. Terminal blocks will be marked with polarity, and connectors will be resistant to heat, vibration, and galling. The cap will provide a weathertight enclosure and a chain will be provided to prevent loss of cap. The cap will be made of cast aluminum.

10. Temperature switches shall normally be avoided and instead a thermocouple will be installed and the setpoint configured in the DCS.

G. Level Instrumentation

1. Ultrasonic or Radar transmitters will be used to measure level in atmospheric tanks, special applications and large tanks. Differential pressure transmitters will be used in tanks at saturated pressure using a liquid-filled reference leg. Guided wave radar level transmitters shall be used in low pressure and vacuum applications where there is a potential for evaporation of the filled leg of a differential pressure level measurement system.

2. All level transmitters shall provide 4-20 mA DC output signals and Hart communications interface. Ultrasonic level transmitters will be 120 VAC powered, with isolated 4-20 mA DC output signals powered from the transmitters.

3. Level instruments for local indication shall be supplied on all tanks. These shall, in general, consist of local magnetic level indicators or gauge glasses with guards to protect glass from breakage. On large tanks, an indicator powered from the level transmitter loop will be provided at grade.

4. Tubular gauge glasses will be used for low-pressure applications. Transparent or reflex gauges will be used for high-pressure applications.

5. All gauge glasses shall be fitted with ballchecks and have means for isolation and flushing (cleaning) glasses. Gauge glass shall not be used where glass breakage cannot be tolerated (such as acid and caustic tanks).

6. Level switches will generally be cage float type, rated for ASME B31.1 requirements. Sump level switches will be float type.

H. Local Control Panels

1. Local control panels will be furnished as complete control systems, including instrumentation and controls piped and wired to headers and terminal blocks. Push buttons and indicating lights will be installed and wired on the control panel for start-up of all motors associated with driven equipment.

2. Large freestanding upright panels will be provided with internal light switch and 120 VAC duplex grounding-type receptacle wired to a junction box to be fed from a separate external circuit. Doors will be the double-swing half type.

3. Voltages in excess of 125 VDC or 120 VAC will be restricted from instrumentation and control systems panels.

4. The color scheme for control/instrument panel indicating lights will be as follows:

   a. Green: Equipment not running/valve closed
   b. Red: Equipment running/valve open
   c. Yellow: Alarm or Tripped

5. Unless otherwise specified, all control switches shall be furnished with contacts rated 10 amperes, 120 volts a-c or 5 amperes, 125 volts d-c, continuously.

6. Alarm contacts will be closed during normal operation and open on fault condition or loss of power.

1.9 Instrument Racks and Enclosures

A. Where instrument access and service conditions permit, close-coupled instrument mounting to process piping with the instrument supported from the pipe tap will be used. This system may be used for pressure transmitters and flow transmitters on orifice flanges. Transmitter valve manifold assemblies shall be welded or screwed into a sockolet or threadolet provided on the pipe or flange. Pressure transmitters shall be furnished complete with an isolation valve and a bleed valve between the isolation valve and the instrument. Differential pressure transmitters shall be furnished complete with two isolation valves and an equalizing valve between the high and low pressure legs after the isolation valves.

B. Close-coupled transmitter mounting shall not be used where dual isolation valves are required or direct access to the instrument cannot be provided.

C. Local instruments that require remote mounting shall be functionally grouped in local panels or transmitter racks rather than individually mounted.

D. Spacing between multiple instruments mounted on the same support will be sufficient to allow ample clearance area in order to perform service, maintenance, calibration, and testing.

E. Indoor racks shall be open structures fabricated from Modular Instrument Support Systems.

F. Terminal blocks shall be 600 volt, front connected, full depth insulating barrier type, with marker strips identifying all internal and external wiring. Terminal blocks shall have at least 20% spare terminals.

G. Wiring for low-level signal transmission (i.e., 4-20 mA, T/Cs and RTDs) shall be twisted pairs or triplets, with shield.

H. Flame resistant insulation shall be used as panel control wiring. Hinge wire shall be extra flexible.

1.10 Instrument Installation

A. General Requirements

1. Instrument process tubing will be designed in accordance with Control System Standard instrument tubing line specifications 150Q-1, Low Pressure Stainless Steel Tubing Line Specification, 250Q-2 High Pressure High Temperature Stainless Steel Line Specification and 250Q-4, High Pressure High Temperature H-grade Stainless Steel Tubing Line Specification. Tubing line specifications utilize Swagelok compression fittings. Design pressure and temperature requirements will determine the appropriate line specification.

2. Instrument air tubing will be designed in accordance with Control System Standard instrument tubing line specification 150Q-1, Low Pressure Stainless Steel Tubing Line Specification.

3. All instruments, process connections, including isolation valves and associated devices, will be located in easily accessible locations for maintenance, calibration, and replacement. All maintenance, calibration, and replacement operations on a given device must be possible without interruption of service to adjacent equipment.

4. Instrument tubing installations will be designed in accordance with ASME B31.1, “Power Piping.”

B. Instrument Sensing Lines

1. Minimum bending radius of instrument sensing line tubing will be three times the tube diameter.

2. Instrument sensing lines will be sloped in their horizontal runs, a minimum of 1/4 inch per foot. In general, liquid and steam lines will slope from their process tap connection down to the instrument. For steam, the line will slope down from the condensate tee to the process connection. In general, gas and non-condensing vapor lines will slope from their process tap connection up to the instrument.

3. Instrument sensing lines will be routed as directly as practical from the process root valve to the instrument. The length of instrument tubing from the root valve to the instrument will be limited to maximum of 40 feet for compressible fluids

and 50 feet for non-compressible fluids. Expansion loops shall be provided to allow for thermal expansion of tubing.

4. Instrument sensing lines will be grouped together as much as practical to benefit from the use of common support members and to present a finished installation that is routed in a neat and orderly manner. Care will be exercised to ensure that spacing between adjacent tubes in the same group is maintained uniform and that tubes do not cross under or over one another at any point. Wherever practical, changes in direction of tubing will be done by the use of tube bends and not tube fittings.

5. A single blowdown valve or double blowdown valves (if the process root valves are doubled) will be installed on the sensing lines of all pressure transmitters that are tapped off liquid or steam process systems. These valves will be located at the instrument and the drains may be headered together. These tapping points shall be equipped with one root valve for design pressures less than 600 psig. For systems with design pressure greater than 600 psig, two root valves shall be utilized.

C. Instrument Air Lines

1. All branch lines from the instrument air line header will be made from the top of the air header and will not be smaller than 1/2 inch. Branch lines will have root valves at the process connections.

D. Instrument Connections

1. Connections for pressure transmitters mounted external to the pipe will be a 3/4 inch sockolet on pipe, mounted on the side of the pipe for liquid and steam lines and on the top for gas applications. On the instrument side of the 3/4 inch root valve, a 3/4 inch SW to 1/2 inch compression fitting will be welded into the root valve by the Piping Contractor.

2. Connections for pressure gauges and switches mounted directly on the pipe will be 3/4 inch sockolet or threadolet according to the piping line specification. Connections will be on the side of the pipe for liquid and steam lines and on the top for gas applications. For sockolet connections, a 3/4 inch plain both ends pipe nipple will be welded into the sockolet, then a 3/4 inch SW root valve, then a 3/4 inch to 1/2 inch reducing insert with a 1/2 inch plain pipe nipple threaded at the top then a 1/2 inch threaded coupling. For threadolet connections, a 3/4 inch

threaded both ends pipe nipple will be threaded into the threadolet, then a 3/4 inch threaded root valve, then a 3/4 inch to 1/2 inch reducing insert with a 1/2 inch threaded pipe nipple threaded at the top then a 1/2 inch threaded coupling. The root valve, reducing insert, and pipe nipple will be installed by the Piping Contractor. (A plain 3/4 inch by threaded 1/2 inch threaded swage may be used in place of the 3/4 inch to 1/2 inch reducing insert with a 1/2 inch plain pipe nipple threaded at the top.)

3. Connections on flow nozzles will be two sets of 3/4 inch socket weld connections mounted on the side of the nozzles. Transmitters for flow nozzles will be mounted external to the nozzles. A 3/4 inch plain both ends pipe nipple and 3/4 inch SW root valve will be installed by the Piping Contractor. On the instrument side of the 3/4 inch root valve, a 3/4 inch SW to 1/2 inch compression fitting will be welded into the root valve by the Piping Contractor. Both sets of taps, including the spare set, will have root valves and the compression fitting installed in the field.

4. Connections on orifice plate flow elements will be through orifice-tapped flanges. Two sets of orifice flange connections will be provided.

5. For installations using 1/2 inch SW taps, 1/2 inch plain both ends pipe nipples from each tap, then 1/2 inch SW root valves, then a 1/2 inch SW to 1/2 inch compression fitting will be shown on the piping isometric drawing and installed by the Piping Contractor. For installations using 1/2 inch threaded taps, 1/2 inch threaded pipe nipples from each tap, then 1/2 inch NPT root valves, then a 1/2 inch NPT to 1/2 inch compression fitting will be shown on the piping isometric drawing and installed by the Piping Contractor. For installations using 3/4 inch taps, 3/4 inch plain both ends pipe nipples from each tap, then 3/4 inch SW root valves, then a 3/4 inch SW to 1/2 inch compression fitting will be shown on the piping isometric drawing and installed by the Piping Contractor. The connections are orientated on the side of the pipe for all applications. If the second set of orifice flange connections is not used, they shall be plugged with plain end plugs.

6. Thermowell immersion length will be between 1/3 and 2/3 the distance to the center of the pipe. Where thermowells are installed in lines smaller than 3 inches, the piping will be expanded to 3 inch size to accommodate the thermowell.

7. Thermowells in high velocity water pipes will have an ASME PTC 19.3 calculation for determination of their resonant frequency. Thermowells that do not meet the acceptance criteria will be resized or relocated as necessary.

8. Thermowells installed in pipes on the high pressure water or gas systems will use a 1-1/2 inch SW sockolet. Thermowells installed in all other systems will use 1 inch SW sockolet or threaded threadolets. Thermowell material for installations in Chrome-Moly alloy pipe shall match the pipe material. All other thermowells shall be 316 SS. Welded thermowells will be installed in the field by the Piping Contractor.

9. Tank level transmitters using DP pressure transmitters mounted external to tanks will be the same as pressure transmitters mounted external to pipe. Tank level transmitters may also be flange mounted to nozzles at the tanks.

10. The tanks that see an operating pressure less than atmospheric will use direct mounted guided wave radar level transmitters. Connections on the tanks will be 1-1/2 inch or 2 inch SW half couplings. These level transmitters will be installed in the field by the Piping Contractor.

11. Magnetic level indicators and water column level gauges will be direct mounted to tanks using 2 inch SW half couplings mounted on the tanks. They will be installed in the field by the Piping Contractor.

12. Radar and Ultrasonic level transmitters will be direct mounted to minimum 6 inch ASME Class 150 flanges on the tops of tanks or wells. Installation of radar or ultrasonic level transmitters will be by the Instrument Installation Contractor.

13. Direct mounted level switches on steam line drip pots will use 1 inch sockolets and 1 inch root valves. Direct mounted level switches will be installed by the Piping Contractor.

1.11 Final Control Elements

A. Control Valves

1. Control valves will be pneumatic or hydraulically operated modulating valves, or pneumatic, hydraulic, or motor-operated on/off service valves.

2. Valve flow coefficient (CV) at rated (normal) operating conditions will not exceed 85% of maximum CV unless stated otherwise on the valve data sheet, and valve will remain above 10% stroke for minimum controllable flow and below 90% stroke for maximum controllable flow.

3. Instrument air shutoff valve and air set, consisting of a combination regulator, filter, pressure gauge, and relief valve, will be provided on each pneumatic control valve assembly.

4. End connections will be socket-weld for 2 inches and under control valve bodies and butt-weld for 2-1/2 inch and over control valve bodies.

5. Valve bodies will be single-port unless otherwise required and will be no less than one-half the line size in which they are installed.

6. Cage guided valves will be used predominantly for steam and water severe service applications where potential for cavitation, flashing, and/or trim noise is present.

7. Valve body material will be as specified in the piping line specifications.

8. All integrally-mounted instrumentation (controllers, positioners, regulators, etc.) will be designed for the stated maximum instrument air supply pressure.

9. Pneumatic actuators shall generally be diaphragm type except where size and operating force require the use of a piston operator. Pneumatic actuators shall be sized to supply the required thrust down to 60 psig instrument air supply pressure.

10. Each control valve shall have a manual operating device or suitable set of manual bypass valves.

11. Electro-pneumatic positioners will be integrally mounted to the control valves. All positioners will be of the digital type and support Hart communication for setup, calibration, and diagnostic functions.

12. The failure position of each valve will be selected based on the service to fail either open (FO), closed (FC), or locked in current position (FL) in event of loss of signal or loss of motive power.

13. In general, limit switches, override solenoids and position transmitters will not be required for modulating control valves.

14. Pilot solenoid valves for on-off service control valves will be designed for 120 VAC with a minimum orifice size of 1/4 inch.

15. Control valve body size shall generally not be less than one standard size smaller than line size for 10 inch and smaller piping systems. In piping systems 12 inches and larger, control valve body size shall generally not be more than two standard sizes smaller than line size. Minimum body size shall be one inch nominal with reduced trim as applicable, except that body size will not exceed line size.

16. All valve position indicators will read 0 percent with valve fully closed and 100 percent with valves fully open with intermediate marking.

B. Control Drives

1. Control drives shall be either of the electric, pneumatic, or hydraulic type suitable for the service conditions.

2. Electric control drives are preferred for modulating service where torque rating exceeds 1000 lb/ft.

3. Instrument air shutoff valve and air set, consisting of a combination regulator, filter, pressure gauge, and relief valve, will be provided on each pneumatic control drive assembly.

4. Generally, all modulating control drives shall fail in position, however, each drive application shall be investigated individually for failure position requirements.

5. All control drives shall be equipped with handwheels or other devices for local operation by one man without disconnecting linkage.

6. All modulating control drives shall include a position transmitter to provide feedback to the DCS. Open and closed limit switches with a minimum of two (2) form C (SPDT) dry contacts shall be provided for all on-off service control drives.

7. Drive housings shall be weatherproof and have heaters where required.

8. Piston type operators are preferred for all pneumatic control drive operators. Operators shall be suitable for outdoor installations. All drives shall operate properly and provide the required shutoff at a supply pressure of 60 psig.

9. Modulating pneumatic control drives shall include integral positioners. Positioners shall be smart electronic type with HART communications capability.

10. An air shut-off valve, filter-regulator, and position transmitter shall be provided for pneumatic control drives with positioners

11. Current to pneumatic converters shall be provided for positioning all control drives provided without positioners.

12. Pneumatic control drives for on-off operation shall include a 120 VAC three-way solenoid valve and open and closed limit switches.

13. Electric control drives for on-off operation shall include integral reversing starter, local control station and terminals for remote control and drive position indication connections. The local control station shall include LOCAL/REMOTE control switch and OPEN, CLOSE, and STOP push buttons. Remote OPEN and CLOSE control commands shall not be sealed in at the drive. An auxiliary dry contact indicating drive available for remote control shall be provided.

1.12 Continuous Emissions Monitoring System (CEMS)

A. A continuous emissions monitoring system (CEMS) will be provided to monitor the gaseous emission levels of regulated constituents. CEMS sample probes will be located in the stack and the CEMS will be located in a building at the base of the stack. This system will be a highly reliable extractive-type design and will record, trend, alarm, and report through the DCS in order to keep the plant operator properly informed.

B. The CEMS will monitor NOx, O2 and CO2. The system will be in compliance with all applicable regulations and the approved Air Permit for the project

C. The CEMS will consist of a sample, hose and sample extraction/conditioning systems, rack mounted analyzers, CEMS equipment enclosure, and a data acquisition and reporting system. The probe will continuously extract a sample for analysis.

D. The system will be designed to permit calibration of analyzers without disconnection of equipment from the process while the unit is in service. The CEMS will provide for

manual/automatic zero and span calibration checks using EPA approved techniques and provide manual/automatic calibration, measure, and record of zero and span drift correction. The system will be designed to allow calibration checks with the system on line.

E. The sample system will be the extractive type. A single microprocessor-based sampling controller will control purge air, calibration gases, sample gases, and direct gases to proper devices for all modes of operation. The controller will receive the raw signals from the analyzer and convert the raw values into the required permit values.

F. The analyzers and sample controller will be located in an enclosure at the base of the stack to minimize the length of sample runs. The enclosure will be heated and air conditioned and have space for maintenance. The calibration gas bottles will be mounted in a rack outside of the enclosure.

G. The data acquisition and reporting system will be a PC based system with both local and control room operator interface. The PC will retrieve data from the sampling controller, format the data for report generation, print reports, store the data for archival purposes, generate alarms, record the reason codes for noncompliant periods, perform other data manipulation tasks such as daily averages, rolling averages, high/low daily value.

H. Each analyzer shall provide measured values and analyzed data for DCS input.

I. The equipment shall have the highest availability and operation-proved reliability. No first generation equipment shall be utilized.

1.13 Vibration Monitoring System

A. A vibration monitoring and analysis system will be provided for the CT.

B. All vibration monitors will be provided by the rotating equipment Contractor mounted in racks within cabinets located near the associated rotating equipment.

C. A vibration analysis computer will be provided with the CT. Communication links will be installed from all monitoring racks to the vibration analysis computer.

D. Vibration monitoring will be provided for the following devices but will not include a complete vibration monitoring rack:

1. Circulating Water Pumps (2)

2. Air Compressors (2)

WorleyParsons
resources & energy

EcoNomics™

NEW YORK STATE ELECTRIC & GAS

STRUCTURAL ENGINEERING
Design Criteria

Document: CAES-1-DB-024-0001

Revision B

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COMPRESSED AIR ENERGY STORAGE PROJECT
STRUCTURAL ENGINEERING
DESIGN CRITERIA

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PROJECT - EPF-0003 STRUCTURAL ENGINEERING

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1.0 STRUCTURAL ENGINEERING DESIGN CRITERIA

1.1 Purpose

This Section establishes criteria for the design, fabrication and installation of materials used in the structural and pipe stress/support work for the NYSEG CAES Project.

1.2 Codes and Standards

The following Codes and Standards will apply to the structural engineering, pipe stress/support engineering, and design work performed on the project. Unless noted otherwise, the edition and published addenda in effect on the date of Contract Award will apply to the work.

In the event of any conflicts between codes, or between specifications and codes, the more stringent regulation will apply.

1. American Concrete Institute (ACI):

    a. ACI 117 - Specification for Tolerances for Concrete Construction and Materials.

    b. ACI 207.2R – Effect of Restraint, Volume Change, and Reinforcement on Cracking of Mass Concrete.

    c. ACI 301 – Specifications for Structural Concrete.

    d. ACI 318 – Building Code Requirements for Structural Concrete.

    e. ACI 347 – Guide to Formwork for Concrete.

    f. ACI 350 – Code Requirements for Environmental Engineering Concrete Structures.

    g. ACI 351.3R – Foundations for Dynamic Equipment.

    h. ACI 360R – Guide to Design of Slabs-on-Ground.

    i. ACI 530 – Building Code Requirements for Masonry Structures.

    j. ACI 530.1 – Specification for Masonry Structures.

2. American Institute of Steel Construction (AISC):

    a. Steel Construction Manual – 13th Edition.

    b. AISC 303 – Code of Standard Practice for Steel Buildings and Bridges.

    c. AISC 341 – Seismic Provisions for Structural Steel Buildings.

    d. AISC 360 – Specification for Structural Steel Buildings.

3. American Iron and Steel Institute (AISI):

    a. SG02-1, “North American Specification for the Design of Cold-Formed Steel Structural Members.”

4. American Petroleum Institute (API):

    a. API STD 650-07 (11th Edition, with Addendum 1 & 2) - Welded Steel Tanks for Oil Storage.

5. American Society of Civil Engineers (ASCE):

    a. 7-05 - Minimum Design Loads for Buildings and Other Structures.

    b. Design of Large Steam Turbine-Generator Foundations, 1987

    c. 37-02 - Design Loads on Structures During Construction (SEI/ASCE Standard).

6. American Society of Mechanical Engineers (ASME):

    a. A17.1 – Safety Code for Elevators and Escalators.

    b. B31.1 – Power Piping Code.

7. American Society of Safety Engineers (ASSE):

    a. ASSE/ANSI A10.4 - Safety Requirements for Personnel Hoists and Employee Elevators.

8. ASTM International (ASTM):

a. See appropriate technical specification for specific references of ASTM Standards for materials used.

9. American Water Works Association (AWWA):

a. D100 – Welded Carbon Steel Tanks for Water Storage.

10. American Welding Society (AWS):

a. D1.1 – Structural Welding Code – Steel.

b. D1.3 – Structural Welding Code – Sheet Steel.

11. Concrete Reinforcing Steel Institute (CRSI):

a. MSP-2 – Manual of Standard Practice.

12. International Code Council, Inc. (ICC):

a. IBC 2006 – International Building Code 2006 as adopted by the 2010 Building Code of New York State with associated amendments.

13. Manufacturers Standard Society of the Valve and Fitting Industry (MSS):

a. SP 58 – Pipe Hangers and Supports – Materials, Design, and Manufacture.

b. SP 69 – Pipe Hangers and Supports – Selection and Application.

c. SP 77 – Guidelines for Pipe Support Contractual Relationships.

d. SP 89 – Fabrication and Installation Practices.

e. SP 90 – Guidelines on Terminology.

14. National Association of Architectural Metals Manufacturers (NAAMM):

a. MBG 531– Metal Bar Grating Manual.

b. MBG 532 – Heavy Duty Metal Bar Grating Manual.

15. National Fire Protection Association (NFPA):

a. NFPA 850 – Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations, 2005 Edition

16. Precast/Prestressed Concrete Institute (PCI):

a. MNL-116 – Manual for quality Control for Plants and Production of Precast and Prestressed Concrete Products.

17. Research Council on Structural Connections (RCSC):

a. Specification for Structural Joints Using ASTM A 325 or A490 Bolts.

18. The Society for Protective Coatings (SSPC):

a. PA-1 – Shop, Field, and Maintenance Painting.

b. SP-1 – Solvent Cleaning.

c. SP-2 – Hand Tool Cleaning.

d. SP-3 – Power Tool Cleaning.

e. SP-5 – Metal Blast Cleaning.

f. SP-6 – Commercial Blast Cleaning.

g. SP-7 – Brush-off Blast Cleaning.

h. SP-10 – Near White Blast Cleaning.

i. SP-11 – Power-Tool Cleaning to Bare Metal.

19. Steel Deck Institute (SDI):

a. SDI 30, Design Manual for Composite Decks, Form Decks and Roof Decks.

b. SDI MOC1, Manual of Construction with Steel Deck.

20. U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), 29 CFR

a. Part 1910 - Occupational Safety and Health Standards.

b. Part 1926 – Safety and Health Regulations for Construction.

1.2.1 References

1. Geotechnical Report for the NYSEG CAES Project (CAES-1-LI-024-001).

1.3 Materials

1.3.1 Structural Steel, Steel Plate, and Accessories

1. Materials:

   See CAES project technical specifications (TS) for specific references of Standards for materials used.

   a. Structural steel wide flange shapes and sections cut from wide flange shapes: ASTM A 992.

   b. Structural steel channels, angles and plates for general use: ASTM A 36.

   c. Structural steel channels, angles of high strength material: ASTM A 529, Grade 50 or ASTM A 572, Grade 50.

   d. Structural plate, high strength material: ASTM A 572, Grade 50.

   e. Rectangular tubing: ASTM A 500, Grade B.

   f. Steel pipe for columns: ASTM A 53, Grade B, Type S.

   g. High-strength bolts (3/4” diameter and larger): ASTM A 325, Type 1 mechanically galvanized per ASTM A 563 and lubricated.

   h. High-strength bolts (up to 5/8” diameter): ASTM A 449 mechanically galvanized and lubricated.

   i. Nuts for use with high-strength and plain bolts: ASTM A 563, heavy hex, Grade DH Mechanically galvanized and lubricated.

   j. Washers: ASTM F 436, mechanically galvanized.

k. Direct tension indicator washers: ASTM F959.

l. Filler plates and shim plates:

1) 3/16-inch or less in thickness: ASTM A 1011, Grade 36.

2) Greater than 3/16-inch in thickness: ASTM A 36.

m. Steel studs: Section 7 of AWS D1.1.

n. Generation Building Crane rails and accessories:

1) Crane rails: ASTM A 759.

2) Joint bars: ASTM A 49.

3) Joint bar bolts: ASTM A 325, Type 1.

4) Pressed or forged steel used for rail clamps and filler plates.

5) High strength bolts for attachment of rails to top flanges of support girders: ASTM A 325, Type 1.

o. Welding electrodes and filler metal:

1) Carbon and alloy steels: AWS D1.1, Table 3.1 for type of steel. Low hydrogen type, 70 ksi, minimum tensile strength.

p. Expansion Bearing Assemblies: CON-SLIDE, Type CHP high load expansion bearings as manufactured by CON-SERV Inc. or equal.

1.3.2 Miscellaneous Metals and Accessories

1. Grating, stair treads and accessories, checkered steel floor plate, and grating assemblies:

a. Materials:

1) Grating, banding, stair treads: ASTM A 1011 Commercial Steel (Type 2).

2) Checkered steel floor plate: ASTM A 36 (or equivalent) with regular raised pattern, galvanized.

3) Toe plate: ASTM A 36 (or equivalent).

4) Saddle clips: ASTM A 653, galvanized.

5) Welded studs: ¼-inch diameter, stainless steel conforming to ASTM A 276, Type 304. Nuts for use with studs, cadmium plated conforming to ASTM A 563.

6) Bolts and nuts for connecting stair treads to stair stringers: 3/8-inch bolts conforming to ASTM A 307 and nuts conforming to ASTM A 563. Bolts and nuts galvanized.

b. Construction:

1) Grating: Welded type, 3/16-inch thick bearing bars X depth to suit loading spaced at 1-3/16 inches center-to center. Crossbars spaced at 4 inches center-to-center. Serrated top for outdoor applications. Use “EPI GRATE CLAMP” saddle clip fasteners or approved equal.

2) Stair treads: Welded type, 1 inch x 3/16-inch bearing bars, 3/16-inch cross bars with cast aluminum checkered plate nosing, (Wooster Type 120 Alumogrit or approved equal). Plain top surface with galvanized finish for level platforms and walkways. Serrated top surface with galvanized finish for sloped conveyor gallery walkways.

3) Banding: Grating panels banded at openings for equipment and piping penetrations. Banding bars 1/4-inch thick.

4) Checkered steel floor plate and grating assemblies to consist of 1-inch deep grating welded to ¼-inch thick checkered floor plate. Checkered plate connected to grating panels with 3/16-inch fillet welds, 1-1/2 inches long, spaced at 1’-0” centers along all panel edges and at 1’-6” centers interior to the panel edges.

5) Toeplate: 1/4-inch plate extending 4 inches above top of floor line.

2. Guardrail system per OSHA design criteria:

a. Materials:

1) Top rails and mid-rails: ASTM A 53, Grade B, Type E or S; or ASTM A 501, 1-1/2-inch standard (schedule 40) pipe.

2) Posts: ASTM A 53, Grade B, Type E or S; or ASTM A 501, 1-1/2-inch schedule 80 pipe.

b. Construction: Welded continuous construction. Two-rail system with top rail 3'-6" above finished floor and mid-rail 1'-9" above finished floor. Posts spaced not more than 8'-0" center-to-center, bolted or welded to supporting steel.

3. Stairs: Channel sections conforming to ASTM A 36. Minimum size channel section used for stringers, C10 x 15.3.

4. Girt systems: Channel sections conforming to ASTM A 36 or wide flange sections conforming to ASTM A 36, ASTM A 572, Grade 50, or ASTM A 992. Sag rods ¾-inch diameter conforming to ASTM A 36.

5. Metal form deck for concrete floors and roofs: ASTM A 653, SS, Grade 80, minimum yield strength of 80 ksi, with G 60 galvanized coating.

a. Non-composite form deck used as permanent forms for elevated concrete floors and roofs having a thickness of 4 to 6 inches:

1) Metal thickness: Minimum 20 gage (0.0358 inches).

2) Flute height: 1-5/16 inches.

3) Flute sides: Plain vertical face or ribbed.

b. Non-composite form deck used as permanent forms for elevated concrete floors having a thickness of 8 inches:

1) Metal thickness: Minimum 18 gage (0.045 inches).

2) Flute height: 2 inches.

3) Flute sides: Plain vertical face or ribbed.

6. Metal deck for roofs (engineering building):

20 gauge minimum, metal coated steel, ASTM A 446, Grade A; hot-dip galvanized in accordance with ASTM A 525, designation G90, before forming; prefabricated side lap units; 1-1/2 inch depth minimum.

7. Metal deck for roofs (pre-engineered building):

   22 gauge minimum, metal coated steel, ASTM A 792 SQ, Grade 50B; with AZ55 coating, before forming; prefabricated T shaped vertical seam side joint; 2 depth minimum.

1.3.3 Pipe Supports

1. Materials for pipe support assemblies and components will be in accordance with ASTM Specifications, the requirements of ASME B31.1, and Manufacturers Standardization Society recommendations for materials, design, and manufacture of pipe hangers and supports (publication SP 58).

2. The following anchoring systems or Engineer-approved equal will be provided for attachments of pipe support assemblies and supplemental steel framing to concrete and masonry structures:

   a. Hilti HDA Undercut Anchoring System.

   b. Hilti HIT-RE-500-SD Adhesive Anchoring System.

   c. Hilti Kwik Bolt TZ Carbon and Stainless Steel Anchors

1.3.4 Concrete Mixes

1. Concrete strength, psi (at 28 days):

Foundations, Piers, Pedestals, Walls, Grade Slabs, Elevated Slabs, Topping Slabs	4,000 psi
Massive Concrete (Minimum dimension of more than 48 inches)	4,000 psi
Water Containing Structures	5,000 psi
Electrical Underground Ductbanks	2,000 psi
Subgrade Mud Mats where required (4 inches thick	2,000 psi

below all mat foundations, footings, and grade beams where specified on drawings), Lean Fill

1.3.5 Concrete, Reinforcing and Concrete Appliances

1. Cement: Portland Cement, ASTM C 150, Type I, II, or V.

2. Fine Aggregates: ASTM C 33. Minimum specific gravity of 2.55 (saturated dry surface basis), ASTM C 128.

3. Coarse Aggregates: ASTM C 33. Specific gravity of 2.6 (saturated dry surface basis) and maximum absorption of 1.5 percent, ASTM C 127.

4. Admixtures:

   a. Air entraining admixture: ASTM C 260. Concrete mix designs developed for foundation, pier, wall, and slab construction, and underground duct banks and manholes to include entrained air in amounts varying from 4.0 percent to 6.0 percent. Concrete mixes for fill concrete will not have entrained air.

   b. Water reducing admixtures: ASTM C 494. Slump limited to 4 inches for concrete with Type A admixture. Slump for mixes using a high range water reducing admixture (superplasticizer) conforming to ASTM C 494, Type F limited to 8 inches.

5. Water: ASTM C 94, Table 1.

6. Maximum temperature of concrete at delivery:

   a. Mass concrete: 80 degrees F per ACI 301 for concrete between 4 to 8 feet in thickness. 70 degrees F per ACI 301 for concrete greater than 8 feet in thickness.

   b. All other concrete: 90 degrees F per ACI 301.

7. Fly Ash: ASTM C 618, Class C or F.

   a. Required weight of fly ash as a percentage of total weight of cementitious material in concrete mix designs:

Placement Type	Minimum	Maximum
Mix designs for mass concrete	15 %	25 %
Mix designs for all other concrete work	15%	20%

8. Liquid membrane curing compounds: ASTM C 309 R, Type 1.

9. Waterstops:

   a. PVC Waterstop Material: dumb bell or serrated center bulb type, polyvinyl chloride, in accordance with CRD-C572.

   b. TPE-R Chemical Resistant Waterstop Material: dumb bell or serrated center bulb type, thermoplastic elastomeric rubber, in accordance with ASTM D 471.

   c. Impervious Laminate Waterstop Material: Parastop II as manufactured by Tremco.

10. Expansion joints:

   a. Filler: ASTM D 1751 or ASTM D 1752 Type II as indicated on the drawings.

   b. Sealer: ASTM C 920, compatible with filler. Sealer will be a multi-component elastomeric joint sealant.

11. Control joints: Saw-cut control joints will be filled with a two-component flexible control joint resin.

12. Reinforcing steel and accessories:

   a. Deformed bars: ASTM A 615, Grade 60.

   b. Bar supports: Class 3, CRSI Manual of Standard Practice, Chapter 3.

   c. Tie wire: Minimum #16 gage black, soft annealed wire.

   d. Bar-to-bar filler metal splice sleeves (cadwelds): ASTM A 513 or A519.

   e. Swaged bar-to-bar splices: ASTM A 108, ASTM A 519, or ASTM A 576.

f. Taper threaded bar-to-bar splices: ASTM A 576.

13. Anchor assemblies and embedded items:

a. All anchors and other embedded items, not requiring chemical resistance, shall be hot-dipped galvanized.

b. Anchors and embedments in the cooling tower area, water treatment area, chemical feed area, chemical unloading area, chemical spill containment areas, and other areas subject to chemical attack or continuous submergence shall be Type 316 stainless steel or engineer approved equal.

c. Anchor assemblies: ASTM F1554, Grade 36, Grade 55 (weldable), or Grade 105.

d. Nuts: ASTM A 563, heavy hex, Grade DH.

e. Washers: Hardened Steel ASTM F 436, or ASTM A 36 fabricated plate washers.

1.3.6 Masonry

1. Concrete block building structures and walls shall be concrete block meeting the following requirements: ASTM C 90, Grade N,,except compression strength shall be 2,000 psi minimum, 8 inch x 16 inch, steam-cured; sand, gravel, or crushed stone aggregates conforming to ASTM C 33; moisture controlled for linear shrinkage of 0.03% or less.

1.3.7 Non-shrink Grout

1. Non-shrink cementitious grout will be used under column base plates and equipment soleplates. The grout will be a Portland cement based pre-packaged mix requiring only the addition of water, and conforming to the requirements of ASTM C 1107, Grades B or C and CRD-C 621.

1.4 Site Design Conditions

1. Frost Depth — 48 inches

2. Site Elevation (approx. finish grade in Power block area) — 340 ft AMSL

1.5 Design Loads

1. The design loads and load combinations described or referenced herein will be the minimum used for the design of structures and foundations for the Kleen Energy Systems Project.

1.5.1 Dead Load

1. Includes all permanent gravity loads due to self-weight of the structure and weight of permanent equipment, tanks, vessels, piping and cable tray.

2. The contents of equipment, tanks, vessels and piping including fluids will be considered as dead load in the design of structures and foundations. The effects of both full and empty conditions will be considered in gravity load combinations.

3. The dead load of electrical raceways, lighting and mechanical systems, and miscellaneous piping suspended from floors and roofs in plant buildings and structures will be accounted for and labeled as uniformly distributed hung loads on the design drawings.

1.5.2 Building/Structure Live Loads

1. General:

    a. Live loads are those produced by the use and occupancy of the structure. Included in this category are floor, platform, walkway, stairway, roof live loads and temporary and/or operating loads from equipment within buildings and structures.

2. Ground floor loads:

    a. Ground floor slabs will be designed for a minimum of 350 psf or HS-20-44 truck load in the power block area and all other areas where a 5-ton forklift can operate. Consideration will be given to designing appropriate areas of the ground floor for support of heavy construction equipment.

    b. Ground floor slabs for shops and auxiliary buildings will be designed for 150 psf. Storage areas will be designed for the actual weight of the stored material, but no less than 150 psf.

3. Elevated platform, walkway, and stairway loads:

a. Unless otherwise required by function or by special purpose, platforms, walkways and stairways covered with metal grating or metal panels consisting of grating and checkered floor plate will be designed for a uniform live load of 125 psf and grating will be designed for a live load of 150 psf.

4. Elevated concrete floor live loads:

a. Turbine building:

Floor Level	Live Load (psf)
Mezzanine Floor	150
Operating Floor	500[1]

1 – Laydown loads – The floor area will be designed for a laydown load of (later) area placed directly over any floor beam with no additional laydown loads within 3 ft. of the periphery.

b. Elevated slabs will be designed for a live load of 125 psf unless specific higher loads are specified for equipments maintenance and laydown from equipment manufacturers.

5. Roofs:

a. Roofs will be designed for snow and ice loads or for a minimum live load of 30 psf, whichever is greater. In addition, roofs will be designed with the capability to support a concentrated load of 300 pounds placed anywhere on the roof.

b. The turbine building roof will be evaluated for the accumulation of rain water in accordance with the provisions of Section 1611 in IBC 2006.

c. All roofs will be designed considering the effects of uplift from wind.

6. Reduction in live loads:

a. The provisions of Section 1607.9.1 in IBC 2006 will be used when considering live load reduction in the design of structures supporting floors, platforms, and walkways.

1.5.3 Crane, Hoist, and Elevator Loads

1. Crane loads will be applied in accordance with Sections 1607.12 IBC 2006 plus the following:

Vertical	Maximum wheel loads plus 25 percent for impact
Horizontal (longitudinal)	10 percent of maximum wheel loads in either direction at top of each runway rail
Horizontal (lateral)	20 percent of sum of the lifted load capacity and trolley weight applied in either direction to the top of the rails. Distribution to each rail will be made with due regard for lateral stiffness of the structure supporting the rails.

2. Hoist loads:

Vertical	Design capacity plus weight of hoist and trolley, if any, plus 15 percent of total for impact.
Horizontal (longitudinal)	10 percent of maximum wheel loads in either direction at top of each runway rail
Horizontal (lateral)	20 percent of sum of the lifted load capacity and trolley weight applied in either direction to the top of the rails.

3. Elevator loads:

Vertical	Design capacity plus weight of cab and appurtenances plus 100 percent of total for impact.

1.5.4 Impact Loads

1. Impact loads will be added to applied loads to account for the dynamic effects associated with operation of equipment or application of live loads to structures. The following impact loads will be used, unless analysis indicates using higher or lower values.

   a. Cranes, hoists, and elevators – Refer to Section 1.5.3.

   b. Rotating and reciprocating equipment – 50 percent of the machine weight (except for Air Expander foundation design) when operating loads are not provided by the vendor.

   c. Elevator machinery – Refer to Section 1.5.3.

   d. Hangers supporting floors and platforms – 33 percent of the sum of the dead and live load.

   e. Rigid pavement design for roadways – 20 percent of the wheel or crawler loads.

1.5.5 Equipment Loads

1. Equipment loads will be specifically determined and located. For major equipment, structural members and bases will be specifically located and designed to carry the equipment load into the structural system. Equipment loads will be noted in the design calculations to permit separation in calculation of uplift and stability.

2. Live loading in areas reserved for equipment laydown during maintenance operations will be increased, if necessary, to meet the capacity requirements for the parts and pieces of equipment to be supported.

3. Equipment dynamic loads shall be considered and applied in accordance with the manufacturer's specifications, criteria, or recommendations, and industry standards, including ACI 351. Rotating parts shall be considered as a vibrating mass.

1.5.6 Pipe Hanger Loads

1. Pipe hanger loads for the major piping systems will be specifically determined and located. Loads imposed on perimeter beams around pipe chase areas will also be considered on an individual basis.

1.5.7 Thermal Loads

1. Thermal load includes self-straining forces and effects arising from contraction or expansion from temperature changes, shrinkage, and moisture changes.

2. Steel structures will be designed with the capability to withstand forces due to thermal loads. Horizontal slots for connections in shear, slide bearing plates for seated connections, and expansion joints in building siding and roofing systems will be used to minimize forces resulting from thermal loads.

3. Concrete sections (walls and slabs) will be reinforced to accommodate stresses resulting from long-term temperature differential at opposite faces.

1.5.8 Snow Loads

1. Snow loads for buildings and structures will be computed using IBC 2006 and ASCE 7-05.

2. Parameters and coefficients from Site Specific Data Sheets, IBC 2006 and Chapter 7 of ASCE 7-05:

Ground Snow Load, p_g (IBC 2006, Figure 1608.2)	35 psf
Exposure Category (IBC 2006, Section 1609.4)	C
Exposure Factor C_e (ASCE 7-05, Table 7-2)	1.0
Occupancy Category of Building and Structures (IBC 2006, Table 1604.5)	III
Importance Factor, I (ASCE 7-05, Table 7-4)	1.1

3. Snow loads for flat roof will be developed in accordance with Section 7.3 of ASCE 7-05.

4. Snow loads for sloped roof will be developed in accordance with Section 7.4 of ASCE 7-05.

5. Snow Partial Loading, Unbalanced Snow Loads, Snow Drift & Sliding & Snow Ponding Instability have to be considered (if applicable) in accordance with Section 7.5 ~ 7.11 of ASCE 7-05.

1.5.9 Ice Loads

1. Ice loads for ice-sensitive open structures (such as truss tower, catwalks, platforms, flagpoles & signs) will be computed using ASCE 7-05. Parameters and coefficients are used in accordance with Chapter 10 of ASCE 7-05.

1.5.10 Wind Loads

1. Wind loads for buildings and structures will be computed using IBC 2006 and ASCE 7-05.

2. Parameters and coefficients from Site Specific Data Sheets, IBC 2006 and Chapter 6 of ASCE 7-05:

Basic Wind Speed, V (IBC 2006, Figure 1609)	90 mph
Exposure Category (IBC 2006, Section 1609.4)	C
Occupancy Category of Buildings and Structures (IBC 2006, Table 1604.5)	III
Importance Factor, I (ASCE 7-05, Table 6-1)	1.15

3. General Procedures:

   a. In general, the Analytical Procedure will be used for wind load calculation in accordance with Section 6.5 of ASCE 7-05.

   b. Wind gust effect factor will be determined in accordance with Section 6.5.8 of ASCE 7-05.

   c. An enclosure classification will be determined in accordance with Section 6.5.9 of ASCE 7-05.

      Topographic effects will be determined in accordance with Section 6.5.7 of ASCE 7-05.

      Per ASCE 7-05 section 6.5.7.1, the CAES site does not meet the criteria for Wind Speed-up over Hills, Ridges and Escarpments. Therefore, the topographic effects does not apply to the wind load calculation (K_{zt} = 1.0).

Topographic Picture of job site for CAES



d. Wind load calculation procedure will be developed in accordance with Section 6.5.3 of ASCE 7-05.

e. Wind loads for enclosed and partially enclosed buildings will be developed in accordance with Section 6.5.12 of ASCE 7-05.

f. Wind loads for open buildings with monoslope, pitched, or troughed roofs will be developed in accordance with Section 6.5.13 of ASCE 7-05.

g. Wind loads for solid freestanding walls and solid signs will be developed in accordance with Section 6.5.14 of ASCE 7-05.

h. Wind loads for other structures will be developed in accordance with Section 6.5.15 of ASCE 7-05.

1.5.11 Seismic Loads

1. Seismic loads for buildings and structures will be computed using IBC 2006.

Site Class (IBC 2006 Table 1613.5.2)	C
Mapped Spectral Response Acceleration, short period (IBC 2006 Figure 1613.5(1))	S_S = 0.162g
Mapped Spectral Response Acceleration, 1 second period (IBC 2006 Figure 1613.5(2))	S_1 = 0.054g
Seismic Design Category (IBC 2006 Table 1613.5.6(1) & Table 1613.5.6(2))	A
Occupancy Category of Building and Structures (IBC 2006 Table 1604.5)	III
Importance Factor, I (ASCE 7-05 Table 11.5-1)	1.25

2. General Procedures (For Buildings)

   a. Seismic loads for building structures will be developed in accordance with the requirements in section 1.4 Site Design Conditions and the provisions of Section 1613 of IBC 2006.

3. General Procedures (For Non-Building Structures)

   a. Seismic loads for non-building structures similar to buildings, non-building structures not similar to buildings, and non-building structures supported by other structures with weight of the non-building structure 25 percent or more of the combined weight of the non-building structure and supported structure will be developed using the procedures in Chapter 15 of ASCE 7-05. Seismic loads for the combustion air and flue gas ductwork and their support structures will be determined in accordance with these criteria.

   b. Seismic loads for mechanical and electrical equipment supported by buildings and structures will be developed in accordance with Chapter 13 of ASCE 7-05.

   c. Seismic loads for architectural components or systems will be developed in accordance with Chapter 13 of ASCE 7-05.

d. Seismic loads for the absorber vessel and other process tanks will be developed in accordance with Appendix E of API 650.

1.5.12 Soil Loads

1. Earth Pressure Parameters will be as specified in Section LATER of the Project Geotechnical Report.

2. The earth pressure on walls during an earthquake will be characterized for design as a transient load increasing uniformly from the base to the top of the wall (inverted triangle). The magnitude of the load will be provided as part the foundation design recommendations in the project geotechnical report.

3. The water table is generally follows the rock contours at this site and localized dewatering can be expected at excavations below elevations of 30 feet.

4. Surcharge loading from adjacent structures will be determined by the project geotechnical engineer. For walls not adjacent to other structures, a uniform surcharge load of 300 psf will be used.

1.5.13 Differential Settlement

1. The effects of differential settlement will be considered in the design of all structures and foundations. Flexible or sliding connections will be used judiciously between adjoining structures to mitigate the effects of differential settlement if required.

1.5.14 Hydraulic Loads

1. Pressurized circulating water, service water, and makeup systems will be designed to a static pressure equal to the shutoff head of the pumps plus static head where applicable. No compensating external loading will be considered.

2. A transient analysis will be made of any piping run of significant length and resulting surge loading will be considered in the pipe design.

3. Pipe and/or tunnel walls will be analyzed for competence against external forces due to soil and surcharge loading with zero internal pressure or vacuum if applicable.

1.5.15 Vehicle Loads

1. HS20-44 loading will be used for roadway design and for surcharge loading over buried piping, culverts, and embankments. Where appropriate, loads from crawler cranes and heavy equipment transport vehicles will be evaluated.

2. Floors in all buildings where warehousing or storage provisions are present will be designed for loads transmitted by a fork lift truck having a material loaded weight of 2,000 pounds on elevated floors or 10,000 pounds on ground floor plus dead load of the fork lift truck.

1.5.16 Construction Loads

1. Structures and foundations will be designed for temporary erection and rigging loads during construction. Structures will include redundancy in the design as required to accommodate leave-out of permanent steel framing during the installation of equipment.

1.5.17 Loading Combinations

1. Combining Nominal Loads Using Allowable Stress Design

    a. Allowable strength design may be used in the design of steel structures. The provisions of Section 2.4 of ASCE 7-05 will be the basis for developing load combinations. The provisions of Design Requirements of Section B3.4 of AISC 360-05 will be the basis for steel structural design.

    b. Allowable stress design will be used in determination of load bearing and stability requirements for foundations and structural serviceability design. The provisions of Section 2.4 of ASCE 7-05 will be the basis for developing load combinations.

    c. Allowable strength for individual members in steel structures will be increased one-third (use Ω/1.33) when subjected to temporary construction or equipment startup loading conditions.

    d. Allowable strength for individual members in steel structures will be increased one-half (use Ω/1.5 but not greater than 0.9 Rn) when subjected to transient load conditions due to failure in mechanical or electrical systems; or when subjected to transient steam and water hammer loads from high energy piping systems. Allowable stresses will be increased when loads from these sources

act alone or when combined with other vertical and horizontal loads. Earthquake load will not be combined with transient loads.

e. ASD load combinations for Dead (D), Live (L or L_r), Snow or Ice (S), Rain (R), Fluid (F), Earth Pressure (H) and Wind (W):

D + F	IBC 2006, Eq. 16-8
D + H + F + L + T	IBC 2006, Eq. 16-9
D + H + F + (L_r or S or R)	IBC 2006, Eq. 16-10
D + H + F + 0.75 (L + T) + 0.75 (L_r or S or R)	IBC 2006, Eq. 16-11
D + H + F + W	IBC 2006, Eq. 16-12
D + H + F + 0.75 (W + L + (L_r or S or R))	IBC 2006, Eq. 16-13
0.6 D + 1.0 H + 1.0 W	IBC 2006, Eq. 16-14

ASD load combinations for Ice (D_i) and Wind-on-ice (W_i) per ASCE 7, Section 2.4.3:

D + H + F + L + T + D_i
D + H + F + 0.7 D_i + 0.7 W_i + S
0.6 D + 0.7 D_i + 0.7 W_i + H

ASD load combinations for Seismic (E):

D + H + F + 0.7 E	IBC 2006, Eq. 16-12
D + H + F + 0.75(0.7 E + L + (L_r or S or R))	IBC 2006, Eq. 16-13
0.6 D + H + 0.7 E	IBC 2006, Eq. 16-15

Special seismic load combinations (IBC 2006 Section 1605.4):

1.2 D + f_1 L + E_m	IBC 2006, Eq. 16-22
0.9 D + E_m	IBC 2006, Eq. 16-23

Note: $E = E_h = \rho Q_E$
$E_m = E_{mh} = \Omega o Q_{E,}$ where Q_E = Effect of horizontal seismic force

2. Combining Factored Loads Using Strength Design

a. Ultimate strength design will be used in the design of concrete structures including foundations, elevated equipment pedestals, and concrete walls. Ultimate strength design may also be used for design of steel structures. The provisions of Section 2.3 of ASCE 7-05 will be the basis for developing factored load combinations along with any specific criteria for combining loads from equipment manufacturers.

b. Loading combinations used for design of the turbine-generator pedestal and mat foundation will be developed using the provisions of ACI 351.3R-04, the provisions of Section 2.3 of ASCE 7-05 and the ASCE publication, "Design of Large Steam Turbine-Generator Foundations" along with any specific criteria for combining loads from equipment manufacturers.

c. Strength Design load combinations for Dead (D), Live (L or L_r), Snow or Ice (S), Rain (R), Fluid (F), Earth Pressure (H) and Wind (W):

1.4 (D + F)	IBC 2006, Eq. 16-1
1.2 (D +F + T) + 1.6 (L + H) + 0.5 (L_r or S or R)	IBC 2006, Eq. 16-2
1.2 D + f_1 L + 1.6 (L_r or S or R)	IBC 2006, Eq. 16-3
1.2 D + 0.8 W + 1.6 (L_r or S or R)	IBC 2006, Eq. 16-3
1.2 D + 1.6 W + f_1 L + 0.5 (Lr or S or R)	IBC 2006, Eq. 16-4
0.9 D + 1.6 W + 1.6 H	IBC 2006, Eq. 16-6

Strength Design load combinations for Seismic (E):

1.2 D + 1.0 E + f_1 L + f_2 S	IBC 2006, Eq. 16-5
0.9 D + 1.0 E + 1.6 H	IBC 2006, Eq. 16-7

Strength Design load combinations for Ice (D_i) and Wind-on-ice (W_i) per ASCE 7, Section 2.3.4:

1.2 (D + F + T) + 1.6 (L + H) + 0.2 D_i + 0.5 S
1.2 D + L + D_i + W_i + 0.5 S
0.9 D + D_i + W_i + 1.6 H

Special seismic load combinations (IBC 2003 Section 1605.4)

1.2 D + f_1 L + E_m	IBC 2006, Eq. 16-22
0.9 D + E_m	IBC 2006, Eq. 16-23

Note: $E = E_h = \rho Q_E$
$E_m = E_{mh} = \Omega o Q_{E,}$ where Q_E = Effect of horizontal seismic force

1.6 Design of Concrete Structures and Foundations

1.6.1 Reinforced Concrete Design

a. Reinforced concrete structures and foundations will be designed in accordance with the following documents:

a. ACI 318-05 – Building Code Requirements for Structural Concrete.

b. ACI 350-06 – Code Requirements for Environmental Engineering Concrete Structures.

c. IBC 2006, Chapters 18 and 19.

d. Specific requirements of ACI or ASCE publications for specialty concrete structures or foundations:

   i. Turbine-generator pedestal – ACI 351.3R-04 & ASCE "Design of Large Steam Turbine-Generator Foundations".

e. Any specific requirements of equipment vendors, including static and dynamic performance criteria for foundations supporting rotating or vibrating equipment.

1.6.2 Foundation Design

1. Support for heavily loaded and/or settlement sensitive structures will be provided by mat type foundation systems. Mat foundations will be used for the Air Expander and Recuperator. Tanks will be supported on ring wall foundations or mats, based on their diameter, height, and location.

2. Soil-supported mat foundations and spread footings will be used for the generation building and pipe bridges, switchyard structures, pre-engineered buildings and enclosures for electrical and mechanical equipment, sumps, and other structures with foundations having relatively low contact pressures. Allowable bearing pressure for sizing foundations and subsurface preparation requirements, such as over-excavation and replacement with structural fill or other soil improvement techniques, will be established based on foundation design recommendations in the project geotechnical report.

3. The effects of fluctuating ground water elevation will be taken into account in the design of all plant foundations including buried pipes, tunnels, sumps, and manholes. Buoyancy on foundations and buried structures will be investigated based on high ground water elevation at grade.

4. Uplift Conditions:

   a. Foundation design conditions resulting in temporary uplift from environmental loads (wind, seismic) or permanent uplift from cantilevered construction will

generally not be permitted. Exceptions will be considered on a case by case basis with the approval of the Project Lead Structural Engineer.

5. Frost protection for soil supported footings, pipes, and other frost-susceptible structures will be designed on a frost depth of 48 inches.

6. Minimum embedment in the soil for all foundations will be two foot with proper soil improvement. Minimum embedment for sidewalks, concrete pads at building doorways, and step off pads for ladders and stairways will be twelve inches.

7. Top surfaces of concrete topping slabs at grade, both interior and exterior, will be sloped at ¼-inch per foot (1/8" minimum) for positive drainage to collection trenches and sumps. This requirement will also apply to the top surface of the cooling tower basin mat.

8. Soil parameters for the design of foundations are as follows:

Geotechnical Data

Passive lateral pressure:	250 pcf*
Allowable skin friction	200 psf
Coefficient of Friction:	0.40
Dynamic Shear Modulus (G'):	16.7 ksi
Poisson's Ratio (μ):	TBD
At-rest earth pressure:	65 pcf
Active earth pressure:	35 pcf
Angle of friction (ϕ):	33°
Total Unit Weight of Soil:	125 pcf
Liquefaction Potential:	Very Low
Water Table:	Below 7.5ft

Average Site Grade: El. TBD

Finished Floor Elevation: El. TBD

9. Factors of safety for foundation design will be as follows:

	Normal	Transient or Construction
Overturning:	1.5	1.25
Sliding:	1.5	1.25
Uplift:	1.15	1.1

a. For calculations that involve overturning, use the combination of loading that produces the greatest ratio of overturning moment to the corresponding vertical load.

$SR_{ot} = M_r / M_o$

M_o = the max overturning moment.

M_r = the resisting moment

1.6.3 Design of Slabs on Grade

1. Design slabs in accordance with ACI 360R, ACI 302.1, and ACI 302.2.

2. Provide a 6 mil polyethylene vapor barrier between the granular base and the concrete for all building slabs and paving placed on subgrade. Use a vapor barrier type recommended for below slab applications. Slabs which are on mudmats or lean fill do not require a vapor barrier.

1.6.4 Design of Formwork

1. Formwork for cast-in-place concrete will be designed in accordance with ACI 301 and ACI 347.

2. The design of formwork will be assigned to the concrete installation contractors.

3. Contractors will be required to account for the following in the design of formwork:

   a. Vertical dead loads including the weight of the wet concrete at 150 pcf, the weight of the reinforcing steel, and the weight of the formwork.

   b. Vertical live loads including any impact load from the weight of moving construction personnel and equipment used for concrete placement.

   c. Lateral load from liquid head of wet concrete calculated in accordance with Chapter 2 of ACI 347 and verified for use at the CAES site; lateral loads from equipment used in the placement of concrete; and lateral load from wind on the formwork calculated in accordance with Section 1.5.10.

4. Contractors will be required to submit engineering design calculations including detailed formwork drawings of the following for review by the Engineer:

   a. All placements requiring massive concrete such as deep foundation mats and footings.

   b. Elevated concrete pedestal structures supporting the compressors, air expander, and transformers.

   c. Concrete walls and roof slab for the circulating pump structure.

   d. Concrete walls and roof slabs of deep sumps and pits in the power block and yard areas.

1.7 Masonry Design

1. Masonry structures will be designed in accordance with the following documents:

   a. ACI 530 – Building Code Requirements for Masonry Structures.

   b. IBC 2006, Chapter 21.

2. Masonry block units will be used to provide an emergency means of egress by providing a fire separation for the stair towers. The masonry units will be hollow cored block with lightweight aggregate, 8” high by 8 or 12” deep by 16” long. Reinforcement will be supplied, both horizontally and vertically, based on actual required design strength, but not less than code required minimums.

3. Masonry block units will be used to provide a fire separation and to limit noise in several other areas. The masonry units will be hollow cored block with lightweight aggregate, 8" high by 8" or 12" deep by 16" long. Reinforcement will be supplied, both horizontally and vertically, based on actual required design strength, but not less than code required minimums.

1.8 Structural Steel Design

1.8.1 Steel Framing Design

1. All steel framed structures shall be designed as "rigid frame" or "simple" braced frames, utilizing single-span beam systems, vertical diagonal bracing at main column lines and horizontal bracing at the roof and major floor levels. The use of rigid frames shall be limited to one-story, open garage, warehouse or shed type structures, or to small prefabricated metal buildings except where required in the generation building to increase stiffness at locations that occur a significant distance from vertically braced bays. Pipe racks may be designed as rigid frames utilizing fully-restrained moment connections or braced frames utilizing vertical diagonal bracing at the column lines and horizontal bracing at rack levels. All other framed structures, except at the generation building which will utilize a dual system of "rigid frame" and "simple" braced frames, shall utilize "simple" braced frame design and construction.

2. Steel framing for platform and floor systems, including struts, horizontal and vertical bracing members, and columns, will be designed in accordance with the AISC 360-05 – Specification for Structural Steel Buildings and the procedures given in the Steel Construction Manual, 13th edition.

3. Each platform beam will be designed for a contingency load at midspan of 5 kips. This load is intended to account for unknown piping, cable tray, and equipment loads. This load will not be transferred to girders or columns, but girders will be designed for the 5 kip concentrated load at midspan. The minimum beam vertical reaction capacity shall be 9 kips.

4. Each brace shall include a 5 kip load in its design as a contingency placed at a location to maximize shear and bending stresses.

5. All primary building columns shall be designed for a collateral load of 25 kips in addition to normal dead and live loads.

6. The depth of beams and girders in floors and platforms will not be less than 1/24 times the span (for non-secondary load bearing members). If members of less depth are used, the allowable unit stress in bending will be decreased by the same ratio as the depth is decreased from that recommended. Refer to applicable Sections for deflection limits on special members such as crane support girders and monorails.

7. A minimum flange width of 5-1/4 inches will be selected for floor and platform members that are part of lateral bracing systems in order to allow for a bolted flange connection.

8. Maximum Deflections:

   The following guidelines for maximum deflection will be followed:

   a. Floor beams – 1/240 x span (live load deflection).

   b. Roof beams – 1/240 x span (live load deflection).

   c. Floor or roof members supporting plaster ceilings or masonry walls – 1/360 x span (for live load)

   d. Structural members supporting masonry walls 1/600 x span or 0.3 in. max. with dead and live load, whichever is more stringent.

   e. Metal panel wall girts:

      1) Vertical – 1/240 x span (for dead load of siding).

      2) Horizontal – 1/180 x span.

   f. Crane and hoist support beams, rails, and monorail support beams. The deflections are based on maximum wheel loads.

      1) 1/600 x span (without impact).

9. Minimum Sizes:

   a. “W” shapes used as framing members – W8 x 15.

   b. “W” shapes used as posts or columns – W10 x 33.

   c. “W” shapes used as misc. supports – W8 x 18.

10. Single angles will not be used except as lateral support for platform members or as posts for small equipment access platforms. Minimum angle size used will be L3x3x1/4.

11. Structural Tees used for horizontal diagonal bracing members and connected by their flanges only will be designed considering the effects of connection eccentricity. The same procedure will apply for double angles connected eccentrically with a single plate on the outstanding legs.

12. Beams spanning between columns and located above the apex of a chevron-type brace will be designed for the full span length between columns. However, the chevron brace will be designed for axial load considering the brace as an intermediate support point for the beam.

13. For hangers consisting of back-to-back members, each back-to-back member will be designed for 75 percent of the total load.

14. Columns will be designed considering all applied moments, including applied point loads between bracing points and the effects of knee-braced platforms.

15. Connections:

    a. Welded and bolted connections will develop greater of following for beams:

        1) Vertical reaction and axial load on the Drawings. Minimum vertical reaction shall be 9 kips.

        2) Strength of framed connections as shown in AISC Steel Construction Manual, Parts 9 thru 15, having connection length (L) greater than one-half “dimension T” as given for beam in the AISC Steel Construction Manual.

    b. In the absence of vertical reactions on Drawings, develop the connection for one-half of total uniform load shear capacity shown in “Maximum Total Uniform Load Tables” of the AISC Steel Construction Manual, plus axial loads given on the Drawings. For short beams where required connection length exceeds beam depth, an exception to design loads criteria will be made based on required capacity versus the available beam depth.

c. All beams framed into columns will have as a minimum, the largest standard connection length (L) allowed based on the dimension "T" given for the beam in Part 1 of the AISC Steel Construction Manual.

d. For trusses, bottom chord braces, sway frames, vertical bracing, hangers, and similar type members, develop either the greater of forces indicated on Drawings or one-half of the effective strength of the member. In addition, connections for trusses and members in bracing systems will meet the minimum bolting requirements below:

WF flange connection	8 bolts
WF web connection	4 bolts
WT flange connection	4 bolts
Single angle	2 bolts
Double angle	2 bolts double shear or 4 bolts single shear

e. Bolting requirements:

1) Pre-tensioned bearing type connections with threads included in the shear plane with high strength bolts (ASTM A 325, Type 1) will be used for standard beam and girder end connections.

2) Slip critical type connections with high strength bolts will be used for horizontal and vertical bracing members, column splices, and all other members subjected to vibratory loads. Allowable bolt shear for slip critical connections will be based on the use of oversized holes to mitigate fit-up problems. These connections will be identified using the designation (SC) on the design drawings.

3) Shear bearing type (snug tight) connections with high strength bolts will be used judiciously for members not subjected to axial load (i.e., in-fill beams in floor and platform systems). Floor and platform beams with shear bearing connections will be identified using the designation ST (snug tight) on the design drawings.

4) Shear bearing type connections using A325 high strength bolts or connections using A449 high-strength bolts will be acceptable for the following:

a) Removable beams.

b) Stairways, landings, and ladders.

c) Girts.

5) With the exception of column base plates, a minimum of two bolts will be used in all connections. For column base plates, a minimum of four bolts will be used, except for small angle posts.

6) Unless otherwise required, end connections for beams, girders, and struts will be Simple Connections as defined by Section J1.2 of the AISC 360-05.

f. Welding requirements:

1) Welded connections will be sized such that stresses within the base or weld metal will not exceed the available stress values presented in Chapter J, Table J2.5 of the AISC 360-05.

2) Prequalified welds conforming to AWS D1.1 will be used in all welded connections.

16. Stability

a. The following criteria will be used to determine the unbraced length used for design of isolated beams and beams supporting grating:

1) Grating will not be considered as lateral support for beams or beam columns. Stair treads will be considered as lateral support for stair stringers at midspan only.

2) Beams or beam columns connected to panel points of horizontal trusses will be considered as laterally supported at the panel point.

3) Members used for lateral bracing will be positioned no more than 3" or 1/6 of the supported member depth below the top or compression flange of the supported member.

4) Parallel beams having less than 20 percent difference in weight and connected by perpendicular beams not connecting to panel points of a horizontal truss will be considered laterally supported in accordance with the following:

   a) Maximum unbraced length used in design will not be less than the beam span divided by the number of beams connected in parallel.

   b) Two parallel beams will be considered braced by one perpendicular beam provided the beam span/spacing ratio is less than 12 (spacing is the distance between parallel beams). If the span/spacing ratio is greater than 12, a horizontal truss will be provided.

   c) When axial load in a parallel beam is greater than 10 kips, a horizontal truss will be provided for lateral support of the beam/column.

5) Parallel beams having more than 20 percent difference in weight and connected by perpendicular beams not connecting to the panel points of a horizontal truss will be considered laterally supported in accordance with the following:

   a) The lighter beam will be considered laterally supported at the connection points of the perpendicular beams. The heavier beam will be considered laterally unsupported for its full span unless braced with a horizontal truss.

6) At the points of support for beams, girders and trusses, restraint against rotation about their longitudinal axis shall be provided.

7) Beam bracing shall prevent the relative displacement of the top and bottom flanges. Lateral stability of beams shall be provided by lateral bracing, torsional bracing or a combination of the two.

8) Horizontal trusses provided only for beam lateral support will be designed for a lateral force equal to 0.008 times the sum of the flange compressive forces for the beams being supported. These beam stability forces will be ignored for the design of other horizontal trusses.

b. Column stability will be evaluated in accordance with the following guidelines:

1) The design of column stability bracing shall be in accordance with the following:

Relative Brace: See AISC 360-05, Appendix 6.2.1

Single Point Brace: See AISC 360-05, Appendix 6.2.2

2) Platform beams and column struts which are required to brace a column, or line of columns, will be designed for the accumulated axial load required to transfer the column stability load to the bracing system. A maximum of 8 columns will be considered to apply load to the bracing system.

3) It will be assumed, since columns tend to buckle in the form of a sine curve, that stability forces cancel between brace points. Accordingly, stability forces will only be considered as shears between braced points and not summed down to grade. Stability forces do not contribute to overturning, therefore columns, column splices, base plates, and anchor bolts will not be designed for stability forces.

1.9 Pipe Support Design and Pipe Stress Analysis

1.9.1 Pipe Support Design

1. In general, piping will be supported from structural steel members or anchored steel plates utilizing the most practical and cost effective configuration and method of attachment.

2. Supplemental steel supporting piping will be designed in accordance with the AISC 360-05 Specification for Structural Steel Buildings in the AISC Manual, 13th edition.

3. Piping 2-1/2 inches in diameter and larger will have supports arranged so that any valve can be removed without need for temporary support of the pipe. Supporting straps

around pipe flanges of valves will not be used. Supports will be positioned near valves and joints that will require removal during maintenance.

4. Pipe support design for high-energy piping will include devices to restrict pipe dynamic loads.

5. Piping will be supported within a maximum span in accordance with either ASME B31.1 or Manufacturers Standardization Society publication SP 69.

6. Pipe restraints for safety valve transients will be evaluated per the requirements of Appendix II in ASME B31.1.

1.9.2 Pipe Stress Analysis

1. Piping exposed to temperatures above 300 degrees F and above will be analyzed using appropriate computer programs for flexibility and stresses. In addition, piping subject to dynamic loads such as steam hammer will be analyzed. Piping systems will be designed to limit forces transmitted to the equipment to that permitted by the equipment manufacturers.

2. Piping not exposed to temperatures above 300 degrees F or not subject to dynamic loads such as steam hammer will not be analyzed. Cold pipe support spacing criteria will be developed per MSS guidelines.

3. Tubing subject to temperatures above 300 degrees F will be reviewed for flexibility including development of support criteria per MSS guidelines.

1.10 Generation Building

1.10.1 Foundations

1. Generation Building Foundation

   a. Building columns will be supported on individual and combined shallow spread footings and equipment located inside the structure will be supported on individual soil supported foundation mats.

   b. The finished topping slab will be sloped for drainage.

   c. See Section 1.6.2 for foundation design requirements.

2. Air Expander Pedestal and Foundation Mat

a. Physical Arrangement

1) The air expander foundation will consist of a large soil supported concrete mat with a raised reinforced concrete pedestal.

b. Acceptance Criteria

Foundation and pedestal structure will be evaluated for conformance with vendor specified static and dynamic criteria.

c. Analytical Approach

1) STAAD Pro will be used to perform the analysis of the combined soil, concrete mat, superstructure & machine. Serviceability (SF of against overturning moment & sliding, soil bearing & settlement, foundation displacement & drift) design will also be determined by STAAD Pro analyses to assess static load criterion given by machine vendor and design codes.

2) DYNA5 will be used to generate the soil frequency-dependant impedance (stiffness & damping ratio) used in the STAAD Pro foundation models.

a) Damping Safety Factor = 2.0 (To reduce the possibility of damping overestimation and thus response underestimation).

b) Soil Material Damping Ratio = 0.05

c) Footing Flexibility = Rigid

d) Foundation Type = Elastic Half-Space and Homogenous

e) Consider Side Embedment Effects

f) Harmonic Loads (fmax = 75Hz, fmin = 0Hz, step = 5hz)

g) The max soil damping ratio (material damping + geometric damping) = 0.5 (for vertical, conservatively use 0.25), 0.2 (for

horizontal), 0.1(for rocking) and 0.15 (for torsional) (ACI 351.3R-04, section 4.2.2)

3) STAAD Pro will be used to perform the modal dynamic (free vibration with composite damping accounted) analysis of the soil-foundation-machine system to solve the natural frequencies (eigenvalues) and mode shapes (eiganvectors). Identify the fundamental frequency (usually the lowest value of the natural frequencies) and mode. They can be compared with the frequency of the acting dynamic force so that a possible resonance condition can be prevented.

4) STAAD Pro will be used to perform the steady state harmonic dynamic analysis of the structure to extract member vibration displacement, velocity, and acceleration amplitudes if required.

5) STAAD Pro will be used to generate member and element forces for use in reinforced concrete load combinations defined in IBC 2006, ACI 318-05, ASCE 7-05, and ASCE Publication “Design of Large Steam Turbine-Generator Foundations.”

6) PCACOL and MathCAD will be used in the design of reinforced concrete members in accordance with IBC 2006 and ACI 318-05.

d. Loads

Design loads will be in accordance with Section 1.5 and the following supplementary loading provisions:

1) Seismic loads will be developed in accordance with Section 1.5.10

Seismic-Force Resisting System – Block type concrete foundation with properties same as Nonbuilding structure not similar to building per the requirements of Section 15.6 and Table 15.4-2 of ASCE 7-05.

Redundancy Factor ρ (based on classification as a non-building type structure) = 1.0

Overstrength Factor Ω_0 = 2.0

Deflection Amplification Factor C_d = 2.5

2) Condenser loads – Condenser loads will be in accordance with loading arrangement diagram provided by the condenser vendor.

3) Primary loads

Primary load category types will be as follows:

D = Dead load
L = Live load
H = Soil load (buoyancy)
E = Seismic load
A = Accident load
O = Operating load (normal torque, normal unbalance, etc.)

e. Load Combinations (confirm with vendor info later)

See Section 1.5.17 for load combinations. (confirm with vendor info later)

1.10.2 Generation Building Superstructure

1. The enclosed structure will be of steel Ordinary Concentrically Braced Frames (OCBF) (simple connection) construction with rigid moment frames as required and with the following features:

   a. The structure will be equipped with a bridge crane to assist with initial installation of the turbine and generator and then after startup, assist with machine maintenance during outages. The crane will be limited in main hook capacity of 35 ton for Cycle 1 and 80 ton for Cycle 2 based on the weight of the heaviest piece of equipment required for maintenance lift following installation of the expander, compressor, turbine and generator. Stepped columns will be used to create a support seat for the crane support girders. The turbine/generator bays will include a number of local platforms for access to and support of equipment and piping systems.

   The platforms will consist of grating over steel framing for providing direct access to the underside of the turbine, generator and other miscellaneous valves and instruments at elevated levels.

   b. The steel roof structure will consist of purlins spanning over top of steel plate girders. Roofing materials will consist of steel deck covered with rigid board insulation and an EPDM roof membrane system.

c. Lateral stability for the building structure will be accomplished by placement of diagonal bracing members in selected bays and the use of moment frames away from the end bays of the building at the east and west ends.

2. Loads

Design loads and load combinations for the generation building structure will be in accordance with Section 1.5 and the following supplementary provisions:

a. Hung loads for electrical and mechanical systems will be considered as dead load and will be accounted for as follows:

Location	Load (psf)
Miscellaneous Platforms	50
Roof between Column Lines	10

b. Seismic loads for the generation building steel superstructure will be developed in accordance with Section 1.5.10 and Section 12.8 of ASCE 7-05 for structures in Seismic Design Category A.

c. Seismic loads for reinforced masonry will be developed in accordance with Section 1.5.10 and Section 12.8 of ASCE 7-05 for structures in Seismic Design Category A.

d. Piping loads – For major piping systems (main steam, hot reheat, cold reheat, feedwater, condensate, extraction) individual pipe support loads will be included in the structural analysis for the turbine building. Loads from small bore piping will be included in dead load allowance.

3. Load Combinations

Load combinations for the turbine building superstructure will be in accordance with Section 1.5.17.

1.11 Combustion Turbine/Generator (If Required)

1.11.1 Foundations

1. Combustion Turbine/Generator Support Structure Foundation

a. The combustion turbine/generator support structures and foundations shall be designed in accordance with the manufacturer's recommendations and the geotechnical report. Both static and dynamic loading criteria set forth by the manufacturer shall be considered. In general, the structure will be a soil supported foundation mat.

1.12 Recuperator Foundation and Structure

1.12.1 Foundations

1. Recuperator Foundations

   a. Recuperator structure will be supported on an individual foundation mat. The foundation mat will be supported by soil.

2. Recuperator Auxiliary Equipment Foundations

   a. Auxiliary equipment at the Recuperator structures will be supported either the Recuperator mat foundation or on individual soil supported foundation mats.

1.12.2 Superstructure

1. Design of structural steel for the Recuperator will be the responsibility of the Recuperator vendor.

2. Steel grating walkways, platforms, and stairways will be provided to facilitate maintenance of all of the equipment items. Service platforms at all levels will be arranged such that they are accessible by walkways from either of two main stair towers provided at one side of each structure. Access to these stairs will be provided from the utility bridge.

1.13 Utility Bridge

1.13.1 Foundations

1. Utility Bridge Foundations

   a. Utility bridge foundations shall be shallow soil supported individual or combined footings.

1.13.2 Superstructure

1. The utility racks and pipe/bridge(s) shall be multilevel steel structures on reinforced concrete foundations. The structure shall consist of galvanized structural steel members in a combination of simple braced, and/or moment resisting frames; field connected with galvanized high-strength bolts. All critical steel piping shall be considered to be top hung from the bottom of steel. Lateral and longitudinal directional wind and seismic forces will be transferred to the lateral load resisting system via horizontal and vertical bracings and moment connections.

2. The dead load of all walkways/platforms, cable trays, analysed piping, and cold piping shall be considered in the utility bridge structural design.

3. A live load of 100 psf shall be used on all the walkways and platforms attached to the utility bridge structure.

4. Seismic loads for the utility bridge steel superstructure shall be developed in accordance with Section 1.5.10 and Section 15.5 of ASCE 7-05 for structures in Seismic Design Category A.

1.14 Cooling Tower Area

1.14.1 Cooling Tower Basin

1. The cooling tower will be of the rectilinear, fiberglass framed, film filled, multiple cell, mechanical induced draft counterflow type and will be supported on a rectangular foundation mat supported by soil. A concrete wall with a height of 4’-0” will be constructed around the perimeter of the mat to form a basin for retaining water fill during tower operation.

2. Loads

   Design loads for the basin mat will be in accordance with Section 1.5 and the following supplementary loading and performance provisions:

   a. Cooling tower loads and performance criteria:

      1) Live load at roof level – per Vendor based on 35 psf ground snow load

      2) Seismic loads developed by Vendor in accordance with the Site Specific Criteria.

3) Crane load – 300 psf surcharge on basin mat

b. Other loads on basin mat:

1) Water fill in basin:

a) Vertical surcharge from 4'-0" (depth to be confirmed) full depth of water.

3. Load Combinations

Load combinations will be in accordance with Section 1.5.17 and the following supplemental provisions:

a. Load combinations for basin concrete design will be as follows from Section 9.2 of ACI 350-06.

b. Required strength shall be multiplied by the environmental durability factors S_d per Section 9.2.6 of ACI 350-06.

1.14.2 Cooling Tower Pump Structure

1. A concrete pump structure 75'-0" long by 27'-8" wide will be provided adjacent to the cooling tower. The bottom mat of the pump structure will be recessed 15'-6" below grade (T/mat El. later) to provide a well for the vertical pumps. The bottom mat of the pump structure and the spillway mat will be supported by soil.

2. The pump structure will be fitted with slots in the roof slab and key ways installed in the walls and base mat to accommodate trash screens, flow modification devices, and stop logs upstream of the circulating water pumps as follows:

a. Trash screens:

Two banks of (later) wide by (later) high frames ((later) required) fabricated from galvanized steel rolled shapes and covered with 0.12-inch diameter, 3/4-inch center-to-center, type 304 stainless wire cloth. Screen assemblies fitted with single 9" x 9" basket along upstream side at bottom for trash drop-out and collection. The trash screens may be fabricated of HDPE materials.

b. Flow distributor screens: (If Required)

One full-width by full-height ((later) wide by (later) high) screen fabricated from galvanized steel rolled shapes. Spacing and configuration of shapes will be as recommended by flow model results.

c. Bulkhead gates: (If Required)

Two full-width by half-height ((later) wide by (later) high) assemblies fabricated from galvanized steel rolled shapes and plates and fitted with rubber bulb seals and strips to minimize leakage while in use.

3. Loads

Design loads for the pump structure will be in accordance with Section 1.5 and the following supplementary loading provisions:

a. Live loads on pump structure roof as follows:

Location	Load
Concrete roof and supporting beams	150 psf
Grating covered openings for screens, etc.	150 psf

b. Circulating water pumps supported on roof – (later) lbs. each

c. Seismic load from sloshing water against walls of pump structure will be calculated in accordance with the section 15.7 of ASCE 7-05.

4. Load Combinations

Load combinations will be in accordance with the provisions of Section 1.5.17.

1.15 Transformer Area

1.15.1 Foundations and Superstructure

1. Transformers

a. All transformers will be supported on individual or common mat foundations. Mat foundations will be supported by soil.

b. Mat foundations will be recessed and fitted with perimeter walls to form pits for water and oil retention. Concrete piers and pedestals will be extended up from the top of recessed foundation mats for support of the transformers at grade elevation Pits will be covered with 1 ½" to 2" deep grating supported by steel beams connected to the pedestals and pit walls (to be confirmed). A 12" thick layer of rocks may be placed on top of steel grating for additional fire protection.

c. Reinforced concrete pit walls will be extended above grade where required for protection of adjacent transformers and plant facilities (i.e., turbine building) in the event of a transformer fire.

d. Sizing Criteria for Pits/Walls

1) Transformer pits

Plan dimensions:

a) Inside face of pit walls should be a minimum of 5'-0" away from the greatest projection on each side of the transformer. Lesser clearance must be approved by project Electrical and Structural engineers.

b) Ground clearance will be provided between the transformer bushings and grounded objects, including concrete fire walls. Clearance will be measured as a sphere with diameter of 5'-0" (to be confirmed) radiating outward from the outside of the transformer bushing.

2) Depth:

a) Minimum depth of retention area will be 1'-0".

b) Pit walls will extend a minimum of 6 inches above grade.

c) Retention area will be sized to contain the full volume of the oil in the transformer plus 10%. No extra allowance for rain, deluge, or fire hose water will be provided for as each pit will be fitted

with a sump and piped to a common collection sump in the yard (to be confirmed).

e. Fire walls

1) NFPA 850, Sections 5.2.4.1– Outdoor oil-insulated transformers should be separated from adjacent structures and from each other by firewalls, spatial separation, or other approved means for the purpose of limiting the damage and potential spread of fire from a transformer failure. Basis for determining minimum (line-of-sight) separation with fire walls will be a transformer oil capacity of over 500 gallons. Separation between structures and a transformer will extend vertically and horizontally as indicated in Figure 5.2.4.3.

2) NFPA 850, Section 5.2.4.4 – Fire walls provided between transformers will extend a minimum of 1'-0" above the top of the transformer casing and oil conservator tank and at least 2"-0" beyond the width of the transformer and cooling radiators.

Fuel Gas Composition

Component	Typical Analysis (mole %)	Range (mole %)
Methane	94.9	87.0 - 96.0
Ethane	2.5	1.8 - 5.1
Propane	0.2	0.1 - 1.5
iso - Butane	0.03	0.01 - 0.3
n - Butane	0.03	0.01 - 0.3
iso - Pentane	0.01	Trace - 0.14
n - Pentane	0.01	Trace - 0.04
Hexanes+	0.01	Trace - 0.06
Nitrogen	1.6	1.3 - 5.6
Carbon Dioxide	0.7	0.1 - 1.0
Oxygen	0.02	0.01 - 0.1
Hydrogen	trace	Trace - 0.02
Specific Gravity	0.585	0.57 – 0.62
Lower Heating Value (Btu/scf), dry basis	960	914 - 1021

Data based on Russell Station Project.

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resources & energy

EcoNomics

NEW YORK STATE ELECTRIC & GAS
COMPRESSED AIR ENERGY STORAGE PROJECT

Electrical Engineering

Plant Switchyard (Collector Station) Design Criteria

Document: CAES-1-DB-023-0003

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COMPRESSED AIR ENERGY STORAGE PROJECT
ELECTRICAL ENGINEERING
PLANT SWITCHYARD (COLLECTOR STATION) DESIGN CRITERIA

Disclaimer

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1. SCOPE

1.1 Background

The Compressed Air Energy Storage (CAES) plant will consist of a separate, electrically driven compression cycle and a natural-gas fired expansion cycle to generate electricity. The CAES plant will use off-peak electricity to compress air into an underground reservoir. When electricity is needed, the compressed air is withdrawn, heated, and passed through an expansion turbine to generate power.

The CAES generated power will flow through the Plant Switchyard, through a 0.7 mile , 115kV single circuit, transmission line commencing at the Plant Switchyard and ending at the Interconnect (POI-Point of Interface) Switchyard where it will interface with existing 115kV NYSEG transmission lines 967 and 970. Existing transmission lines 967 and 970 run from the AES Greenidge Station to the Montour Falls Station. The Plant Switchyard (Collector Station) shall be an outdoor, open-air, ring bus type arrangement.

The Scope of this document is for the Plant switchyard (Collector Station). The Interconnect (POI) Switchyard Design Criteria is described in document CAES-1-DB-023-0002.

1.2 Equipment To Be Provided

A. The switchyard shall consist of the following major equipment:

Equipment	Quantity
• 123kV Class Deadtank SF6 High Voltage Circuit Breakers.	6
• Center Break Disconnect Switches:	28
• Surge Arresters, 115 kV System Voltage	3
• 1-phase CCVT, 115kV System Voltage	18
• Overhead Lightning Protection System	1 Lot
• Switchyard Relay and Control System	1 Lot

Equipment	Quantity
• Extended Range Metering Equipment , 1-Phase	15
• Switchyard AC Distribution System	1 Lot
• Primary and Backup Battery, (2) Battery Chargers, UPS and DC Distribution Panels	1 Lot
• Aluminum Tubular Bus and Accessories. Main bus conductor size is 3" AL Sch 40, 6061-T6.	1 Lot
• 550 kV BIL Suspension Insulators with deadend ACSR Cable Terminators	1 Lot
• 550kV BIL Station Post Type Bus Support Insulators	1 Lot
• Underground and above grade raceway system for use by both the Vendor for installing his cable within the switchyard.	1 Lot
• Switchyard lighting system	1 Lot
• Control and Instrumentation Signal Interface	1 Lot
• Switchyard Miscellaneous equipment (conductor, connectors, etc.)	1 Lot

• Steel Structures for outgoing lines terminations, equipment and bus supporting system	1 Lot
• Foundations for all structures and equipment	1 Lot
• Grounding System	1 Lot
• Fencing, Gates, Grading , Retaining Walls, Soil Erosion and Sedimentation Control, and Yard Surfacing	1 Lot
• Foundation Excavation, Backfill, and Compaction	1 Lot
• Switchyard Control House complete with lighting.	One

2. CODES AND STANDARDS

A. The latest edition and published addenda of the following publications in effect on the date of Contract Award are a part of this Section. All equipment furnished and work performed shall comply with the approved standards, specifications, regulations, codes and tests of the following:

1. ANSI American National Standards Institute
2. ASME American Society of Mechanical Engineers
3. FERC Federal Energy Regulatory Commission
4. IEEE Institute of Electrical & Electronics Engineers

- IEEE C37.04, “IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers”.
- IEEE C37.06, “IEEE Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis-Preferred Ratings and Related Required Capabilities for Voltages Above 1000V”.
- IEEE C37.09, “IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis”.
- IEEE C37.012, "IEEE Application Guide for Capacitive Current Switching for AC High-Voltage Circuit Breakers."
- IEEE C37.016, "IEEE Standard for AC High-Voltage Circuit Switchers rated 15.5kV through 245kV".
- IEEE C57.13, “IEEE Standard Requirements for Instrument Transformers”.
- IEEE C57.19.00, “IEEE Standard General Requirements and Test Procedure for Power Apparatus Bushings”.

- IEEE 605-2008, "IEEE Guide for Bus Design in Air Insulated Substations".
- IEEE 80-2000, "IEEE Guide for Safety in AC Substation Grounding"
- IEEE 998-1996, "IEEE Guide for Direct Lightning Stroke Shielding of Substations"
- IEEE 1410-2010, "IEEE Guide for Improving the Lightning Performance of Electric Power Overhead Distribution Lines"
- IEEE 1243-1997, "Guide for Improving the Lightning Performance of Transmission Lines"
- IEEE 485-1997, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications"
- IEEE 450-2002, "IEEE Recommended Practice for Maintenance, Testing and Replacement of Vented lead-Acid Batteries for Stationary Applications"
- IEEE C2-2007, National Electrical Safety Code

5. IES Illuminating Engineering Society

6. NBC National Building Code

7. NERC North American Electric Reliability Corporation

- NERC CIP Standards

8. NPCC Northeast Power Coordination Council, Inc.

- Directory #1 "Design and Operation of the Bulk Power System"
- Directory #4 "Bulk Power System Protection Criteria"

9. NYSEG New York State Electric & Gas

- Bulletin 86-01 "Requirements For The Interconnection of Generation, Transmission and End-User Facilities".
- NYSEG Specifications and Standards

10. NEMA National Electrical Manufacturer's Association

- MG-1, “Motors and Generators”

11. REA Rural Electrification Act

- 1724E-300, "Design Guide for Rural Substations"

B. In the event of any conflict between codes, or between Specifications and codes, the more stringent regulation shall apply.

3. DESIGN AND CONSTRUCTION FEATURES

3.1 Terminal Points

Terminal points listed below and further indicated in the enclosed drawings are indicative only. The Vendor shall determine the exact terminal point arrangements in coordination with the interfacing Vendor/agencies/utility company.

- 115kV dead end structure to interface to Interconnect (POI) Switchyard--(1) location
- 115kV dead end structures for Plant 115kV supply –(4) locations
- For control and signaling between the Plant Switchyard and the Interconnect (POI) Switchyard the terminal point shall be the fiber optic communication cables in the OPGW located on the 115kV dead end structure to the Interconnect (POI) Switchyard. (1) location.

3.2 Design Requirements

A. General:

All equipment and material furnished shall meet the following general requirements:

- Utility Interconnection Requirements as stated in NYSEG specification SPR-980.
- Ring bus arrangement with 6 total breakers.
- The Plant Switchyard shall be designed such that it can easily be made to meet NPCC Bulk Power System Protection Criteria. This means that each element of the 115kV station is to be protected by two independent protection groups, the groups must be physically separated and no common failure can disable both systems.
- Conform to the requirements REA Bulletin 1724E-300 for outdoor switchyard equipment and materials. These are minimum requirements and are superseded by any more stringent requirements mentioned in this specification.
- Overall space limitations as indicated in the Drawings.

- Sufficient aisle space for operation, maintenance and removal/replacement of equipment.
- A clear space of at least 10 feet must be maintained on the exterior of all fences. Switchyard buildings may be no closer than 15 feet from the fence.
- Conform interphase spacing and clearance to the recommended NYSEG standards, unless larger dimensions are indicated.
- Be suitable for the application and not overstressed mechanically or electrically.
- Instrument transformers used for revenue metering applications in New York must be PSC (Public Service Commission) approved. The following PSC website contains a list of approved devices: http://www.dps.state.ny.us/approved_meter_list.pdf.
- All equipment furnished shall perform satisfactorily under the stipulated site conditions stated in an attachment included with the Engineering Requisition.
- All Local, State and National codes and standards.

B. Switchyard Equipment:

1. The 123kV Class circuit breakers shall be provided with dual tripping coils rated for the DC control voltage stated in the Engineering Requisition.
2. Synch-check facilities shall be provided for the switchyard circuit breakers.
3. The 123 kV equipment and connections shall be designed to withstand without damage or distortion the stresses caused by an electrical fault having the maximum fault level specified in the Engineering Requisition (ac rms symmetrical) for 3 seconds.
4. The 123 kV circuit breakers shall be capable of interrupting maximum fault current and line charging currents.
5. Full electrical interlocking facilities shall be provided for the circuit breakers and disconnect switches to ensure safe operation of the equipment under all service conditions.

6. Surge Arrestors shall be sized as follows: If the system is effectively grounded for all single contingencies, i.e. the system Ro/X1 < 1 and X0/X1 < 3; then use a 96kV rated arrester with a 76kV MCOV. If the system is not effectively grounded, use a full voltage 120kV arrestor with a 98kV MCOV.

7. Any equipment required to meet NERC Cybersecurity (CIPS 2-9) must be installed.

8. Extended range revenue metering CT's are required.

C. Bus System:

1. The tubular bus system shall be as per NYSEG 115kV Standard Module drawing SME-AFT-SD which uses 3" AL, Sch 40 , 6061-T6 bus as the main conductor. The bus conductor system shall be verified to not exceed the bus conductor limits as specified on NYSEG drawing SUO-CCA-05. The sag under any loading conditions shall not exceed 1/2 the diameter of the bus tubing.

2. Incoming shield wire shall contain fiber optic conductors for data communication.

3. The loading and strength to be used in designing the aerial line shall comply with Grade B loading criteria of Section 26 of the National Electric Safety Code (NESC) . For calculating conductor tension the total load on the wire or conductor shall be the resultant of a vertical and a horizontal load component calculated at the applicable temperature plus the corresponding constant given in Table 250-1 of the NESC. The Vendor shall provide the Engineer/Owner with copies of the conductor sizing and sag engineering calculations for approval to support this bus design. The vertical load component on a wire or conductor shall be the weight of the conductor plus the weight of any spacers, or equipment that it supports and ice where required by Rule 250 of the NESC. The horizontal load component on a wire or conductor shall be the horizontal wind pressure as determined under Rule 250, or 25.6 psf (whichever is greater) applied at a right angle to the direction of the line using the projected area of the conductor, spacers or equipment that it supports and ice where required by Rule 250 of the NESC. Insulators used on the aerial line shall meet the requirements of Section 27 of the NESC. Arial insulators shall be non-ceramic.

D. Clearances:

The clearances shall be per NESC and NYSEG requirements.

E. Switchyard Control and Metering Concept:

1. General Notes and Comments:

The interface for the control and monitoring of 115kV switchyard components shall be from the following locations:

- Local at the equipment
- Switchyard Control Panel (SCP)
- SCADA System
- Plant DCS (Distributed Control System)

2. Disconnect Switches:

All command operations shall be initiated either locally at the equipment or remotely. When both the upstream and downstream disconnect switches associated with a breaker are open, that breaker shall be allowed to operate in a "LOCAL" mode. For normal operation of a breaker to be allowed, both the upstream and downstream disconnect switches associated with a breaker must be closed. Mechanical indication of the disconnect switch position shall be visible locally at the equipment. Status contacts for both open and closed position feedback of the disconnect switches shall be provided for use by the switchyard control panel (SCP), Plant DCS system and the switchyard SCADA system.

3. Open Commands:

The motor operated disconnect switches shall have the capability to be opened at any time, local at the Disconnect Switch Local Control Panel (DSLCP) if its associated circuit breaker is open (no load operation only). It shall be able to be opened remote from the Switchyard Control Panel (SCP) or remote via Plant DCS or SCADA systems if its associated circuit breaker are open (no load operation only).

4. Close Commands:

The capability of issuing a motor operated disconnect switch closure command shall be dependent upon location as well as disconnect status. Local/Remote (L/R) selector switch(es) shall be incorporated into each Disconnect Switch Local Control Panel (DSLCP) and the Switchyard Control Panel (SCP) to ensure that any switch closing operation can be initiated from only one location at a time. For each L/R switch a separate DCS status contact shall be required.

a. Local at the Motor Operated Disconnect Switch (DSLCP):

A close command can only be initiated at the switch, if the L/R switch on the disconnect switch local operator panel is in LOCAL mode and the associated circuit breakers are open. If the associated circuit breaker is closed, the local close command is inactive. All other interlocks shall be by-passed in this mode.

b. Switchyard Control Panel (SCP):

All the motor operated disconnect switches shall be capable of being closed if the associated circuit breaker is in the Open position, and the L/R switch on the Disconnect Switch Local Control Panel (DSLCP) is in Remote mode and the L/R switch on the Switchyard Control Panel (SCP) is in Local mode.

c. Plant DCS/SCADA:

All the motor operated disconnect switches shall be capable of being closed if the associated circuit breaker is in the Open position and the L/R switch on the Disconnect Switch Local Control Panel (DSLCP) is in Remote mode and the L/R switch on the Switchyard Control Panel (SCP) is in Remote mode.

5. Circuit Breakers:

The circuit breakers shall be controlled as indicated below. Hard-wired permissives and interlocks are the responsibility of the Vendor. Status contacts for both open and closed position feedback of each of the circuit breakers shall be provided at the switchyard control panel, the Plant DCS system and the SCADA system. Interposing relays shall be provided by the Vendor for DCS commands, if required.

6. Open Commands:

The circuit breakers shall have the capability to be opened at any time, local at the Circuit Breaker Local Control Panel (CBLCP), remote from the Switchyard Control Panel (SCP) or remote via the Plant DCS or SCADA systems.

7. Close Commands:

The capability of issuing a circuit breaker closure command shall be dependent upon location as well as disconnect status. Local/Remote (L/R) selector switch(es) shall be incorporated into each Circuit Breaker Local Control Panel (CBLCP) and the Switchyard Control Panel (SCP) to ensure that any breaker closing operation can be initiated from only one location at a time. For each L/R switch a separate DCS status contact shall be required.

a. Local at the Circuit Breaker (CBLCP):

A close command can only be initiated at the breaker, if the L/R switch on the circuit breaker local operator panel is in LOCAL mode and the associated disconnect switches are closed. If the disconnect switches on either side of the circuit breaker are open, the local close command is inactive. All other interlocks shall be by-passed in this mode.

b. Switchyard Control Panel (SCP):

All the circuit breakers shall be capable of being closed if the disconnect switches on either side of the respective circuit breaker are in Closed position, and the L/R switch on the Circuit Breaker Local Control Panel (CBLCP) is in Remote mode and the L/R switch on the Switchyard Control Panel (SCP) is in Local mode and the appropriate switchyard synchronizing check relay permissive is energized and all lockout relays are reset.

c. Plant DCS/SCADA:

All the circuit breakers shall be capable of being closed if the disconnect switches on either side of the respective circuit breaker are in Closed position and the L/R switch on the Circuit Breaker Local Control Panel (CBLCP) is in Remote mode and the L/R switch on the Switchyard Control Panel (SCP) is in Remote mode and the appropriate switchyard synchronizing check relay permissive is energized and all lockout relays are reset.

F. Annunciation:

The Switchyard Control Panel (SCP) shall have audiovisual annunciators. Any abnormality in the switchyard equipment and its auxiliary systems shall be annunciated at the Switchyard Control Panel. Group alarm (pretrip and trip) for each circuit and strategic auxiliary system shall be wired to the interface terminal panel for remote alarm via SCADA or Plant DCS. The trip circuits of each circuit breaker and the lockout relay coils shall be supervised and alarmed at Switchyard Control Panel.

G. DCS/SCADA Interface Requirements

1. The interface for discrete contacts shall be defined as alarms, status, or control. The shelf state contact positions shall be configured to provide the appropriate feedback signal. Alarm contacts shall be designed such that the contact shall be in the open position when in the alarm state. Status contacts shall be designed such that the contact shall be in the closed position when in the stated position. Digital input alarm and status contacts shall be rated for pilot duty. All contacts provided for digital input signals to the DCS shall be dry contacts. Interrogation voltage for DCS digital inputs shall be supplied from the DCS and shall be

24VDC or 48VDC. The contacts for other than digital inputs shall be configured as dry contacts, and shall be capable of either AC or DC wetting voltages stated in the Engineering Requisition.

2. Control outputs are dry contacts with the wetting voltage supplied by the Vendor. These contacts shall be programmed as momentary contacts with a contact closure time of 1.0 seconds. DCS digital outputs shall be rated as 10A 120VAC or 0.5A 125VDC inductive. Where necessary, interposing relays shall be used to prevent damage to the DCS/SCADA output contacts.

3. The Plant DCS operator interface shall be located in the power plant control room and shall be provided by Others. The wiring interface from the interface terminal panel to the DCS I/O termination cabinet shall be by Others. The DCS and SCADA system I/O wiring termination shall be configured to observe signal type and distance separation criteria as provided in LATER. As a minimum, the wiring interface for analog and digital terminations shall occupy opposite sides of the cabinet and separated from all other control and protection wiring. All wiring shall utilize twisted shielded pairs with an overall shield for multiple pair cables. All shields shall be terminated next to their respective signal wire terminations.

4. A RTU (Remote Terminal Unit) is required for SCADA. The RTU will be specified and commissioned by NYSEG/RGE.

5. Plant Switchyard breaker amperes will be derived from an SEL-351-6 relay dedicated to each breaker.

6. The RTU must be powered from the substation battery. A 4-wire leased telephone facility will need to be ordered and procured by the Plant Switchyard Owner. The telephone equipment must be powered by the station battery. Status points use a dry "a" contact (wetting voltage supplied by the RTU) to indicate the state of a circuit breaker.

7. The Interconnect Switchyard Vendor will determine if NYISO plant dispatch information is to be supplied through the Interconnect (POI) Station RTU in DNP 3.0 Protocol or via a separate Plant Switchyard RTU.

8. All I/O point contacts shall be identified on vendor drawings and shall include the appropriate I/O point tags. These point tags shall be provided during the review cycle.

9. Responsibility for designing the control and automation strategy for the switchyard shall remain with the switchyard Vendor. All documentation for modulating and discrete control and all equipment operating sequence requirements to be implemented in the DCS or SCADA system shall be provided by the switchyard Vendor. After review and approval by the Engineer/Owner, this control and sequencing strategy shall be implemented. A design review meeting between NYSEG, the switchyard Vendor and NYISO shall be held.

10. The switchyard Vendor shall provide the following documentation to support the implementation of the switchyard control strategy:

    a. I/O List

    Prepare a list of all inputs and outputs required between the switchyard and the DCS and SCADA system. The I/O list shall indicate all points to be included in the Sequence of Events (SOE) recording system.

    b. Control Logic Diagrams

    The switchyard Vendor shall prepare drawings defining the control logic for the supplied equipment. The control logic drawings shall include complete definition of all modulating and discrete control logic for all supplied equipment. Modulating and discrete control logic diagrams shall be provided as separate drawings.

    All control and monitoring signals associated with the switchyard equipment shall be included with all permissives and interlocks for safe and efficient operation of the equipment in all operating conditions, both normal and emergency. All sensors, indicators, alarms, setpoints, control commands, final elements, control switches, and other operator interface elements shall be included.

    The drawings shall include both hardwired control elements provided by the switchyard Vendor for local operator interface and control, and control elements to be implemented in the software of the DCS or SCADA system. The drawings shall clearly indicate portions of the control logic implemented in the field control elements provided by the switchyard supplier and portions of the control logic to be implemented by DCS/SCADA.

11. Control & Protective Relaying

a. The transmission line connecting the Plant Switchyard and the Interconnect switchyard shall require two sets of high speed protection. Since this will be new line construction, fiber will be used for both high-speed protection systems. Current differential relaying will be provided for the "A" and "B" relay packages.

b. There will be two independent groups covering each zone of protection. These groups may be of the same manufacturer but should not utilize the same technology. The schemes shall be physically separated.

c. ANSI C800 relay accuracy CT's are used for protective relays unless otherwise specified.

d. Control and Protective relaying shall be located within the Pre-Engineered Metal Control House to be supplied by the Vendor.

e. The Vendor shall be responsible for all internal panel wiring as well as between the panels and between panels field devices.

f. The Vendor shall design, supply, factory test, deliver to site, unload and store at site install, test and commission one set of control and relay panels for the switchyard containing the devices shown on the one-line diagrams and other drawings and documents included with the Engineering Requisition and as required by the Owner.

3.3 Low Voltage AC Power Distribution System

A. The Vendor shall design, supply, install, test and place in service a low voltage AC power distribution system for the switchyard. The AC Power distribution system for the Plant Switchyard shall be two independent house service supplies with an Automatic Transfer Switch (ATS).

B. The low voltage power distribution system shall distribute electrical power for all required functions in the switchyard, including:

1. Circuit breaker charging motors

2. Space heaters

3. Lighting

4. Convenience Outlets at switchyard equipment

C. The Vendor as part of his system design shall ensure that all system protective devices are properly sized and suitably coordinated with other system protective devices to ensure the safety and reliability of the system.

D. All system cable and wiring shall be designed, supplied, installed, tested and placed in service by the Vendor.

E. At a minimum the completed system shall comply with the applicable requirements of the latest edition of the NESC.

3.4 Lighting and Receptacle System

A. The Vendor shall design, supply, install, test and place in service a complete lighting and receptacle system for the switchyard.

B. Unless indicated otherwise, the illumination levels of different areas to be maintained shall be as per the IES standards.

C. Power distribution panels shall comply with the requirements of Specification **LATER**.

D. The lighting and receptacle system shall comply with the requirements of Specification **LATER**.

E. The Vendor shall furnish back-up calculations to justify the number and size of fixtures included in his design, the sizes of all cable and wire included in his design and the sizes of all cable raceways used to circuit illumination system wiring. These calculations shall be subject to Owner/Engineer's approval.

3.5 DC Control Power System

A. The dc system shall be designed to provide reliable power for switchyard equipment control and protection.

B. Two lead-acid station battery systems are required including two separate battery chargers. Each battery system must be capable of supplying the complete emergency load of the station. DC for the independent protection groups shall be fed from physically separate DC panels.

C. The dc system shall be designed and sized in accordance with IEEE 485 as applicable. The battery shall be sized to supply the control power for at least 8 hours after loss of ac power to the battery charger or as required by NERC or NPCC criteria. The Vendor shall develop the load profile to be used in the sizing of the battery and shall submit the battery calculation for review and approval.

D. The dc system shall be operated ungrounded to prevent a single ground fault from disabling the dc system. Provisions shall be provided for checking and alarming for grounds on the positive or negative leads.

E. All circuits shall be properly protected to limit the damage to the faulted circuit.

3.6 Grounding System

A. The Vendor shall design, supply, install, test and place in service a switchyard ground grid as required to cover the entire switchyard area. It shall provide personnel protection from electrical shock and lightning. The Vendor shall measure the soil resistivity and calculate the length of the conductor and cross-section of conductor required for the grounding grid so as to maintain the touch and step voltages within allowable limits. The procedure given in the publication IEEE-80 shall be followed for grounding. The calculation shall be submitted to Engineer for approval.

B. The fault current to be considered in calculation shall be as specified in the Engineering Requisition. The fault clearing time shall be considered as 0.5 second.

C. The grounding resistance of the switchyard shall not be more then 1.0 ohm.

D. The Vendor shall extend the below grade ground grid above grade and connect all steel structures, electrical equipment, overhead static lines and lightning protection downconductor circuits to the grounding system. The Vendor shall provide conductor sizing calculations and installation details to the Engineer for approval.

E. Stranded bare copper conductor shall be used for grounding and unless specifically indicated shall be laid at a minimum 18” below grade unless more depth is required to suit the design requirement and standards and codes.

F. The switchyard area shall be covered with crushed rock as required by the grounding calculations.

3.7 Lightning Protection

A. The switchyard equipment shall be shielded from direct lightning strikes by shield wires and/or lightning masts. The design shall follow the recommendations of IEEE 998-1996, IEEE1410-2010 and IEEE 1243-1997. Vendor's lightning protection design is subject to approval by Owner/Engineer.

B. Lightning arrestors shall be provided on all incoming transmission lines to protect equipment from lightning induced surges.

C. Preliminary estimate of lightning protection equipment also includes the following which is subject to change during Vendor's final design:

1. (4) Lightning Masts for capacitor bank area, 60'height. Reference NYSEG Drawing SMN-LMH-94.

2. (4) Lightning Masts for the ring bus area, 60' height. Reference NYSEG Drawing SMN-LMH-94.

3. Ten (10) Air Termination Rods, 21 feet height. NYSEG SS #800-795-03. To be located on top of overhead conductor towers.

3.8 Capacitor Bank

A. A capacitor bank, if required, is proposed to be located on the eastern side of the Plant Switchyard and will consist of four 50MVAR fuseless capacitor groups for a total of 200MVAR. Each 50MVAR capacitor group will be controlled by a circuit switcher. Series reactors shall be provided for each capacitor group to limit back-to-back switching current. The connection of the capacitor bank to the Plant Switchyard will be via bus conductor. It should be noted that the Capacitor bank location is also being considered at the Interconnect Switchyard.

4. CIVIL/STRUCTURAL FEATURES

This section describes the civil, structural, and architectural design basis for the facility's structures, and general civil work. All civil/structural work will be designed in accordance with applicable codes, industry standards, and local, state, and federal regulations. All required local building permits and inspections will be obtained by the Contractor. See Appendix A for Site Specific Data.

4.1 Facility Description

The switchyard will consist of a control house building, bus support structures, transformers, circuit breakers, disconnect switches, surge arresters, ccvt's, and other miscellaneous switchyard equipment.

Surface finishing (roads, ground cover, etc.) for the site will be as indicated on the General Arrangement drawing. The project will be located within a new perimeter fence. Main access to and from the site will be off of the paved main entrance road.

4.2 Sitework

Civil works design shall comply with the requirements of New York State Electric and Gas Corporation's "Site Development Standard Requirements" Specification unless otherwise indicated. (Ref. Specification SP-1442)

A. Stormwater Management

Assumed stream can collect stormwater and therefore no retention pond needed in preliminary design.

A Stormwater Pollution Prevention Plan (SWPPP) will be developed by the Company for the final stabilized site. The stormwater management plan for use during construction phase and during operation shall be developed by the Engineer with support from specialty engineering services. The intent of the stormwater management plan and the SWPPP will be to preserve the existing pre-development drainage patterns to the extent possible. The plan will include a clean stormwater collection system and an industrial stormwater collection system, consisting of catch basins, piping, a subsurface detention basin, and a suitable water treatment facility as required by the New York Department of Environmental Conservation (DEC). The stormwater collection systems will collect runoff from developed areas of the site and discharge them appropriately.

B. Roads and Parking

Asphalt site roads and parking will be provided for access, operation and maintenance as shown on the General Arrangement drawing. Alternative access, if required by local regulations, will be provided as shown on the general arrangement drawing.

C. Site Area Paving

Areas within the power block will be surfaced with concrete or gravel as shown on the General Arrangement drawing. All roads will be paved with asphalt unless specifically shown otherwise on the General Arrangement. The roads will be designed in general accordance with the recommendations presented in the Geotechnical Report and designed to withstand the loading conditions.

Site roads will be provided that will conform to the following:

Operating speed of 10 miles per hour.

Minimum road width of 12 feet, with 2-foot shoulders.

AASHTO HS-20-44 loading conditions (minimum requirement).

Maximum transverse gradient of 2 percent.

D. Wetlands Protection

The Contractor will comply with requirements specified by any laws, codes, and permits.

E. Landscaping and Fencing

Any detailed landscape design, fine grading, furnishing and placement of trees, shrubbery, and/or grass, will be provided by the Company. Any embankment area around the perimeter of the switchyard and any unpaved areas on site will be gravel. The Contractor will restore to its original condition any offsite area that is disturbed during construction.

Contractor will furnish and install temporary chain link fencing around the contractor parking area as shown on the Construction Laydown, Staging, and Parking Plan. Contractor will also furnish and install a gate at the new site entrance point. The gate will serve as both the construction entrance gate and the permanent site entrance gate following completion of construction. The gate shall be a new 25-foot-wide automatic slide

main gate, with a keypad for vehicle use. A temporary guard house shall be placed at the permanent site gate during construction. Following completion of construction, the temporary guard house shall be removed.

4.3 Structural Design

A. Codes and Standards:

The 2010 New York State Building Code and local/state-building codes will be incorporated into the design of building and structures. Steel structures will be designed in accordance with the design specifications for structural steel buildings published by the American Institute of Steel Construction (AISC). Reinforced concrete structures will be designed in accordance with the design requirements for concrete buildings and structures published by the American Concrete Institute (ACI).

Allowable variances and applicable local code interpretations will be established before project commencement.

Additionally all plant areas and structures will be designed and configured to meet OSHA requirements contained in Part 1910 of the U.S. Code of Federal Regulations.

B. Steel Structure Design and Fabrication:

The design and fabrication of the supporting steel structures shall comply with the New York State Electric and Gas Corporation's "Structures, Material Requirements for Substation Structures" specification requirements. (Ref. Specification SP-1 252).

The structures shall include but not be limited to the following:

Qty.	Description
5	115kV deadend structures per NYSEG structure type SMDE-3-25.
26	115kV disconnect switch supports
5	115kV CCVT supports (for 3 CCVT's)
3	115kV CCVT supports (for single CCVT)

1 Lot	115 kV bus support insulators

The Vendor shall perform a structural analysis of all steel structures designed and shall submit the same to the Engineer for approval.

The Vendor shall submit material and fabrication specifications to the Engineer for approval.

Structure used to support manufacturer supplied equipment shall comply with the manufacturer's suggested (recommended) support design.

C. Loads and Load Combinations

1. Dead Loads

Dead loads will consist of the weight of all permanent construction including, but not limited to, fixed equipment, framing, bus work, and any other structures, contents of transformers, etc.

2. Seismic Loads

All equipment will be designed to withstand the seismic loading requirement specified in the governing building code for the specified seismic zone

In addition, equipment anchorages and supports will be designed to prevent overturning, displacement and dislocation in accordance with governing building code requirements.

3. Wind Loads

Wind pressures and shape factors will be applied to all system components and exposed equipment in accordance with governing building code.

Allowances will not be made for the effect of shielding by other structures.

4. Snow Loads

The overturning moment calculated from wind pressure will not exceed two thirds of the dead load resisting moment. The uplifting forces calculated from the wind

pressure will not exceed two thirds of the resisting dead loads and adequate structure-foundation ties will be designed to resist wind forces.

Snow loads, including potential drifting, will be applied to all buildings, structures and exposed equipment in accordance with the governing building code using IBC 2009 and ASCE 7-05.

5. Ice Loads

Ice loads will be applied to all structures and exposed equipment in accordance with the governing building code using IBC 2009 and ASCE 7-05.

6. Other Loads

Other expected loads (short circuit loads, etc) required to predict the response of structures will be considered where appropriate.

Proper load combinations will be used for structural steel and reinforced concrete to comply with the applicable codes and standards and with vendor requirements.

7. Structural Steel

Nonheaded anchor bolts will conform to ASTM A 1554 Grade 36, unless higher strength bolting materials are required by design. Exterior exposed anchor bolts that are not high-grade fine thread will not be hot dipped galvanized.

The galvanized coating used on switchyard steel structures shall have an average thickness of 5 mils with no point being less than 4 mils.

D. Foundation Design:

1. Structural Concrete

Foundation design shall comply with the requirements of New York State Electric and Gas Corporation's "Foundations Standard Requirements" Specification unless otherwise indicated. (Ref. Specification SP-1445)

Concrete design shall comply with the requirements of the New York State Electric and Gas Corporation's "Materials Specification for Concrete" specification unless otherwise indicated. (Ref. Specification TD-1070)

The Vendor shall design and install foundations all switchyard equipment and structures including but not limited to the following:

- 115kV circuit breakers
- 115 kV disconnect switches
- 115 kV bus supports
- 115 kV CCVT instrument transformers
- 115kV Metering Equipment
- 115 kV transmission line dead end structures and turning towers
- Switchyard outdoor lighting standards
- Relay and control house
- Lightning Masts

All foundations shall be reinforced concrete spread footings or augur type drill caissons. The Vendor shall be responsible for providing the reaction forces at the top of the foundation for the transformer dead-end structures to the Owner.

Anchor bolt diameters, material and projection above the concrete shall be specified by the Vendor. The Vendor shall provide the anchor bolt location drawings and templates for field installation of the anchor bolts.

The Vendor shall submit foundation design calculations and drawings to the Engineer for approval.

4.4 Wire and Cable

Wire and cable design requirements and material requirements shall be in accordance with the following specifications:

LATER	Control Cable
LATER	Instrument Cable
LATER	LV Power Cable
LATER	Wire and Cable Installation

4.5 Cable Raceways

Cable raceway design and material requirements shall be in accordance with the following specifications:

LATER	Conduit
LATER	Embedded Conduits, Underground Ductbanks & Trenches
LATER	Cable Tray

5. TESTING

5.1 General

A. The requirements of this clause shall be met in conjunction with the other sections of the Engineering Requisition.

B. All inspection/tests to be performed during manufacture, fabrication and trial operation shall be as stated in the Engineering Requisition.

C. Where no specific test is mentioned, the various materials and equipment shall be tested in accordance with the appropriate standards, or other recommendations. Where no appropriate standard is available, tests shall be carried out in accordance with manufacturer's standard, subject to the prior approval of the Owner/Engineer.

D. Before commencement of any test, copies of relevant drawings and documents shall be submitted to the Owner/Engineer and approval obtained.

E. Switchyard testing shall include Doble, Ductor and Thermal Imaging tests.

5.2 Test Certificates

All principal test records, test certificates and performance details for all tests carried out in accordance with the provisions of this Contract shall be supplied to the Owner/Engineer. These test records, certificates and performance details shall be supplied for all tests, whether or not the Engineer has witnessed them. The information given on such test certificates and performance details shall be sufficient to identify the material or equipment to which the certificate refers. Certificates shall also bear the contract reference and heading.

5.3 Tests at Site

These tests shall be carried out for different equipment, material and systems prior to and during commissioning of the switchyard. The Vendor shall submit a detail test schedule including the procedure for the site tests for Owner/Engineer's approval.

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6. ADDITIONAL INFORMATION

TYPICAL VALUES FOR MAJOR SWITCHYARD EQUIPMENT

Power Circuit Breakers:

4.2.1	a.	Type	Dead Tank SF6 Gas
	b.	Rated Voltage	123 kV rms Rated Maximum Voltage
	c.	Basic Insulation Level	550 kV
	e.	Rated Continuous Current	2000 A rms
	f.	Rated Interrupting Current	40 kA sym. rms
	g.	Rated Interrupting Time	3 cycles
	j.	Frequency	60 Hz
	k.	3-Second Short Time Current Carrying Capability	40 kA sym. rms

Disconnect Switch:

4.2.2	a.	Nominal Voltage	115 kV
	b.	Rated Maximum Voltage	121 kV
	c.	Type	3-Phase Group Operated
	d.	Current Rating	2000A Continuous, 100kA Momentary
	h.	BIL	550 kV
	i.	Frequency	60 Hertz

APPENDIX A – SITE SPECIFIC DATA

Location	Reading, NY
Project Name	caes pROJECT
Site Conditions	
Max Dry Bulb Temperature (°F)	86
Coincident Wet Bulb Temperature (°F)	71
Winter Dry Bulb Temperature (°F)	-2
TOP OF CONCRETE (TOC) Elevation, (feet above mean sea level)	TBD
FROST LINE, in	54
Soil Type	CLAY, SILT, MAINLY SAND AND GRAVEL
ALLOWABLE SOIL LOAD BEARING CAPACITY	3000 PSF
Precipitation	
24 hr. Maximum, 25 Year Storm (in)	4.5

Wind Loading

DESIGN CODE	2010 NEW YORK STATE BUILDING CODE
WIND ZONE	C
Basic Wind Speed	90 mph
Occupancy Category	iii
Exposure Category	C
Importance Factor	1.15

Seismic

Design Code	2010 NEW YORK STATE BUILDING CODE
SITE CLASS	C
Seismic DESIGN CATEGORY	B
SITE COEFFICIENT	Fa=1.6, fv=2.4
Seismic Coefficient	Ss=0.2, Sl=0.006
IMPORTANCE FACTOR	1.25

SNOW LOAD

DESIGN CODE	2010 NEW YORK STATE BUILDING CODE

BASIC SNOW LOAD	Pf=25 psf
IMPORTANCE FACTOR	1.10

WorleyParsons
resources & energy

EcoNomics

NEW YORK STATE ELECTRIC & GAS
COMPRESSED AIR ENERGY STORAGE PROJECT

Electrical Engineering

Interconnect (POI) Switchyard Design Criteria

Document: CAES-1-DB-023-0002

Revision: A

Date: September 2011

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COMPRESSED AIR ENERGY STORAGE PROJECT
ELECTRICAL ENGINEERING
INTERCONNECT (POI) SWITCHYARD DESIGN CRITERIA

Disclaimer

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1. SCOPE

1.1 Background

The Compressed Air Energy Storage (CAES) plant will consist of a separate, electrically driven compression cycle and a natural-gas fired expansion cycle to generate electricity. The CAES plant will use off-peak electricity to compress air into an underground reservoir. When electricity is needed, the compressed air is withdrawn, heated, and passed through an expansion turbine to generate power.

The CAES generated power will flow through the Plant Switchyard, through a 0.7 mile , 115kV single circuit, transmission line commencing at the Plant Switchyard and ending at the Interconnect (POI-Point of Interface) Switchyard where it will interface with existing 115kV NYSEG transmission lines 967 and 970. Existing transmission lines 967 and 970 run from the AES Greenidge Station to the Montour Falls Station. The Interconnect (POI) switchyard shall be outdoor, open-air, breaker-and-a-half type arrangement.

The Scope of this document is for the Interconnect (POI) switchyard. The Plant Switchyard Design Criteria is described in document CAES-1-DB-023-0003.

1.2 Equipment To Be Provided

A. The switchyard shall consist of the following major equipment:

Equipment	Quantity
• 123kV Class Deadtank SF6 High Voltage Circuit Breakers.	10
• Center Break Disconnect Switches:	27
• Surge Arresters, 115 kV System Voltage	18
• 1-phase CCVT, 115kV System Voltage	20
• Overhead Lightning Protection System	1 Lot
• Switchyard Relay and Control System	1 Lot

Equipment	Quantity
• Extended Range Metering Equipment for CAES Plant Power, 1-Phase	3
• Switchyard AC Distribution System	1 Lot
• Primary and Backup Battery, (2) Battery Chargers, UPS and DC Distribution Panels	1 Lot
• Aluminum Tubular Bus and Accessories. Main bus conductor size is 3" AL Sch 40, 6061-T6.	1 Lot
• 550 kV BIL Suspension Insulators with deadend ACSR Cable Terminators	1 Lot
• 550kV BIL Station Post Type Bus Support Insulators	1 Lot
• Underground and above grade raceway system for use by both the Vendor for installing his cable within the switchyard.	1 Lot
• Switchyard lighting system	1 Lot
• Control and Instrumentation Signal Interface	1 Lot
• Switchyard Miscellaneous equipment (conductor, connectors, etc.)	1 Lot

• Steel Structures for outgoing lines terminations, equipment and bus supporting system	1 Lot
• Foundations for all structures and equipment	1 Lot
• Grounding System	1 Lot
• Fencing, Gates, Grading , Retaining Walls, Soil Erosion and Sedimentation Control, and Yard Surfacing	1 Lot
• Foundation Excavation, Backfill, and Compaction	1 Lot
• Switchyard Control House complete with lighting.	One

2. CODES AND STANDARDS

A. The latest edition and published addenda of the following publications in effect on the date of Contract Award are a part of this Section. All equipment furnished and work performed shall comply with the approved standards, specifications, regulations, codes and tests of the following:

1. ANSI American National Standards Institute
2. ASME American Society of Mechanical Engineers
3. FERC Federal Energy Regulatory Commission
4. IEEE Institute of Electrical & Electronics Engineers

- IEEE C37.04, “IEEE Standard Rating Structure for AC High-Voltage Circuit Breakers”.
- IEEE C37.06, “IEEE Standard for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis-Preferred Ratings and Related Required Capabilities for Voltages Above 1000V”.
- IEEE C37.09, “IEEE Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis”.
- IEEE C37.012, "IEEE Application Guide for Capacitive Current Switching for AC High-Voltage Circuit Breakers".
- IEEE C37.016, "IEEE Standard for AC High-Voltage Circuit Switchers rated 15.5kV through 245kV".
- IEEE C57.13, “IEEE Standard Requirements for Instrument Transformers”.
- IEEE C57.19.00, “IEEE Standard General Requirements and Test Procedure for Power Apparatus Bushings”.

- IEEE 605-2008, "IEEE Guide for Bus Design in Air Insulated Substations".
- IEEE 80-2000, "IEEE Guide for Safety in AC Substation Grounding"
- IEEE 998-1996, "IEEE Guide for Direct Lightning Stroke Shielding of Substations"
- IEEE 1410-2010, "IEEE Guide for Improving the Lightning Performance of Electric Power Overhead Distribution Lines"
- IEEE 1243-1997, "Guide for Improving the Lightning Performance of Transmission Lines"
- IEEE 485-1997, "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications"
- IEEE 450-2002, "IEEE Recommended Practice for Maintenance, Testing and Replacement of Vented lead-Acid Batteries for Stationary Applications"
- IEEE C2-2007, National Electrical Safety Code

5. IES Illuminating Engineering Society

6. NBC National Building Code

7. NERC North American Electric Reliability Corporation

- NERC CIP Standards

8. NPCC Northeast Power Coordination Council, Inc.

- Directory #1 "Design and Operation of the Bulk Power System"
- Directory #4 "Bulk Power System Protection Criteria"

9. NYSEG New York State Electric & Gas

- SPR-980 "115kV Point of Interconnection Station Guide"
- Bulletin 86-01 "Requirements For The Interconnection of Generation, Transmission and End-User Facilities".
- NYSEG Substation Layout Drawing SLE-BHAANA for 115kV breaker-and-a-half configuration.
- NYSEG Specifications and Standards

10. NEMA National Electrical Manufacturer's Association

- MG-1, “Motors and Generators”

11. REA Rural Electrification Act

- 1724E-300, "Design Guide for Rural Substations"

B. In the event of any conflict between codes, or between Specifications and codes, the more stringent regulation shall apply.

3. DESIGN AND CONSTRUCTION FEATURES

3.1 Terminal Points

Terminal points listed below and further indicated in the enclosed drawings are indicative only. The Vendor shall determine the exact terminal point arrangements in coordination with the interfacing Vendor/agencies/utility company.

- 115kV dead end structures to interface with existing NYSEG transmission lines 967 and 970– (4) locations
- 115kV dead end structure for Isolation Breaker –(1) location
- For control and signaling between the Interface Switchyard and the Plant Switchyard the terminal point shall be the fiber optic communication cables in the OPGW located on the 115kV dead end structure for the Isolation Breaker. (1) location.

3.2 Design Requirements

A. General:

All equipment and material furnished shall meet the following general requirements:

- Utility Interconnection Requirements as stated in NYSEG specification SPR-980.
- Breaker-and-a-half arrangement with 9 total breakers per NYSEG standard SLE-BHAANA.
- NYSEG/RGE requires an isolation breaker. Ownership of the isolation breaker will be transferred to the CAES Plant Owner. NYSEG/RGE must have the ability for emergency trip and lockout of the isolation breaker. NYSEG/RGE will not have the capability to close the isolation breaker. The isolation breaker shall be located immediately adjacent to the Interconnect Switchyard (POI Station).
- Interconnect Switchyard shall be designed such that it can easily be made to meet NPCC Bulk Power System Protection Criteria. This means that each element of the 115kV station is to be protected by two independent protection groups, the groups must be physically separated and no common failure can disable both systems.

- Conform to the requirements REA Bulletin 1724E-300 for outdoor switchyard equipment and materials. These are minimum requirements and are superseded by any more stringent requirements mentioned in this specification.
- Overall space limitations as indicated in the Drawings.
- Sufficient aisle space for operation, maintenance and removal/replacement of equipment.
- A clear space of at least 10 feet must be maintained on the exterior of all fences. Switchyard buildings may be no closer than 15 feet from the fence.
- The Interconnect Switchyard may not be located on a NYSEG/RGE Right of Way.
- Conform interphase spacing and clearance to the recommended NYSEG standards, unless larger dimensions are indicated.
- Be suitable for the application and not overstressed mechanically or electrically.
- Instrument transformers used for revenue metering applications in New York must be PSC (Public Service Commission) approved. The following PSC website contains a list of approved devices: http://www.dps.state.ny.us/approved_meter_list.pdf.
- All equipment furnished shall perform satisfactorily under the stipulated site conditions stated in an attachment included with the Engineering Requisition.
- All Local, State and National codes and standards.

B. Switchyard Equipment:

1. The 123kV Class circuit breakers shall be provided with dual tripping coils rated for the DC control voltage stated in the Engineering Requisition.
2. Synch-check facilities shall be provided for the switchyard circuit breakers.
3. The 123 kV equipment and connections shall be designed to withstand without damage or distortion the stresses caused by an electrical fault having the maximum fault level specified in the Engineering Requisition (ac rms symmetrical) for 3 seconds.

4. The 123 kV circuit breakers shall be capable of interrupting maximum fault current and line charging currents.

5. Full electrical interlocking facilities shall be provided for the circuit breakers and disconnect switches to ensure safe operation of the equipment under all service conditions.

6. Surge Arrestors shall be sized as follows: If the system is effectively grounded for all single contingencies, i.e. the system Ro/X1 < 1 and X0/X1 < 3; then use a 96kV rated arrester with a 76kV MCOV. If the system is not effectively grounded, use a full voltage 120kV arrestor with a 98kV MCOV.

7. Any equipment required to meet NERC Cybersecurity (CIPS 2-9) must be installed.

8. Extended range revenue metering CT's are required.

C. Bus System:

1. The tubular bus system shall be as per NYSEG 115kV Standard Module drawing SME-AFT-SD which uses 3" AL, Sch 40 , 6061-T6 bus as the main conductor. The bus conductor system shall be verified to not exceed the bus conductor limits as specified on NYSEG drawing SUO-CCA-05. The sag under any loading conditions shall not exceed 1/2 the diameter of the bus tubing.

2. Incoming shield wires shall contain fiber optic conductors for data communication.

3. The loading and strength to be used in designing the aerial line shall comply with Grade B loading criteria of Section 26 of the National Electric Safety Code (NESC) . For calculating conductor tension the total load on the wire or conductor shall be the resultant of a vertical and a horizontal load component calculated at the applicable temperature plus the corresponding constant given in Table 250-1 of the NESC. The Vendor shall provide the Engineer/Owner with copies of the conductor sizing and sag engineering calculations for approval to support this bus design. The vertical load component on a wire or conductor shall be the weight of the conductor plus the weight of any spacers, or equipment that it supports and ice where required by Rule 250 of the NESC. The horizontal load component on a wire or conductor shall be the horizontal wind pressure as determined under Rule 250, or 25.6 psf (whichever is greater) applied at a right

angle to the direction of the line using the projected area of the conductor, spacers or equipment that it supports and ice where required by Rule 250 of the NESC. Insulators used on the aerial line shall meet the requirements of Section 27 of the NESC. Arial insulators shall be non-ceramic.

D. Clearances:

The clearances shall be per NESC and NYSEG requirements.

E. Switchyard Control and Metering Concept:

1. General Notes and Comments:

The interface for the control and monitoring of 115kV switchyard components shall be from the following locations:

- Local at the equipment
- Switchyard Control Panel (SCP)
- SCADA System

2. Disconnect Switches:

All command operations shall be initiated either locally at the equipment or remotely. When both the upstream and downstream disconnect switches associated with a breaker are open, that breaker shall be allowed to operate in a “LOCAL” mode. For normal operation of a breaker to be allowed, both the upstream and downstream disconnect switches associated with a breaker must be closed. Mechanical indication of the disconnect switch position shall be visible locally at the equipment. Status contacts for both open and closed position feedback of the disconnect switches shall be provided for use by the switchyard control panel (SCP) and the switchyard SCADA system.

3. Open Commands:

The motor operated disconnect switches shall have the capability to be opened at any time, local at the Disconnect Switch Local Control Panel (DSLCP) if its associated circuit breaker is open (no load operation only). It shall be able to be opened remote from the Switchyard Control Panel (SCP) or remote via the SCADA systems if its associated circuit breaker is open (no load operation only).

4. Close Commands:

The capability of issuing a motor operated disconnect switch closure command shall be dependent upon location as well as disconnect status. Local/Remote (L/R) selector switch(es) shall be incorporated into each Disconnect Switch Local Control Panel (DSLCP) and the Switchyard Control Panel (SCP) to ensure that any switch closing operation can be initiated from only one location at a time. For each L/R switch a separate status contact shall be required.

a. Local at the Motor Operated Disconnect Switch (DSLCP):

A close command can only be initiated at the switch, if the L/R switch on the disconnect switch local operator panel is in LOCAL mode and the associated circuit breakers are open. If the associated circuit breaker is closed, the local close command is inactive. All other interlocks shall be by-passed in this mode.

b. Switchyard Control Panel (SCP):

All the motor operated disconnect switches shall be capable of being closed if the associated circuit breaker is in the Open position, and the L/R switch on the Disconnect Switch Local Control Panel (DSLCP) is in Remote mode and the L/R switch on the Switchyard Control Panel (SCP) is in Local mode.

c. SCADA:

All the motor operated disconnect switches shall be capable of being closed if the associated circuit breaker is in the Open position and the L/R switch on the Disconnect Switch Local Control Panel (DSLCP) is in Remote mode and the L/R switch on the Switchyard Control Panel (SCP) is in Remote mode.

5. Circuit Breakers:

The circuit breakers shall be controlled as indicated below. Hard-wired permissives and interlocks are the responsibility of the Vendor. Status contacts for both open and closed position feedback of each of the circuit breakers shall be provided at the switchyard control panel and the SCADA system.

6. Open Commands:

The circuit breakers shall have the capability to be opened at any time, local at the Circuit Breaker Local Control Panel (CBLCP), remote from the Switchyard Control Panel (SCP) or remote via the SCADA systems.

7. Close Commands:

The capability of issuing a circuit breaker closure command shall be dependent upon location as well as disconnect status. Local/Remote (L/R) selector switch(es) shall be incorporated into each Circuit Breaker Local Control Panel (CBLCP) and the Switchyard Control Panel (SCP) to ensure that any breaker closing operation can be initiated from only one location at a time. For each L/R switch a separate status contact shall be required.

a. Local at the Circuit Breaker (CBLCP):

A close command can only be initiated at the breaker, if the L/R switch on the circuit breaker local operator panel is in LOCAL mode and the associated disconnect switches are closed. If the disconnect switches on either side of the circuit breaker are open, the local close command is inactive. All other interlocks shall be by-passed in this mode.

b. Switchyard Control Panel (SCP):

All the circuit breakers shall be capable of being closed if the disconnect switches on either side of the respective circuit breaker are in Closed position, and the L/R switch on the Circuit Breaker Local Control Panel (CBLCP) is in Remote mode and the L/R switch on the Switchyard Control Panel (SCP) is in Local mode and the appropriate switchyard synchronizing check relay permissive is energized and all lockout relays are reset.

c. SCADA:

All the circuit breakers shall be capable of being closed if the disconnect switches on either side of the respective circuit breaker are in Closed position and the L/R switch on the Circuit Breaker Local Control Panel (CBLCP) is in Remote mode and the L/R switch on the Switchyard Control Panel (SCP) is in Remote mode and the appropriate switchyard synchronizing check relay permissive is energized and all lockout relays are reset.

F. Annunciation:

The Switchyard Control Panel (SCP) shall have audiovisual annunciators. Any abnormality in the switchyard equipment and its auxiliary systems shall be annunciated at the Switchyard Control Panel. Group alarm (pretrip and trip) for each circuit and strategic auxiliary system shall be wired to the interface terminal panel for remote alarm via SCADA. The trip circuits of each circuit breaker and the lockout relay coils shall be supervised and alarmed at Switchyard Control Panel.

G. SCADA Interface Requirements

1. The interface for discrete contacts shall be defined as alarms, status, or control.

2. A RTU (Remote Terminal Unit) is required for SCADA. The RTU will be specified and commissioned by NYSEG/RGE.

3. Interconnect Switchyard breaker amperes will be derived from an SEL-351-6 relay dedicated to each breaker.

4. The RTU must be powered from the substation battery. A 4-wire leased telephone facility will need to be ordered and procured by the Interconnect Switchyard Owner. The telephone equipment must be powered by the station battery. The RTU control output contacts are normally open contacts. When a control sequence is initiated, the normally open contact will close momentarily for 250 ms (1000ms for RGE) and then reopen. This applies to both trip and close controls for the circuit breakers. Status points use a dry "a" contact (wetting voltage supplied by the RTU) to indicate the state of a circuit breaker.

5. It is the Interconnect Switchyard Vendor's responsibility to determine if NYISO plant dispatch information is to be supplied through the Interconnect (POI) Station RTU in DNP 3.0 Protocol or via a separate Plant Switchyard RTU.

6. All I/O point contacts shall be identified on vendor drawings and shall include the appropriate I/O point tags. These point tags shall be provided during the review cycle.

7. As a minimum, the wiring interface for analog and digital terminations shall occupy opposite sides of the cabinet and separated from all other control and protection wiring. All wiring shall utilize twisted shielded pairs with an overall shield for multiple pair cables. All shields shall be terminated next to their respective signal wire terminations.

8. Responsibility for designing the control and automation strategy for the switchyard shall remain with the switchyard Vendor. All documentation for modulating and discrete control and all equipment operating sequence requirements to be implemented in the SCADA system shall be provided by the switchyard Vendor. After review and approval by the Engineer/Owner, this control and sequencing strategy shall be implemented. A design review meeting between NYSEG, the switchyard Vendor and NYISO shall be held.

9. The switchyard Vendor shall provide the following documentation to support the implementation of the switchyard control strategy:

   a. I/O List

      Prepare a list of all inputs and outputs required between the switchyard and the SCADA system. The I/O list shall indicate all points to be included in the Sequence of Events (SOE) recording system.

b. Control Logic Diagrams

The switchyard Vendor shall prepare drawings defining the control logic for the supplied equipment. The control logic drawings shall include complete definition of all modulating and discrete control logic for all supplied equipment. Modulating and discrete control logic diagrams shall be provided as separate drawings.

All control and monitoring signals associated with the switchyard equipment shall be included with all permissives and interlocks for safe and efficient operation of the equipment in all operating conditions, both normal and emergency. All sensors, indicators, alarms, setpoints, control commands, final elements, control switches, and other operator interface elements shall be included.

The drawings shall include both hardwired control elements provided by the switchyard Vendor for local operator interface and control, and control elements to be implemented in the software of the SCADA system. The drawings shall clearly indicate portions of the control logic implemented in the field control elements provided by the switchyard supplier and portions of the control logic to be implemented by SCADA.

10. Control & Protective Relaying

a. The transmission line connecting the Plant Switchyard and the Interconnect switchyard shall require two sets of high speed protection. Since this will be new line construction, fiber will be used for both high-speed protection systems. Current differential relaying will be provided for the "A" and "B" relay packages.

b. There will be two independent groups covering each zone of protection. These groups may be of the same manufacturer but should not utilize the same technology. The schemes shall be physically separated.

c. ANSI C800 relay accuracy CT's are used for protective relays unless otherwise specified.

d. Control and Protective relaying shall be located within the Pre-Engineered Metal Control House to be supplied by the Vendor.

e. The Vendor shall be responsible for all internal panel wiring as well as between the panels and between panels field devices.

f. The Vendor shall design, supply, factory test, deliver to site, unload and store at site install, test and commission one set of control and relay panels for the switchyard containing the devices shown on the one-line diagrams and other drawings and documents included with the Engineering Requisition and as required by the Owner.

3.3 Low Voltage AC Power Distribution System

A. The Vendor shall design, supply, install, test and place in service a low voltage AC power distribution system for the switchyard. The AC Power distribution system for the Interconnect Switchyard shall be two independent house service supplies with an Automatic Transfer Switch (ATS).

B. The low voltage power distribution system shall distribute electrical power for all required functions in the switchyard, including:

1. Circuit breaker charging motors
2. Space heaters
3. Lighting
4. Convenience Outlets at switchyard equipment

C. The Vendor as part of his system design shall ensure that all system protective devices are properly sized and suitably coordinated with other system protective devices to ensure the safety and reliability of the system.

D. All system cable and wiring shall be designed, supplied, installed, tested and placed in service by the Vendor.

E. At a minimum the completed system shall comply with the applicable requirements of the latest edition of the NESC.

3.4 Lighting and Receptacle System

A. The Vendor shall design, supply, install, test and place in service a complete lighting and receptacle system for the switchyard.

B. Unless indicated otherwise, the illumination levels of different areas to be maintained shall be as per the IES standards.

C. Power distribution panels shall comply with the requirements of Specification **LATER**.

D. The lighting and receptacle system shall comply with the requirements of Specification **LATER**.

E. The Vendor shall furnish back-up calculations to justify the number and size of fixtures included in his design, the sizes of all cable and wire included in his design and the sizes of all cable raceways used to circuit illumination system wiring. These calculations shall be subject to Owner/Engineer's approval.

3.5 DC Control Power System

A. The dc system shall be designed to provide reliable power for switchyard equipment control and protection.

B. Two lead-acid station battery systems are required including two separate battery chargers. Each battery system must be capable of supplying the complete emergency load of the station. DC for the independent protection groups shall be fed from physically separate DC panels.

C. The dc system shall be designed and sized in accordance with IEEE 485 as applicable. The battery shall be sized to supply the control power for at least 8 hours after loss of ac power to the battery charger or as required by NERC or NPCC criteria. The Vendor shall develop the load profile to be used in the sizing of the battery and shall submit the battery calculation for review and approval.

D. The dc system shall be operated ungrounded to prevent a single ground fault from disabling the dc system. Provisions shall be provided for checking and alarming for grounds on the positive or negative leads.

E. All circuits shall be properly protected to limit the damage to the faulted circuit.

3.6 Grounding System

A. The Vendor shall design, supply, install, test and place in service a switchyard ground grid as required to cover the entire switchyard area. It shall provide personnel protection from electrical shock and lightning. The Vendor shall measure the soil resistivity and calculate the length of the conductor and cross-section of conductor required for the grounding grid so as to maintain the touch and step voltages within allowable limits. The procedure given in the publication IEEE-80 shall be followed for grounding. The calculation shall be submitted to Engineer for approval.

B. The fault current to be considered in calculation shall be as specified in the Engineering Requisition. The fault clearing time shall be considered as 0.5 second.

C. The grounding resistance of the switchyard shall not be more then 1.0 ohm.

D. The Vendor shall extend the below grade ground grid above grade and connect all steel structures, electrical equipment, overhead static lines and lightning protection downconductor circuits to the grounding system. The Vendor shall provide conductor sizing calculations and installation details to the Engineer for approval.

E. Stranded bare copper conductor shall be used for grounding and unless specifically indicated shall be laid at a minimum 18” below grade unless more depth is required to suit the design requirement and standards and codes.

F. The switchyard area shall be covered with crushed rock as required by the grounding calculations.

3.7 Lightning Protection

A. The switchyard equipment shall be shielded from direct lightning strikes by shield wires and/or lightning masts. The design shall follow the recommendations of IEEE 998-1996, IEEE1410-2010 and IEEE 1243-1997. Vendor's lightning protection design is subject to approval by Owner/Engineer.

B. Lightning arrestors shall be provided on all incoming transmission lines to protect equipment from lightning induced surges.

C. Preliminary estimate of lightning protection equipment also includes the following which is subject to change during Vendor's final design:

1. (4) Lightning Masts for capacitor bank area (if required), 60'height. Reference NYSEG Drawing SMN-LMH-94.

2. Twelve (14) Air Termination Rods, 21 feet height. NYSEG SS #800-795-03. To be located on top of overhead conductor towers.

3.8 Capacitor Bank

A. A capacitor bank, if required, is proposed to be located to the west of the Transmission Right-Of-Way and will consist of four 50MVAR fuseless capacitor groups for a total of 200MVAR. Each 50MVAR capacitor group will be controlled by a circuit switcher. Series reactors shall be provided for each capacitor group to limit back-to-back switching current. It should be noted that the Capacitor bank location is also being considered at the Plant Switchyard.

B. The capacitor bank, if located at the Interconnect Switchyard, will be connected to the switchyard by 285 circuit feet of Crosslinked Polyethylene (XLPE) Solid Dielectric Cable. The 115kV underground bus will be encased in a single steel casing. There will be six 115kV terminators and six lightning arrestors required. The terminators will rest on a stand-alone termination structure. Special engineering considerations will have to be applied when selecting the surge arrestors due to the capacitor bank.

4. CIVIL/STRUCTURAL FEATURES

This section describes the civil, structural, and architectural design basis for the facility's structures, and general civil work. All civil/structural work will be designed in accordance with applicable codes, industry standards, and local, state, and federal regulations. All required local building permits and inspections will be obtained by the Contractor. See Appendix A for Site Specific Data.

4.1 Facility Description

The switchyard will consist of a control house building, bus support structures, transformers, circuit breakers, disconnect switches, surge arresters, ccvt's, and other miscellaneous switchyard equipment.

Surface finishing (roads, ground cover, etc.) for the site will be as indicated on the General Arrangement drawing. The project will be located within a new perimeter fence. Main access to and from the site will be off of the paved main entrance road (Jennings Road).

4.2 Sitework

Civil works design shall comply with the requirements of New York State Electric and Gas Corporation's "Site Development Standard Requirements" Specification unless otherwise indicated. (Ref. Specification SP-1442)

A. Stormwater Management

Assumed stream can collect stormwater and therefore no catch basin needed in preliminary design.

A Stormwater Pollution Prevention Plan (SWPPP) will be developed by the Company for the final stabilized site. The stormwater management plan for use during construction phase and during operation shall be developed by the Engineer with support from specialty engineering services. The intent of the stormwater management plan and the SWPPP will be to preserve the existing pre-development drainage patterns to the extent possible. The plan will include a clean stormwater collection system and an industrial stormwater collection system, consisting of catch basins, piping, a subsurface detention basin, and a suitable water treatment facility as required by the New York Department of Environmental Conservation (DEC). The stormwater collection systems will collect runoff from developed areas of the site and discharge them appropriately.

B. Roads and Parking

Asphalt site roads and parking will be provided for access, operation and maintenance as shown on the General Arrangement drawing. Alternative access, if required by local regulations, will be provided as shown on the general arrangement drawing.

C. Site Area Paving

Areas within the power block will be surfaced with concrete or gravel as shown on the General Arrangement drawing. All roads will be paved with asphalt unless specifically shown otherwise on the General Arrangement. The roads will be designed in general accordance with the recommendations presented in the Geotechnical Report and designed to withstand the loading conditions.

Site roads will be provided that will conform to the following:

Operating speed of 10 miles per hour.

Minimum road width of 12 feet, with 2-foot shoulders.

AASHTO HS-20-44 loading conditions (minimum requirement).

Maximum transverse gradient of 2 percent.

D. Wetlands Protection

The Contractor will comply with requirements specified by any laws, codes, and permits.

E. Landscaping and Fencing

Any detailed landscape design, fine grading, furnishing and placement of trees, shrubbery, and/or grass, will be provided by the Company. Any embankment area around the perimeter of the switchyard and any unpaved areas on site will be gravel. The Contractor will restore to its original condition any offsite area that is disturbed during construction.

Contractor will furnish and install temporary chain link fencing around the contractor parking area as shown on the Construction Laydown, Staging, and Parking Plan. Contractor will also furnish and install a gate at the new site entrance point off of Jennings Road. The gate will serve as both the construction entrance gate and the permanent site entrance gate following completion of construction. The gate shall be a new 25-foot-wide

automatic slide main gate, with a keypad for vehicle use. A temporary guard house shall be placed at the permanent site gate during construction. Following completion of construction, the temporary guard house shall be removed.

4.3 Structural Design

A. Codes and Standards:

The 2010 New York State Building Code and local/state-building codes will be incorporated into the design of building and structures. Steel structures will be designed in accordance with the design specifications for structural steel buildings published by the American Institute of Steel Construction (AISC). Reinforced concrete structures will be designed in accordance with the design requirements for concrete buildings and structures published by the American Concrete Institute (ACI).

Allowable variances and applicable local code interpretations will be established before project commencement.

Additionally all plant areas and structures will be designed and configured to meet OSHA requirements contained in Part 1910 of the U.S. Code of Federal Regulations.

B. Steel Structure Design and Fabrication:

The design and fabrication of the supporting steel structures shall comply with the New York State Electric and Gas Corporation's "Structures, Material Requirements for Substation Structures" specification requirements. (Ref. Specification SP-1 252).

The structures shall include but not be limited to the following:

Qty.	Description
10	115kV deadend structures per NYSEG Drawing SLE-BHAANA structure type SMDE-3-25.
17	115kV disconnect switch supports
15	115kV CCVT supports
1 Lot	115 kV bus support insulators

The Vendor shall perform a structural analysis of all steel structures designed and shall submit the same to the Engineer for approval.

The Vendor shall submit material and fabrication specifications to the Engineer for approval.

Structure used to support manufacturer supplied equipment shall comply with the manufacturer's suggested (recommended) support design.

C. Loads and Load Combinations

1. Dead Loads

Dead loads will consist of the weight of all permanent construction including, but not limited to, fixed equipment, framing, bus work, and any other structures, contents of transformers, etc.

2. Seismic Loads

All equipment will be designed to withstand the seismic loading requirement specified in the governing building code for the specified seismic zone

In addition, equipment anchorages and supports will be designed to prevent overturning, displacement and dislocation in accordance with governing building code requirements.

3. Wind Loads

Wind pressures and shape factors will be applied to all system components and exposed equipment in accordance with governing building code.

Allowances will not be made for the effect of shielding by other structures.

4. Snow Loads

The overturning moment calculated from wind pressure will not exceed two thirds of the dead load resisting moment. The uplifting forces calculated from the wind pressure will not exceed two thirds of the resisting dead loads and adequate structure-foundation ties will be designed to resist wind forces.

Snow loads, including potential drifting, will be applied to all buildings, structures and exposed equipment in accordance with the governing building code using IBC 2009 and ASCE 7-05.

5. Ice Loads

Ice loads will be applied to all structures and exposed equipment in accordance with the governing building code using IBC 2009 and ASCE 7-05.

6. Other Loads

Other expected loads (short circuit loads, etc) required to predict the response of structures will be considered where appropriate.

Proper load combinations will be used for structural steel and reinforced concrete to comply with the applicable codes and standards and with vendor requirements.

7. Structural Steel

Nonheaded anchor bolts will conform to ASTM A 1554 Grade 36, unless higher strength bolting materials are required by design. Exterior exposed anchor bolts that are not high-grade fine thread will not be hot dipped galvanized.

The galvanized coating used on switchyard steel structures shall have an average thickness of 5 mils with no point being less than 4 mils.

D. Foundation Design:

1. Structural Concrete

Foundation design shall comply with the requirements of New York State Electric and Gas Corporation's "Foundations Standard Requirements" Specification unless otherwise indicated. (Ref. Specification SP-1445)

Concrete design shall comply with the requirements of the New York State Electric and Gas Corporation's "Materials Specification for Concrete" specification unless otherwise indicated. (Ref. Specification TD-1070)

The Vendor shall design and install foundations all switchyard equipment and structures including but not limited to the following:

- 115kV circuit breakers
- 115 kV disconnect switches
- 115 kV bus supports
- 115 kV CCVT instrument transformers
- 115kV Metering Equipment
- 115 kV transmission line dead end structures and turning towers
- Switchyard outdoor lighting standards
- Relay and control house
- Lightning Masts

All foundations shall be reinforced concrete spread footings or augur type drill caissons. The Vendor shall be responsible for providing the reaction forces at the top of the foundation for the transformer dead-end structures to the Owner.

Anchor bolt diameters, material and projection above the concrete shall be specified by the Vendor. The Vendor shall provide the anchor bolt location drawings and templates for field installation of the anchor bolts.

The Vendor shall submit foundation design calculations and drawings to the Engineer for approval.

4.4 Wire and Cable

Wire and cable design requirements and material requirements shall be in accordance with the following specifications:

LATER	Control Cable
LATER	Instrument Cable
LATER	LV Power Cable
LATER	Wire and Cable Installation

4.5 Cable Raceways

Cable raceway design and material requirements shall be in accordance with the following specifications:

LATER	Conduit
LATER	Embedded Conduits, Underground Ductbanks & Trenches
LATER	Cable Tray

5. TESTING

5.1 General

A. The requirements of this clause shall be met in conjunction with the other sections of the Engineering Requisition.

B. All inspection/tests to be performed during manufacture, fabrication and trial operation shall be as stated in the Engineering Requisition.

C. Where no specific test is mentioned, the various materials and equipment shall be tested in accordance with the appropriate standards, or other recommendations. Where no appropriate standard is available, tests shall be carried out in accordance with manufacturer's standard, subject to the prior approval of the Owner/Engineer.

D. Before commencement of any test, copies of relevant drawings and documents shall be submitted to the Owner/Engineer and approval obtained.

E. Switchyard testing shall include Doble, Ductor and Thermal Imaging tests.

5.2 Test Certificates

All principal test records, test certificates and performance details for all tests carried out in accordance with the provisions of this Contract shall be supplied to the Owner/Engineer. These test records, certificates and performance details shall be supplied for all tests, whether or not the Engineer has witnessed them. The information given on such test certificates and performance details shall be sufficient to identify the material or equipment to which the certificate refers. Certificates shall also bear the contract reference and heading.

5.3 Tests at Site

These tests shall be carried out for different equipment, material and systems prior to and during commissioning of the switchyard. The Vendor shall submit a detail test schedule including the procedure for the site tests for Owner/Engineer's approval.

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6. ADDITIONAL INFORMATION

TYPICAL VALUES FOR MAJOR SWITCHYARD EQUIPMENT

Power Circuit Breakers:

4.2.1	a.	Type	Dead Tank SF6 Gas
	b.	Rated Voltage	123 kV rms Rated Maximum Voltage
	c.	Basic Insulation Level	550 kV
	e.	Rated Continuous Current	2000 A rms
	f.	Rated Interrupting Current	40 kA sym. rms
	g.	Rated Interrupting Time	3 cycles
	j.	Frequency	60 Hz
	k.	3-Second Short Time Current Carrying Capability	40 kA sym. rms

Disconnect Switch:

4.2.2	a.	Nominal Voltage	115 kV
	b.	Rated Maximum Voltage	121 kV
	c.	Type	3-Phase Group Operated
	d.	Current Rating	2000A Continuous, 100kA Momentary
	h.	BIL	550 kV
	i.	Frequency	60 Hertz

APPENDIX A – SITE SPECIFIC DATA

Location	Reading, NY
Project Name	caes pROJECT
Site Conditions	
Max Dry Bulb Temperature (°F)	86
Coincident Wet Bulb Temperature (°F)	71
Winter Dry Bulb Temperature (°F)	-2
TOP OF CONCRETE (TOC) Elevation, (feet above mean sea level)	TBD
FROST LINE, in	54
Soil Type	CLAY, SILT, MAINLY SAND AND GRAVEL
ALLOWABLE SOIL LOAD BEARING CAPACITY	3000 PSF
Precipitation	
24 hr. Maximum, 25 Year Storm (in)	4.5

Wind Loading

DESIGN CODE	2010 NEW YORK STATE BUILDING CODE
WIND ZONE	C
Basic Wind Speed	90 mph
Occupancy Category	iii
Exposure Category	C
Importance Factor	1.15

Seismic

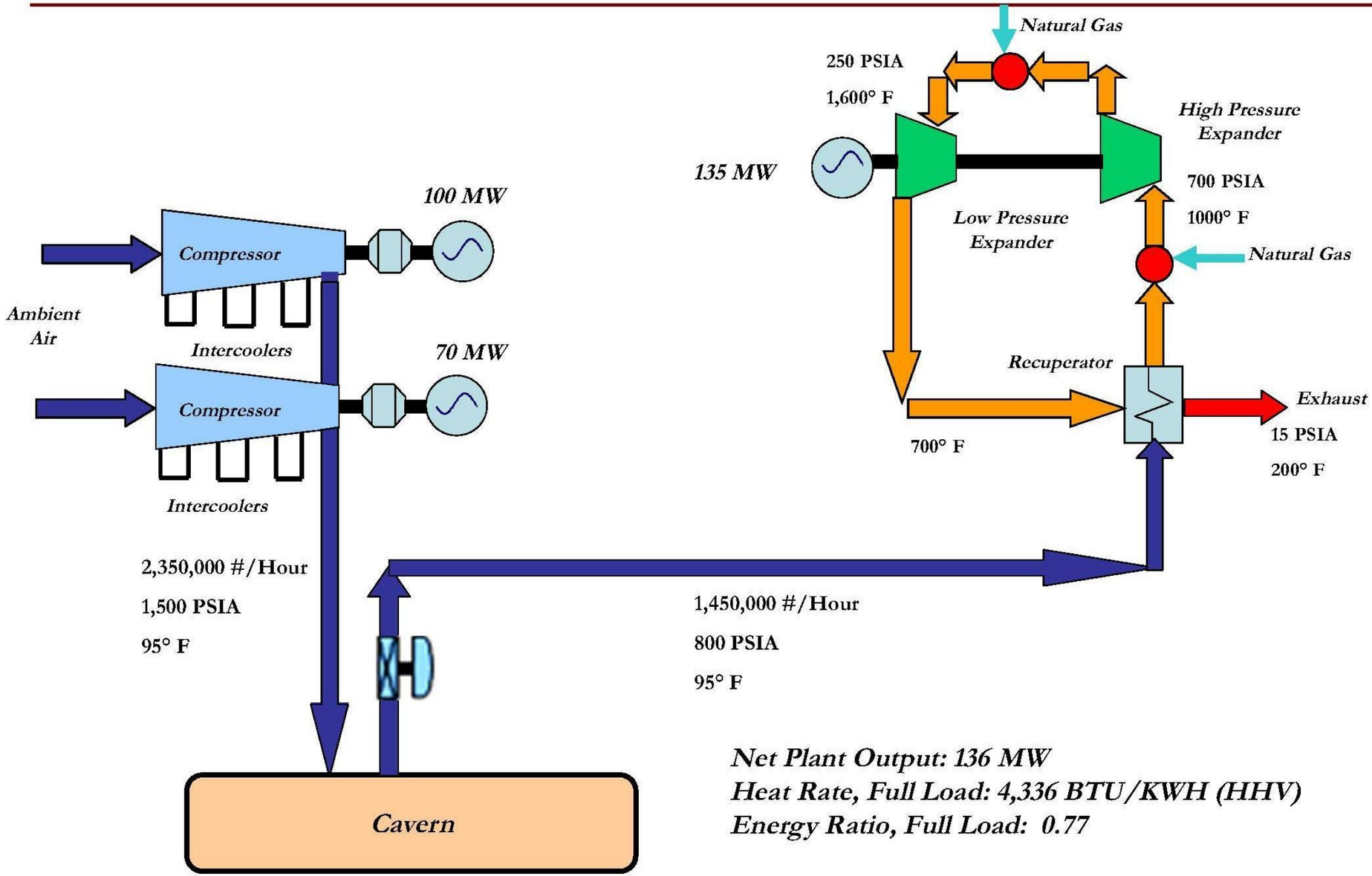
Design Code	2010 NEW YORK STATE BUILDING CODE
SITE CLASS	C
Seismic DESIGN CATEGORY	B
SITE COEFFICIENT	Fa=1.6, fv=2.4
Seismic Coefficient	Ss=0.2, Sl=0.006
IMPORTANCE FACTOR	1.25

SNOW LOAD

DESIGN CODE	2010 NEW YORK STATE BUILDING CODE

BASIC SNOW LOAD	Pf=25 psf
IMPORTANCE FACTOR	1.10

Seneca CAES Project, Cycle #1



Net Plant Output: 136 MW
Heat Rate, Full Load: 4,336 BTU/KWH (HHV)
Energy Ratio, Full Load: 0.77

PRELIMINARY DESIGN

NOTES:

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC	LEAD DISC. ENGINEER	PROJ. ENGR MGR	PROJECT MANAGER
A	12/12/11	ISSUED FOR INFORMATION	JEV	HGE		HGE	HGE		MH

PRELIMINARY STATUS LDE H.G. EISENBISE 12/12/11	DATE	REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.
APPROVED STATUS LDE	DATE	REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: JEV	ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF PE: STATE: LIC. NO.: DATE:
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

OneWay to zero harm

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WorleyParsons resources & energy

CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

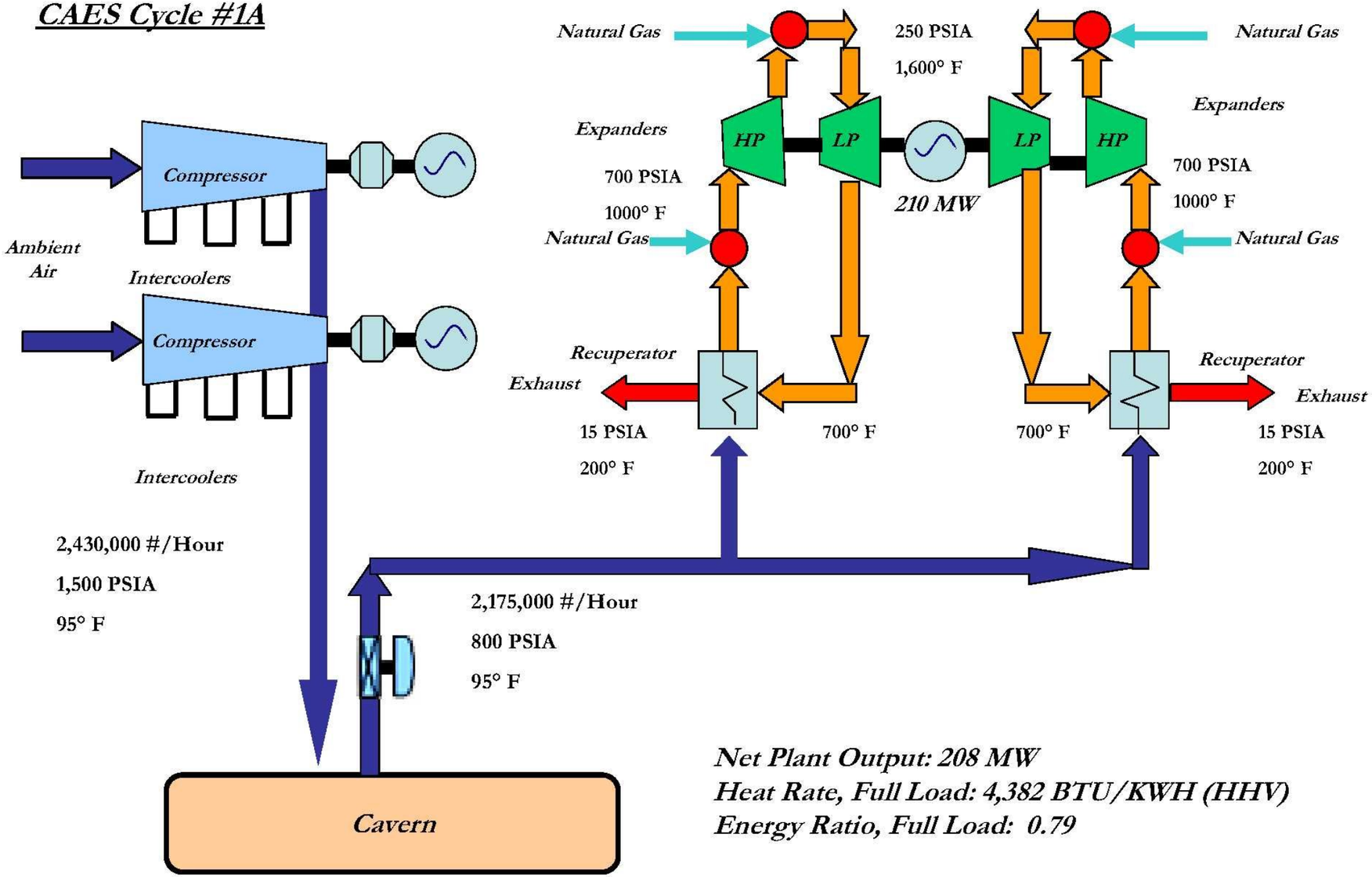
FLOW DIAGRAM
CYCLE 1

SCALE: NONE | DRAWING SIZE: ARCH D (36" x 24")

WORLEYPARSONS DWG. NO.: CAES-1-DW-012-305-001 | REV: A

...\caes-1-dw-012-305-001.dgn 12/12/2011 12:18:11 PM

CAES Cycle #1A



Net Plant Output: 208 MW
Heat Rate, Full Load: 4,382 BTU/KWH (HHV)
Energy Ratio, Full Load: 0.79

PRELIMINARY DESIGN

NOTES:

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/TECH SPEC	LEAD DISC. ENGINEER	PROJ. ENGR. MANAGER	PROJECT MANAGER
A	12/12/11	ISSUED FOR INFORMATION	JEV	HGE		HGE	HGE		MH

PRELIMINARY STATUS — DATE
LDE H.G. EISENBISE 12/12/11
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE
LDE
REPRESENTS REVIEWED AND APPROVED DESIGN, ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL

DRAWN BY: JEV
CHECKED BY: H.G. EISENBISE
LEAD DESIGNER:
ENGINEER/TECH SPECIALIST: H.G. EISENBISE
PROJECT ENGINEERING MANAGER:
PROJECT MANAGER: M. HOLDRIDGE

PROFESSIONAL ENGINEER'S SEAL

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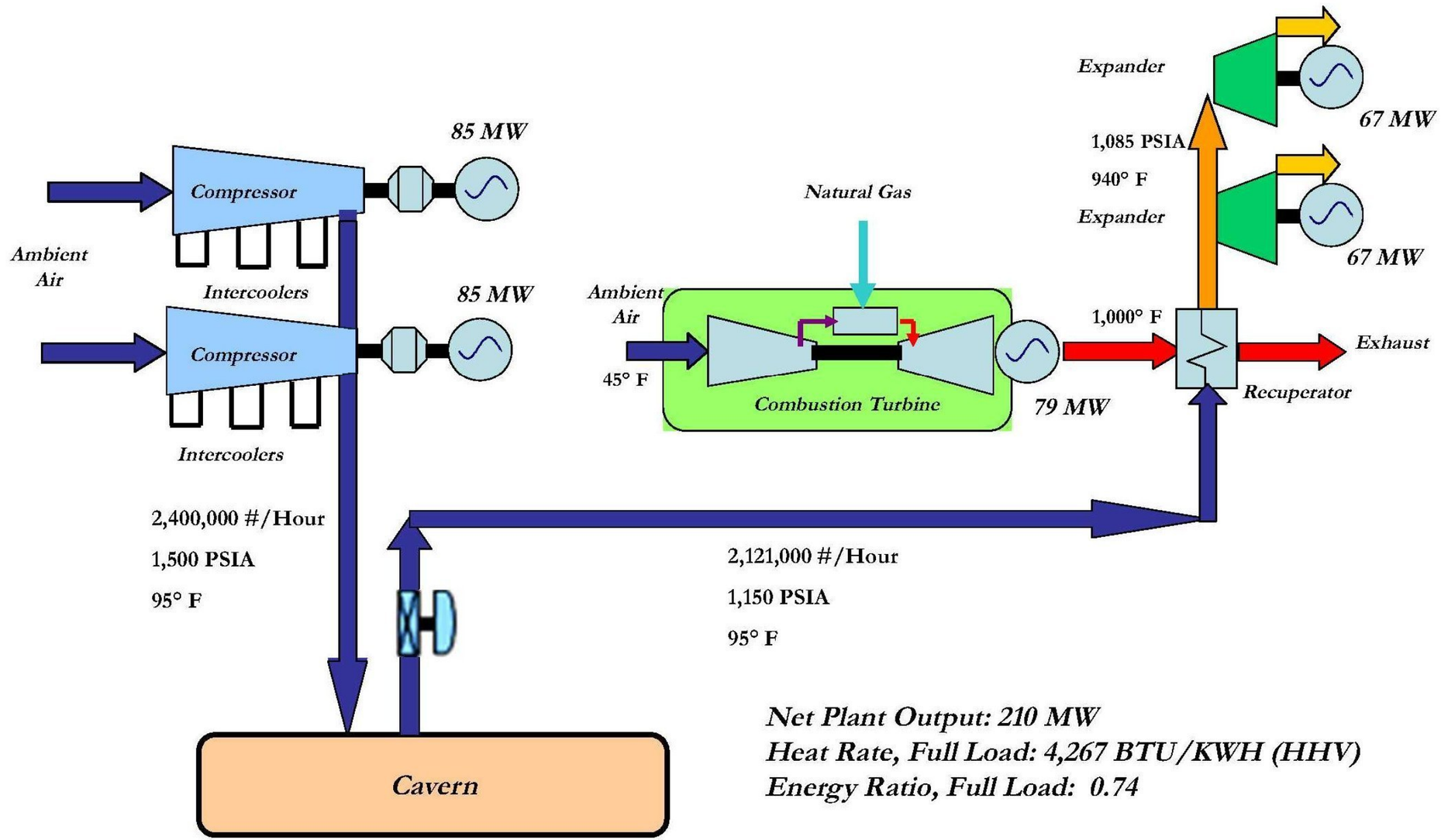
CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

FLOW DIAGRAM
CYCLE 1A

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-012-305-003
REV: A

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Seneca CAES Project, Cycle #2



Net Plant Output: 210 MW
Heat Rate, Full Load: 4,267 BTU/KWH (HHV)
Energy Ratio, Full Load: 0.74

PRELIMINARY DESIGN

NOTES:

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	LEAD DISC TECH SPEC	PROJ ENGR MANAGER	PROJECT MANAGER
A	12/12/11	ISSUED FOR INFORMATION	JEV	HGE		HGE	HGE	MH

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ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: JEV	
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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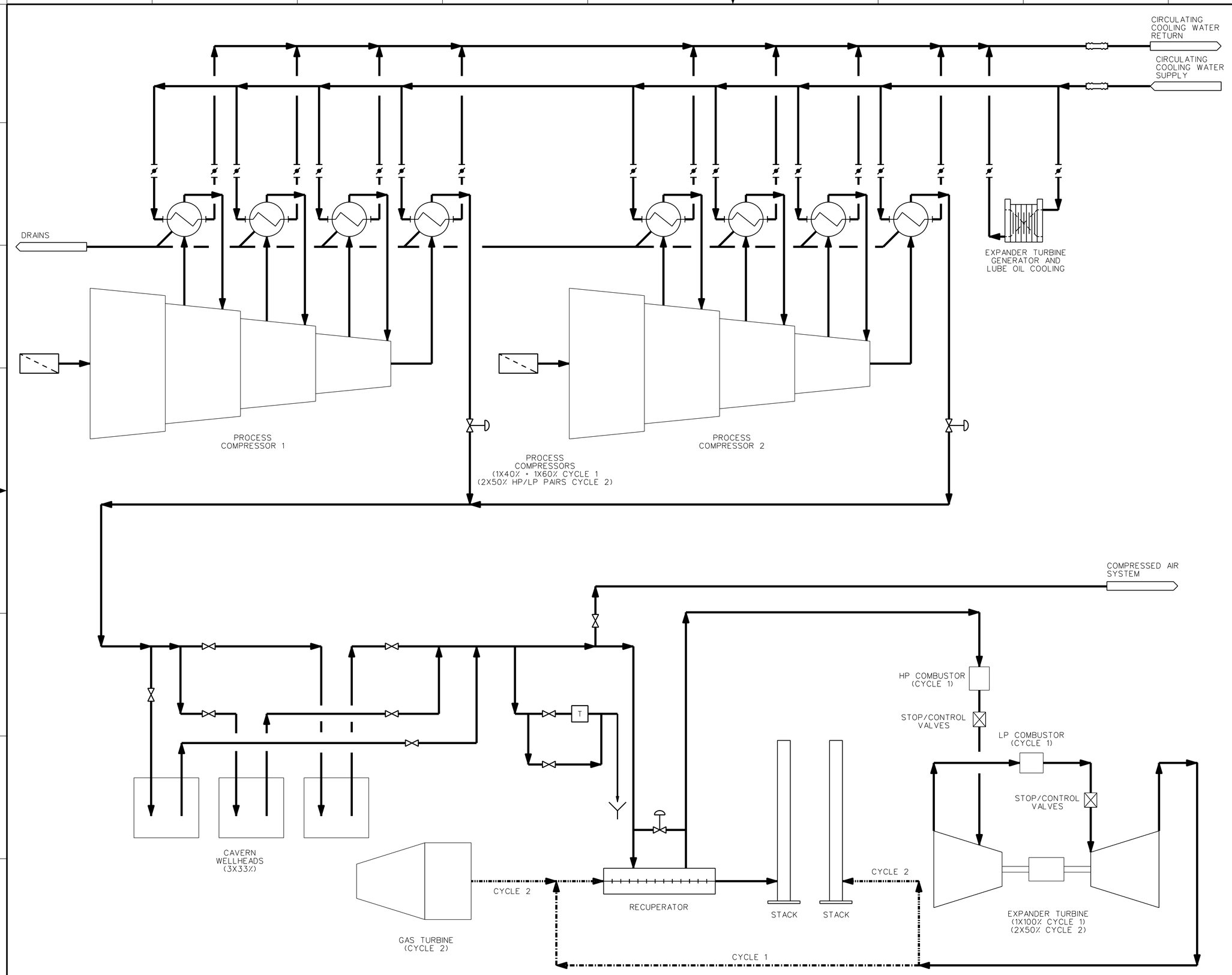
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CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

FLOW DIAGRAM
CYCLE 2

SCALE: NONE — DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-012-305-002 — REV: A

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NOTES:

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	LEAD DISC. ENGINEER	PROJ. ENGR. MANAGER	PROJECT MANAGER
B	10, 11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH

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DRAWN BY: TAD	
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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LIC. NO.: _____ DATE: _____

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CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

BLOCK DIAGRAM
CAES CYCLES

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-022-304-001
REV: B

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Seneca Compressed Air Energy Storage Project

MAJOR EQUIPMENT LIST (CYCLE 1)

The list below is indicative only based on Preliminary Engineering.

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
PROCESS AIR COMPRESSOR EQUIPMENT AND AUXILIARIES						
	AIR COMPRESSOR (DR 5000)	1	**CONFIGURATION:** 1 x 60% **CAPACITY:** 390 lbs/sec (high amb.) **POWER:** 108,000 kW	Dresser Rand	Cycle 1	Datum D24A6 and D16R6B HP/IP centrifugal compressors and Frame 5000 LP Axial Compressor
	AIR COMPRESSOR (DR 4000)	1	**CONFIGURATION:** 1 x 40% **CAPACITY:** 214 lbs/sec (high amb.) **POWER:** 60,000 kW	Dresser Rand	Cycle 1	Datum D20A6 and D14R6B HP/IP centrifugal compressors and Frame 4000 LP Axial Compressor
	AIR COMPRESSOR TURNING GEAR	2	**RATED POWER:** 20 HP	Dresser Rand	Cycle 1	
	AIR INLET ANTI-ICIING SYSTEM	2		Dresser Rand	Cycle 1	
	LUBE OIL SYSTEM	2		Dresser Rand	Cycle 1	Including pumps, reservoir, heater, filters, and coolers.
	LUBE OIL HEATERS	2	**RATED POWER:** 30 kW			
	LUBE OIL MIST SEPARATORS	3	**RATED POWER:** 2.5 kW			3 x 50%
	LUBE OIL CONDITIONER	1	**RATED POWER:** 1 kW			
	MAIN LUBE OIL PUMPS	2	**CONFIGURATION:** 2 x 100% **RATED POWER:** 150 HP			AC Powered
	BACKUP LUBE OIL PUMPS	1	**CONFIGURATION:** 1 x 100% **RATED POWER:** 80 HP			DC Powered
	CONTROL OIL SYSTEM JACKING OIL PUMPS	1	**RATED POWER:** 20 HP	Dresser Rand	Cycle 1	
	INTER/AFTER COOLERS w/ MOSITURE SEPARATORS	10		Dresser Rand	Cycle 1	5 per compressor
	COMPRESSOR LCI SOFT STARTER	1		Dresser Rand	Cycle 1	Single starter for both compressors
	AIR COMPRESSOR NOISE ENCLOSURE	2		EPCM	Cycle 1	
AIR TURBINE GENERATOR EQUIPMENT AND AUXILIARIES						
	AIR TURBINE GENERATOR	1	**OUTPUT:** 135 MW **GENERATOR:** 160 MVA **VOLTAGE:** 13.8 kV **POWER FACTOR:** 0.85	Dresser Rand	Cycle 1	Includes HP and LP Section with Combustors
	AIR TURBINE TURNING GEAR	1	**RATED POWER:** 20 HP	Dresser Rand	Cycle 1	

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	LUBE OIL SYSTEM	1		Dresser Rand	Cycle 1	Including pumps, reservoir, heater, filters, and coolers.
	LUBE OIL HEATERS	2	**RATED POWER:** 30 kW			Per System
	LUBE OIL MIST SEPARATORS	3	**RATED POWER:** 2.5 kW			3 x 50%, Per System
	LUBE OIL CONDITIONER	1	**RATED POWER:** 1 kW			Per System
	MAIN LUBE OIL PUMPS	2	**CONFIGURATION:** 2 x 100% **RATED POWER:** 150 HP			AC Powered, Per System
	BACKUP LUBE OIL PUMPS	1	**CONFIGURATION:** 1 x 100% **RATED POWER:** 80 HP			DC Powered, Per System
	WATER INJECTION PUMP	1	**RATED POWER:** 40 HP	Dresser Rand	Cycle 1	
	CONTROL OIL SYSTEM JACKING OIL PUMPS	1	**RATED POWER:** 20 HP	Dresser Rand	Cycle 1	
	TURBINE NOISE ENCLOSURE	1		EPCM	Cycle 1	
RECUPERATOR EQUIPMENT AND AUXILIARIES						
	AIR TURBINE WASTE HEAT RECUPERATOR	1	**PRESSURE:** 900 psig **TEMPERATURE:** 623 deg F **AIR FLOW:** 1,440,000 lb/hr	Dresser Rand	Cycle 1	SCR and CO Catalyst.
	INLET DUCTWORK AND EXPANSION JOINT	1		Dresser Rand	Cycle 1	
	OUTLET DUCTWORK AND EXPANSION JOINT	1		Dresser Rand	Cycle 1	
	SCR SYSTEM	1	**MAX NOx AT STACK:** 2.0 ppmvd NOx	Dresser Rand	Cycle 1	Including ammonia vaporization and injection skid.
	AMMONIA VAPORIZER	1				1 per system
	DILUTION AIR BLOWERS	2	**RATED POWER:** 15 HP			2 x 100% per system
	CO CATALYST SYSTEM	1	**MAX CO AT STACK:** 2.0 ppmvd CO	Dresser Rand	Cycle 1	
	EXHAUST DUCT STACK	1	**STACK HEIGHT:** 181 ft **STACK DIAMETER:** 13 ft	Dresser Rand	Cycle 1	
	EXHAUST STACK DAMPER	1		Dresser Rand	Cycle 1	
COMPRESSED GAS						
	BULK NITROGEN STORAGE AND PIPING	1 LOT		EPCM	Cycle 1	Bottles, regulators, and instruments

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
AMMONIA STORAGE AND HANDLING SYSTEM						
	AMMONIA HANDLING & UNLOADING SYSTEM	1	**DELIVERY:** 1 Unloading Station	EPCM	Cycle 1	Based on 19% Aqueous Ammonia
	AQUEOUS AMMONIA STORAGE TANK	1	**CAPACITY:** 10,000 Gallons	EPCM	Cycle 1	Shop fabricated, horizontal tank
	AMMONIA FORWARDING PUMPS	2	**CONFIGURATION:** 2 x 100% **CAPACITY:** 4 GPM **TOTAL HEAD:** 200 ft **RATED POWER:** 1.00 HP	EPCM	Cycle 1	Positive displacement pumps
CIRCULATING WATER PUMPS AND PIPING						
	CIRCULATING WATER PUMPS	2	**CONFIGURATION:** 2 x 50% **FLOW:** 30,000 GPM **TOTAL HEAD:** 60 ft **RATED POWER:** 600 HP	EPCM	Cycle 1	Vertical, wet pit, mix flow pump.
	AUXILIARY COOLING WATER PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 3,900 GPM **TOTAL HEAD:** 60 ft **RATED POWER:** 125 HP	EPCM	Cycle 1	Vertical, wet pit, mix flow pump.
COOLING TOWER						
	COOLING TOWER	1	**DUTY:** 600 MMBtu/hr **FLOW:** 60,000 GPM **# OF FANS:** 5 **RATED POWER:** 250 HP/fan	EPCM	Cycle 1	Plume Abatement Option
	COOLING TOWER TRASH SCREENS	2		EPCM	Cycle 1	To suit basin design
	CIRCULATING WATER FEED SYSTEM	1 LOT		EPCM	Cycle 1	Complete system with controls, pumps, and storage tanks.
	ACID METERING PUMPS AND STORAGE		**RATED POWER:** 1 HP			2 x 100% Pumps with storage tote
	SODIUM HYPOCHLORITE METERING PUMPS AND STORAGE		**RATED POWER:** 1 HP			2 x 100% Pumps with storage tote
	CORROSION INHIBITOR METERING PUMPS AND STORAGE		**RATED POWER:** 1 HP			2 x 100% Pumps with storage tote
	SODIUM BISULFITE METERING PUMPS AND STORAGE		**RATED POWER:** 1 HP			2 x 100% Pumps with storage tote
SERVICE / RAW WATER						
	RAW WATER SUPPLY PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 450 GPM **TOTAL HEAD:** 650 ft **RATED POWER:** 125 HP	EPCM	Cycle 1	Vertical, wet pit pump.

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	AIR BACKWASH BLOWER	2	**RATED POWER:** 20 HP	EPCM	Cycle 1	2 x 100% air blower. Power to be verified by supplier.
	SERVICE / FIRE WATER STORAGE TANK	1	**CAPACITY:** 700,000 gallons	EPCM	Cycle 1	Field erected, carbon steel 62 ft x 32 ft (D x H)
	SERVICE WATER PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 85 GPM **TOTAL HEAD:** 230 ft **RATED POWER:** 15.00 HP	EPCM	Cycle 1	Horizontal skid mounted centrifugal pumps
POTABLE WATER						
	POTABLIZATION SKID	1	**CAPACITY:** 10 gpm	Water Treatment Suppiler	Cycle 1	Activated carbon filter and sodium hypochlorite dosing. 2 x 100% pumps
	SODIUM HYPOCHLORITE PUMPS	2	**RATED POWER:** 1 HP			
	POTABLE WATER STORAGE TANK	1	**CAPACITY:** 14,400 gallons	EPCM	Cycle 1	Field erected, carbon steel 14 ft 4 in x 12 ft (D x H)
	POTABLE WATER PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 75 GPM **TOTAL HEAD:** 150 ft **RATED POWER:** 7.50 HP	EPCM	Cycle 1	Horizontal skid mounted centrifugal pumps
	EMERGENCY EYE-WASH STATIONS & SAFETY SHOWERS	3		EPCM	Cycle 1	For areas where chemical exposure is possible. Instantaneous water heaters included.
WATER TREAMENT						
	MULTIMEDIA FILTER SKID	2	**CONFIGURATION:** 2 x 100% **CAPACITY:** 45 GPM	Water Treatment Suppiler	Cycle 1	
	MULTIMEDIA FILTER BACKWASH PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 50 GPM **TOTAL HEAD:** 120 ft **RATED POWER:** 5 HP	Water Treatment Suppiler	Cycle 1	Pump size to be verified by supplier data
	AIR SCOUR BLOWER	1	**RATED POWER:** 10 HP	Water Treatment Suppiler	Cycle 1	1 x 100% air blower. Power to be verified by supplier.
	REVERSE OSMOSIS / ELECTRODEIONIZATION UNIT	1	**CONFIGURATION:** 1 x 100% **PRODUCT FLOW:** 25 GPM	Water Treatment Suppiler	Cycle 1	
	REVERSE OSMOSIS FEED PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 30 GPM **TOTAL HEAD:** 450 ft **RATED POWER:** 10.00 HP	Water Treatment Suppiler	Cycle 1	Capacity TBD by supplier
	ANTI SCALANT FEED SKID AND PUMPS	1 LOT	**CONFIGURATION:** 2 x 100% **RATED POWER:** 1 HP	Water Treatment Suppiler	Cycle 1	2 x 100% pumps, including chemical storage
	SODIUM BISULFITE FEED SKID AND PUMPS	1 LOT	**CONFIGURATION:** 2 x 100% **RATED POWER:** 1 HP	Water Treatment Suppiler	Cycle 1	2 x 100% pumps, including chemical storage
	CAUSTIC FEED SKID AND PUMPS	1 LOT	**CONFIGURATION:** 2 x 100% **RATED POWER:** 1 HP	Water Treatment Suppiler	Cycle 1	2 x 100% pumps, including chemical storage

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	DEMINERALIZED WATER STORAGE TANK	1	**CAPACITY:** 30,000 gallons	EPCM	Cycle 1	Field-erected, 304 SS. 18 ft x 16 ft (D x H)
	DEMINERALIZED WATER SUPPLY PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 30 GPM **TOTAL HEAD:** 200 ft **RATED POWER:** 7.5 HP	EPCM	Cycle 1	Horizontal skid mounted centrifugal pumps
WASTE WATER TREATMENT						
	MECHANICAL EQUIPMENT BUILDING SUMP	1	**SIZE:** 3 x 10 ft (Dia x Height)	EPCM	Cycle 1	Reinforced concrete sump
	MECHANICAL EQUIPMENT BUILDING SUMP PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 100 gpm **TOTAL HEAD:** 75 ft **RATED POWER:** 7.5 HP	EPCM	Cycle 1	Submersible pumps, complete with controls.
	WAREHOUSE / MAINTENANCE BUILDING SUMP	1	**SIZE:** 3 x 10 ft (Dia x Height)	EPCM	Cycle 1	Reinforced concrete sump with protective lining
	WAREHOUSE / MAINTENANCE BUILDING SUMP PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 100 gpm **TOTAL HEAD:** 75 ft **RATED POWER:** 7.5 HP	EPCM	Cycle 1	Submersible pumps, complete with controls.
	COOLING TOWER CHEMICAL BUILDING SUMP	1	**SIZE:** 3 x 10 ft (Dia x Height)	EPCM	Cycle 1	Reinforced concrete sump
	COOLING TOWER CHEMICAL BUILDING SUMP PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 100 gpm **TOTAL HEAD:** 75 ft **RATED POWER:** 7.5 HP	EPCM	Cycle 1	Submersible pumps, complete with controls.
	TURBINE/COMPRESSOR BUILDING SUMP	1	**SIZE:** 3 x 10 ft (Dia x Height)	EPCM	Cycle 1	Pre-cast concrete manhole
	TURBINE/COMPRESSOR BUILDING SUMP PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 100 gpm **TOTAL HEAD:** 75 ft **RATED POWER:** 7.5 HP	EPCM	Cycle 1	Sewage grinder pumps, complete with controls. Designed to handle sanitary waste.
	OIL/WATER SEPARATOR (API)	1	**CAPACITY:** 600 gpm	EPCM	Cycle 1	Horizontal, cylindrical, above ground, static separator.
	O/WS EFFLUENT TRANSFER PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 600 gpm **TOTAL HEAD:** 75 ft 25 HP	EPCM	Cycle 1	Submersible pumps, complete with controls
	STORM WATER TRANSFER SUMP	1	**SIZE:** 3 x 10 ft (Dia x Height)	EPCM	Cycle 1	Pre-cast concrete manhole
	STORM WATER TRANSFER PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 10 gpm **TOTAL HEAD:** 75 ft **RATED POWER:** 1 HP	EPCM	Cycle 1	Submersible pumps, complete with controls.

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	PACKAGED SANITARY SYSTEM	1	**CAPACITY:** 10 gpm	EPCM	Cycle 1	
	SEWAGE GRINDER PUMPS		**CONFIGURATION:** 2 x 100% **RATED POWER:** 7.5 HP			Sewage grinder pumps, complete with controls. Designed to handle sanitary waste.
PLANT AIR EQUIPMENT						
	INSTRUMENT AIR DRYER	2	**FLOW:** 200 scfm	EPCM	Cycle 1	Dual tower, heatless regenerated desiccant dryers with pre and after filters
	WET AIR RECIEVER	1	**CAPACITY:** 40 ft^3	EPCM	Cycle 1	Located directly upstream of dryers.
	TURBINE / COMPRESSOR AIR RECIEVER	1	**CAPACITY:** 40 ft^3	EPCM	Cycle 1	Located in turbine / compressor building.
FUEL GAS EQUIPMENT						
	FUEL GAS ULTRASONIC FLOW METER	1		EPCM	Cycle 1	
	FUEL GAS CHROMATOGRAPH	1		EPCM	Cycle 1	
	FUEL GAS DEWPOINT HEATER	1	**DESIGN FLOW:** 31,800 lbs/hr	EPCM	Cycle 1	Natural gas fired.
	FUEL GAS REGULATION STATION	2	**CONFIGURATION:** 2 x 100% **DESIGN FLOW:** 30,000 lbs/hr	EPCM	Cycle 1	GT fuel gas supply
	FUEL GAS CONDITIONING SKID WITH FILTER / SEPARATOR VESSEL AND DRAIN TANK	1	**CONFIGURATION:** 1 x 100% **DESIGN FLOW:** 30,000 lbs/hr	EPCM	Cycle 1	
	FUEL GAS COMPRESSOR SKID	1	**CONFIGURATION:** 1 x 100% **DESIGN FLOW:** 9,500 lbs/hr **DISCHARGE PRES:** 943 psig **SUCTION PRES:** 700 psig **RATED POWER:** 75 HP	Dresser Rand	Cycle 1	Including lube oil and gas coolers.
	FUEL GAS COALESCING FILTER SKID (FINAL FILTERS) w/ DRAIN TANK	2 Skids	**CONFIGURATION:** 2 x 100% **DESIGN FLOW:** 30,000 lbs/hr	EPCM	Cycle 1	2 x 100% filters per skid. Vertical, carbon steel vessel per ASME Section VIII with stainless steel mesh pad, removal to 1µ. Skid is completely pre-piped.
FIRE PROTECTION						
	FIRE WATER PUMP	1	**CONFIGURATION:** 1 x 100% **FLOW:** 2,000 GPM **TOTAL HEAD:** 350 ft **RATED POWER:** 200 HP	EPCM	Cycle 1	Horizontal split case pump with diesel engine.

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	FIRE WATER PUMP	1	**CONFIGURATION:** 1 x 100% **FLOW:** 2,000 GPM **TOTAL HEAD:** 350 ft **RATED POWER:** 200 HP	EPCM	Cycle 1	Horizontal split case pump with electric drive
	FIRE WATER JOCKEY PUMP	1	**CONFIGURATION:** 1 x 100% **FLOW:** 25 GPM **TOTAL HEAD:** 350 ft **RATED POWER:** 5 HP	EPCM	Cycle 1	Horizontal jockey pump
	FIRE EXTINGUISHERS	1 LOT		EPCM	Cycle 1	Per NFPA Standards
	FIRE EQUIPMENT ENCLOSURE	1	Electric heat, lightings, and ventilation.	EPCM	Cycle 1	Pre-Fabricated enclosure for firewater pumps and related equipment.
BUILDING HVAC AND VENTILATION						
	COMPLETE HVAC SYSTEM	2	**NUMBER OF BUILDINGS:** 1 **RATING:** 25 TON per system	EPCM	Cycle 1	Grade mounted, redundant systems for Administration Building / Visitors Center
	VENTILATION SYSTEMS	6	**NUMBER OF BUILDINGS:** 3 **FLOW:** 38000 CFM for 6 Fans **FLOW:** 13,000 CFM for 2 Fans **NUMBER OF LOUVERS:** 14 (10 FT height x 7 FT width)	EPCM	Cycle 1	For Mechanical Equipment Building, Maintenance Building, Turbine / Compressor Building.
	ELECTRIC UNIT HEATERS	12	**NUMBER OF BUILDINGS:** 3 **POWER USAGE:** 50 kW per unit	EPCM	Cycle 1	For Mechanical Equipment Building, Maintenance Building, Turbine / Compressor Building.
TRANSFORMERS						
	GENERATOR STEP UP TRANSFORMER	1	**Rating:** 90/150 MVA 115-13.8 kV	EPCM	Cycle 1	GSU
	STATION AUXILLIARY TRANSFORMER	1	**Rating:** 45/75 MVA 115-13.8 kV	EPCM	Cycle 1	5000 Train transformer
	STATION AUXILLIARY TRANSFORMER	1	**Rating:** 78/130 MVA 115-13.8 kV	EPCM	Cycle 1	4000 Train transformer
	STATION AUXILLIARY TRANSFORMER	1	**Rating:** 7.5-9.375 MVA 115-13.8 kV	EPCM	Cycle 1	4.16kV loads
NON-SEGREGATED PHASE BUS DUCT						
	NON SEGREGATED PHASE BUS DUCT	1 Lot	**Rating:** 8000 A 15 kV 100 KA	EPCM	Cycle 1	For generator to Step-up transformer
	NON SEGREGATED PHASE BUS DUCT	1 Lot	**Rating:** 8000 A 15 kV 63 KA	EPCM	Cycle 1	For 5000 Train to transformer
	NON SEGREGATED PHASE BUS DUCT	1 Lot	**Rating:** 4000 A 15 kV 63 KA	EPCM	Cycle 1	For 4000 Train to transformer

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	NON SEGREGATED PHASE BUS DUCT OR CABLE BUS	1 Lot	**Rating:** 1200 A 15 kV 50 KA	EPCM	Cycle 1	For 4.16kV switchgear to transformer
POWER DISTRIBUTION CENTERS						
	MAIN PDC	1 Lot		EPCM	Cycle 1	Includes all MV Switchgear 480v Transformers, LV Switchgear, MCCs, DC equipment, batteries, UPS equipment except that relating to the Cooling Tower.
	COOLING TOWER PDC	1 Lot		EPCM	Cycle 1	Includes all 480v Transformers, MCCs, DC equipment, UPS equipment relating to the Cooling Tower.
MISCELLANEOUS						
	EMERGENCY NATURAL GAS GENERATOR	1	**RATED POWER:** 1500 kW	EPCM	Cycle 1	937.5 kVA
	OVERHEAD CRANE - TURBINE / COMPRESSOR BUILDING	1	**CAPACITY:** 35 ton	EPCM	Cycle 1	With a 15 ton auxiliary hook.
	HOIST - MECHANICAL EQUIPMENT BUILDING	1	**CAPACITY:** 5 ton	EPCM	Cycle 1	Monorail, underhung.
	HOIST - GAS COMPRESSOR STATION	1	**CAPACITY:** 3 ton	EPCM	Cycle 1	Fuel gas compressor building. Monorail, underhung.
	ELEVATOR	1	**CAPACITY:** 2500 lbs **RATED POWER:** 25 HP	EPCM	Cycle 1	Office Elevator
CONTINUIOUS EMMISIONS MONITORING SYSTEM						
	CEMS, EQUIPMENT, ANALYZERS, SHELTER, SAMPLE LINES, PROBES, HMI'S, PLC'S, ETC.	1 LOT		EPCM	Cycle 1	CEMS, equipment, analyzers, shelter, sample lines, probes, HMI's, PLC's, ect.
DISTRIBUTED CONTROL SYSTEM						
	COMPLETE DISTRIBUTED CONTROL SYSTEM FOR THE BALANCE OF PLANT EQUIPMENT	1 LOT		Dresser Rand	Cycle 1	

Seneca Compressed Air Energy Storage Project

MAJOR EQUIPMENT LIST (Cycle 1A)

The list below is indicative only based on Preliminary Engineering.

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
PROCESS AIR COMPRESSOR EQUIPMENT AND AUXILIARIES						
	AIR COMPRESSOR (DR 5000)	2	**CONFIGURATION:** 2 x 50% **CAPACITY:** 323 lbs/sec (avg amb.) **POWER:** 85,000 kW	Dresser Rand	Cycle 1A	Datum D22R6B and D18R6B HP/IP centrifugal compressors and Frame 5000 LP Axial Compressor
	AIR COMPRESSOR TURNING GEAR	2	**RATED POWER:** 20 HP	Dresser Rand	Cycle 1A	
	AIR INLET ANTI-ICIING SYSTEM	2		Dresser Rand	Cycle 1A	
	LUBE OIL SYSTEM	2		Dresser Rand	Cycle 1A	Including pumps, reservoir, heater, filters, and coolers.
	LUBE OIL HEATERS	2	**RATED POWER:** 30 kW			
	LUBE OIL MIST SEPARATORS	3	**RATED POWER:** 2.5 kW			3 x 50%
	LUBE OIL CONDITIONER	1	**RATED POWER:** 1 kW			
	MAIN LUBE OIL PUMPS	2	**CONFIGURATION:** 2 x 100% **RATED POWER:** 150 HP			AC Powered
	BACKUP LUBE OIL PUMPS	1	**CONFIGURATION:** 1 x 100% **RATED POWER:** 80 HP			DC Powered
	CONTROL OIL SYSTEM JACKING OIL PUMPS	1	**RATED POWER:** 20 HP	Dresser Rand	Cycle 1A	
	INTER/AFTER COOLERS w/ MOSITURE SEPARATORS	10		Dresser Rand	Cycle 1A	5 per compressor
	COMPRESSOR LCI SOFT STARTER	1		Dresser Rand	Cycle 1A	Single starter for both compressors
	AIR COMPRESSOR NOISE ENCLOSURE	2		EPCM	Cycle 1A	

AIR TURBINE GENERATOR EQUIPMENT AND AUXILIARIES						
	AIR TURBINE GENERATOR	2	**OUTPUT:** 105 MW **GENERATOR:** 130 MVA **VOLTAGE:** 13.8 kV **POWER FACTOR:** 0.85	Dresser Rand	Cycle 1A	Includes HP and LP Section with Combustors and a single common generator
	AIR TURBINE TURNING GEAR	2	**RATED POWER:** 20 HP	Dresser Rand	Cycle 1A	

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	LUBE OIL SYSTEM	2		Dresser Rand	Cycle 1A	Including pumps, reservoir, heater, filters, and coolers.
	LUBE OIL HEATERS	2	**RATED POWER:** 30 kW			Per System
	LUBE OIL MIST SEPARATORS	3	**RATED POWER:** 2.5 kW			3 x 50%, Per System
	LUBE OIL CONDITIONER	1	**RATED POWER:** 1 kW			Per System
	MAIN LUBE OIL PUMPS	2	**CONFIGURATION:** 2 x 100% **RATED POWER:** 150 HP			AC Powered, Per System
	BACKUP LUBE OIL PUMPS	1	**CONFIGURATION:** 1 x 100% **RATED POWER:** 80 HP			DC Powered, Per System
	WATER INJECTION PUMP	2	**RATED POWER:** 40 HP	Dresser Rand	Cycle 1A	
	CONTROL OIL SYSTEM JACKING OIL PUMPS	2	**RATED POWER:** 20 HP	Dresser Rand	Cycle 1A	
	TURBINE NOISE ENCLOSURE	2		EPCM	Cycle 1A	
RECUPERATOR EQUIPMENT AND AUXILIARIES						
	AIR TURBINE WASTE HEAT RECUPERATOR	2	**PRESSURE:** 900 psig **TEMPERATURE:** 623 deg F **AIR FLOW:** 1,440,000 lb/hr	Dresser Rand	Cycle 1A	SCR and CO Catalyst.
	INLET DUCTWORK AND EXPANSION JOINT	2		Dresser Rand	Cycle 1A	
	OUTLET DUCTWORK AND EXPANSION JOINT	2		Dresser Rand	Cycle 1A	
	SCR SYSTEM	2	**MAX NOx AT STACK:** 2.0 ppmvd NOx	Dresser Rand	Cycle 1A	Including ammonia vaporization and injection skid.
	AMMONIA VAPORIZER	1				1 per system
	DILUTION AIR BLOWERS	2	**RATED POWER:** 15 HP			2 x 100% per system
	CO CATALYST SYSTEM	2	**MAX CO AT STACK:** 2.0 ppmvd CO	Dresser Rand	Cycle 1A	
	EXHAUST DUCT STACK	2	**STACK HEIGHT:** 181 ft **STACK DIAMETER:** 13 ft	Dresser Rand	Cycle 1A	
	EXHAUST STACK DAMPER	2		Dresser Rand	Cycle 1A	
COMPRESSED GAS						
	BULK NITROGEN STORAGE AND PIPING	1 LOT		EPCM	Cycle 1A	Bottles, regulators, and instruments

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
AMMONIA STORAGE AND HANDLING SYSTEM						
	AMMONIA HANDLING & UNLOADING SYSTEM	1	**DELIVERY:** 1 Unloading Station	EPCM	Cycle 1A	Based on 19% Aqueous Ammonia
	AQUEOUS AMMONIA STORAGE TANK	1	**CAPACITY:** 10,000 Gallons	EPCM	Cycle 1A	Shop fabricated, horizontal tank
	AMMONIA FORWARDING PUMPS	2	**CONFIGURATION:** 2 x 100% **CAPACITY:** 4 GPM **TOTAL HEAD:** 200 ft **RATED POWER:** 1.00 HP	EPCM	Cycle 1A	Positive displacement pumps
CIRCULATING WATER PUMPS AND PIPING						
	CIRCULATING WATER PUMPS	2	**CONFIGURATION:** 2 x 50% **FLOW:** 30,000 GPM **TOTAL HEAD:** 60 ft **RATED POWER:** 600 HP	EPCM	Cycle 1A	Vertical, wet pit, mix flow pump.
	AUXILIARY COOLING WATER PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 3,900 GPM **TOTAL HEAD:** 60 ft **RATED POWER:** 125 HP	EPCM	Cycle 1A	Vertical, wet pit, mix flow pump.
COOLING TOWER						
	COOLING TOWER	1	**DUTY:** 600 MMBtu/hr **FLOW:** 60,000 GPM **# OF FANS:** 5 **RATED POWER:** 250 HP/fan	EPCM	Cycle 1A	Plume Abatement Option
	COOLING TOWER TRASH SCREENS	2		EPCM	Cycle 1A	To suit basin design
	CIRCULATING WATER FEED SYSTEM	1 LOT		EPCM	Cycle 1A	Complete system with controls, pumps, and storage tanks.
	ACID METERING PUMPS AND STORAGE		**RATED POWER:** 1 HP			2 x 100% Pumps with storage tote
	SODIUM HYPOCHLORITE METERING PUMPS AND STORAGE		**RATED POWER:** 1 HP			2 x 100% Pumps with storage tote
	CORROSION INHIBITOR METERING PUMPS AND STORAGE		**RATED POWER:** 1 HP			2 x 100% Pumps with storage tote
	SODIUM BISULFITE METERING PUMPS AND STORAGE		**RATED POWER:** 1 HP			2 x 100% Pumps with storage tote
SERVICE / RAW WATER						
	RAW WATER SUPPLY PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 450 GPM **TOTAL HEAD:** 650 ft **RATED POWER:** 125 HP	EPCM	Cycle 1A	Vertical, wet pit pump.

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	AIR BACKWASH BLOWER	2	**RATED POWER:** 20 HP	EPCM	Cycle 1A	2 x 100% air blower. Power to be verified by supplier.
	SERVICE / FIRE WATER STORAGE TANK	1	**CAPACITY:** 700,000 gallons	EPCM	Cycle 1A	Field erected, carbon steel 62 ft x 32 ft (D x H)
	SERVICE WATER PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 85 GPM **TOTAL HEAD:** 230 ft **RATED POWER:** 15.00 HP	EPCM	Cycle 1A	Horizontal skid mounted centrifugal pumps
POTABLE WATER						
	POTABLIZATION SKID SODIUM HYPOCHLORITE PUMPS	1 2	**CAPACITY:** 10 gpm **RATED POWER:** 1 HP	Water Treatment Suppiler	Cycle 1A	Activated carbon filter and sodium hypochlorite dosing. 2 x 100% pumps
	POTABLE WATER STORAGE TANK	1	**CAPACITY:** 14,400 gallons	EPCM	Cycle 1A	Field erected, carbon steel 14 ft 4 in x 12 ft (D x H)
	POTABLE WATER PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 75 GPM **TOTAL HEAD:** 150 ft **RATED POWER:** 7.50 HP	EPCM	Cycle 1A	Horizontal skid mounted centrifugal pumps
	EMERGENCY EYE-WASH STATIONS & SAFETY SHOWERS	3		EPCM	Cycle 1A	For areas where chemical exposure is possible. Instantaneous water heaters included.
WATER TREAMENT						
	MULTIMEDIA FILTER SKID	2	**CONFIGURATION:** 2 x 100% **CAPACITY:** 45 GPM	Water Treatment Suppiler	Cycle 1A	
	MULTIMEDIA FILTER BACKWASH PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 50 GPM **TOTAL HEAD:** 120 ft **RATED POWER:** 5 HP	Water Treatment Suppiler	Cycle 1A	Pump size to be verified by supplier data
	AIR SCOUR BLOWER	1	**RATED POWER:** 10 HP	Water Treatment Suppiler	Cycle 1A	1 x 100% air blower. Power to be verified by supplier.
	REVERSE OSMOSIS / ELECTRODEIONIZATION UNIT	1	**CONFIGURATION:** 1 x 100% **PRODUCT FLOW:** 25 GPM	Water Treatment Suppiler	Cycle 1A	
	REVERSE OSMOSIS FEED PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 30 GPM **TOTAL HEAD:** 450 ft **RATED POWER:** 10.00 HP	Water Treatment Suppiler	Cycle 1A	Capacity TBD by supplier
	ANTI SCALANT FEED SKID AND PUMPS	1 LOT	**CONFIGURATION:** 2 x 100% **RATED POWER:** 1 HP	Water Treatment Suppiler	Cycle 1A	2 x 100% pumps, including chemical storage
	SODIUM BISULFITE FEED SKID AND PUMPS	1 LOT	**CONFIGURATION:** 2 x 100% **RATED POWER:** 1 HP	Water Treatment Suppiler	Cycle 1A	2 x 100% pumps, including chemical storage
	CAUSTIC FEED SKID AND PUMPS	1 LOT	**CONFIGURATION:** 2 x 100% **RATED POWER:** 1 HP	Water Treatment Suppiler	Cycle 1A	2 x 100% pumps, including chemical storage

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	DEMINERALIZED WATER STORAGE TANK	1	**CAPACITY:** 30,000 gallons	EPCM	Cycle 1A	Field-erected, 304 SS. 18 ft x 16 ft (D x H)
	DEMINERALIZED WATER SUPPLY PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 30 GPM **TOTAL HEAD:** 200 ft **RATED POWER:** 7.5 HP	EPCM	Cycle 1A	Horizontal skid mounted centrifugal pumps
WASTE WATER TREATMENT						
	MECHANICAL EQUIPMENT BUILDING SUMP	1	**SIZE:** 3 x 10 ft (Dia x Height)	EPCM	Cycle 1A	Reinforced concrete sump
	MECHANICAL EQUIPMENT BUILDING SUMP PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 100 gpm **TOTAL HEAD:** 75 ft **RATED POWER:** 7.5 HP	EPCM	Cycle 1A	Submersible pumps, complete with controls.
	WAREHOUSE / MAINTENANCE BUILDING SUMP	1	**SIZE:** 3 x 10 ft (Dia x Height)	EPCM	Cycle 1A	Reinforced concrete sump with protective lining
	WAREHOUSE / MAINTENANCE BUILDING SUMP PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 100 gpm **TOTAL HEAD:** 75 ft **RATED POWER:** 7.5 HP	EPCM	Cycle 1A	Submersible pumps, complete with controls.
	COOLING TOWER CHEMICAL BUILDING SUMP	1	**SIZE:** 3 x 10 ft (Dia x Height)	EPCM	Cycle 1A	Reinforced concrete sump
	COOLING TOWER CHEMICAL BUILDING SUMP PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 100 gpm **TOTAL HEAD:** 75 ft **RATED POWER:** 7.5 HP	EPCM	Cycle 1A	Submersible pumps, complete with controls.
	TURBINE/COMPRESSOR BUILDING SUMP	1	**SIZE:** 3 x 10 ft (Dia x Height)	EPCM	Cycle 1A	Pre-cast concrete manhole
	TURBINE/COMPRESSOR BUILDING SUMP PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 100 gpm **TOTAL HEAD:** 75 ft **RATED POWER:** 7.5 HP	EPCM	Cycle 1A	Sewage grinder pumps, complete with controls. Designed to handle sanitary waste.
	OIL/WATER SEPARATOR (API)	1	**CAPACITY:** 600 gpm	EPCM	Cycle 1A	Horizontal, cylindrical, above ground, static separator.
	O/WS EFFLUENT TRANSFER PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 600 gpm **TOTAL HEAD:** 75 ft 25 HP	EPCM	Cycle 1A	Submersible pumps, complete with controls
	STORM WATER TRANSFER SUMP	1	**SIZE:** 3 x 10 ft (Dia x Height)	EPCM	Cycle 1A	Pre-cast concrete manhole
	STORM WATER TRANSFER PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 10 gpm **TOTAL HEAD:** 75 ft **RATED POWER:** 1 HP	EPCM	Cycle 1A	Submersible pumps, complete with controls.

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	PACKAGED SANITARY SYSTEM	1	**CAPACITY:** 10 gpm	EPCM	Cycle 1A	
	SEWAGE GRINDER PUMPS		**CONFIGURATION:** 2 x 100% **RATED POWER:** 7.5 HP			Sewage grinder pumps, complete with controls. Designed to handle sanitary waste.
PLANT AIR EQUIPMENT						
	INSTRUMENT AIR DRYER	2	**FLOW:** 200 scfm	EPCM	Cycle 1A	Dual tower, heatless regenerated desiccant dryers with pre and after filters
	WET AIR RECIEVER	1	**CAPACITY:** 40 ft^3	EPCM	Cycle 1A	Located directly upstream of dryers.
	TURBINE / COMPRESSOR AIR RECIEVER	1	**CAPACITY:** 40 ft^3	EPCM	Cycle 1A	Located in turbine / compressor building.
FUEL GAS EQUIPMENT						
	FUEL GAS ULTRASONIC FLOW METER	1		EPCM	Cycle 1A	
	FUEL GAS CHROMATOGRAPH	1		EPCM	Cycle 1A	
	FUEL GAS DEWPOINT HEATER	1	**DESIGN FLOW:** 31,800 lbs/hr	EPCM	Cycle 1A	Natural gas fired.
	FUEL GAS REGULATION STATION	2	**CONFIGURATION:** 2 x 100% **DESIGN FLOW:** 30,000 lbs/hr	EPCM	Cycle 1A	GT fuel gas supply
	FUEL GAS CONDITIONING SKID WITH FILTER / SEPARATOR VESSEL AND DRAIN TANK	1	**CONFIGURATION:** 1 x 100% **DESIGN FLOW:** 30,000 lbs/hr	EPCM	Cycle 1A	
	FUEL GAS COMPRESSOR SKID	1	**CONFIGURATION:** 1 x 100% **DESIGN FLOW:** 9,500 lbs/hr **DISCHARGE PRES:** 943 psig **SUCTION PRES:** 700 psig **RATED POWER:** 75 HP	Dresser Rand	Cycle 1A	Including lube oil and gas coolers.
	FUEL GAS COALESCING FILTER SKID (FINAL FILTERS) w/ DRAIN TANK	2 Skids	**CONFIGURATION:** 2 x 100% **DESIGN FLOW:** 30,000 lbs/hr	EPCM	Cycle 1A	2 x 100% filters per skid. Vertical, carbon steel vessel per ASME Section VIII with stainless steel mesh pad, removal to 1µ. Skid is completely pre-piped.
FIRE PROTECTION						
	FIRE WATER PUMP	1	**CONFIGURATION:** 1 x 100% **FLOW:** 2,000 GPM **TOTAL HEAD:** 350 ft **RATED POWER:** 200 HP	EPCM	Cycle 1A	Horizontal split case pump with diesel engine.

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	FIRE WATER PUMP	1	**CONFIGURATION:** 1 x 100% **FLOW:** 2,000 GPM **TOTAL HEAD:** 350 ft **RATED POWER:** 200 HP	EPCM	Cycle 1A	Horizontal split case pump with electric drive
	FIRE WATER JOCKEY PUMP	1	**CONFIGURATION:** 1 x 100% **FLOW:** 25 GPM **TOTAL HEAD:** 350 ft **RATED POWER:** 5 HP	EPCM	Cycle 1A	Horizontal jockey pump
	FIRE EXTINGUISHERS	1 LOT		EPCM	Cycle 1A	Per NFPA Standards
	FIRE EQUIPMENT ENCLOSURE	1	Electric heat, lightings, and ventilation.	EPCM	Cycle 1A	Pre-Fabricated enclosure for firewater pumps and related equipment.
BUILDING HVAC AND VENTILATION						
	COMPLETE HVAC SYSTEM	2	**NUMBER OF BUILDINGS:** 1 **RATING:** 25 TON per system	EPCM	Cycle 1A	Grade mounted, redundant systems for Administration Building / Visitors Center
	VENTILATION SYSTEMS	6	**NUMBER OF BUILDINGS:** 3 **FLOW:** 38000 CFM for 6 Fans **FLOW:** 13,000 CFM for 2 Fans **NUMBER OF LOUVERS:** 14 (10 FT height x 7 FT width)	EPCM	Cycle 1A	For Mechanical Equipment Building, Maintenance Building, Turbine / Compressor Building.
	ELECTRIC UNIT HEATERS	12	**NUMBER OF BUILDINGS:** 3 **POWER USAGE:** 50 kW per unit	EPCM	Cycle 1A	For Mechanical Equipment Building, Maintenance Building, Turbine / Compressor Building.
TRANSFORMERS						
	GENERATOR STEP UP TRANSFORMER	1	**Rating:** 144/240 MVA 115-13.8 kV	EPCM	Cycle 1A	GSU
	STATION AUXILLIARY TRANSFORMER	1	**Rating:** 45/75 MVA 115-13.8 kV	EPCM	Cycle 1A	5000 Train transformer
	STATION AUXILLIARY TRANSFORMER	1	**Rating:** 78/130 MVA 115-13.8 kV	EPCM	Cycle 1A	4000 Train transformer
	STATION AUXILLIARY TRANSFORMER	1	**Rating:** 7.5-9.375 MVA 115-13.8 kV	EPCM	Cycle 1A	4.16kV loads
NON-SEGREGATED PHASE BUS DUCT						
	NON SEGREGATED PHASE BUS DUCT	1 Lot	**Rating:** 8000 A 15 kV 100 KA	EPCM	Cycle 1A	For generator to Step-up transformer
	NON SEGREGATED PHASE BUS DUCT	1 Lot	**Rating:** 8000 A 15 kV 63 KA	EPCM	Cycle 1A	For 5000 Train to transformer
	NON SEGREGATED PHASE BUS DUCT	1 Lot	**Rating:** 4000 A 15 kV 63 KA	EPCM	Cycle 1A	For 4000 Train to transformer

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	NON SEGREGATED PHASE BUS DUCT OR CABLE BUS	1 Lot	**Rating:** 1200 A 15 kV 50 KA	EPCM	Cycle 1A	For 4.16kV switchgear to transformer
POWER DISTRIBUTION CENTERS						
	MAIN PDC	1 Lot		EPCM	Cycle 1A	Includes all MV Switchgear 480v Transformers, LV Switchgear, MCCs, DC equipment, batteries, UPS equipment except that relating to the Cooling Tower.
	COOLING TOWER PDC	1 Lot		EPCM	Cycle 1A	Includes all 480v Transformers, MCCs, DC equipment, UPS equipment relating to the Cooling Tower.
MISCELLANEOUS						
	EMERGENCY NATURAL GAS GENERATOR	1	**RATED POWER:** 1500 kW	EPCM	Cycle 1A	937.5 kVA
	OVERHEAD CRANE - TURBINE / COMPRESSOR BUILDING	1	**CAPACITY:** 35 ton	EPCM	Cycle 1A	With a 15 ton auxiliary hook.
	HOIST - MECHANICAL EQUIPMENT BUILDING	1	**CAPACITY:** 5 ton	EPCM	Cycle 1A	Monorail, underhung.
	HOIST - GAS COMPRESSOR STATION	1	**CAPACITY:** 3 ton	EPCM	Cycle 1A	Fuel gas compressor building. Monorail, underhung.
	ELEVATOR	1	**CAPACITY:** 2500 lbs **RATED POWER:** 25 HP	EPCM	Cycle 1A	Office Elevator
CONTINUIOUS EMMISIONS MONITORING SYSTEM						
	CEMS, EQUIPMENT, ANALYZERS, SHELTER, SAMPLE LINES, PROBES, HMI'S, PLC'S, ETC.	1 LOT		EPCM	Cycle 1A	CEMS, equipment, analyzers, shelter, sample lines, probes, HMI's, PLC's, ect.
DISTRIBUTED CONTROL SYSTEM						
	COMPLETE DISTRIBUTED CONTROL SYSTEM FOR THE BALANCE OF PLANT EQUIPMENT	1 LOT		Dresser Rand	Cycle 1A	

Seneca Compressed Air Energy Storage Project

MAJOR EQUIPMENT LIST (CYCLE 2)

The list below is indicative only based on Preliminary Engineering.

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
COMBUSTION TURBINE EQUIPMENT AND AUXILIARIES						
	COMBUSTION TURBINE AND GENERATOR	1	**OUTPUT:** 85 MW (45 deg F) **NO_x EMISSIONS:** 9 ppmvd @ 15% O2 **VOLTAGE:** 13.8 kV **POWER FACTOR:** 0.90	GE	Cycle 2	GE 7EA Natural Gas Fuel TEWAC Generator
	COMBUSTION TURBINE ENCLOSURE	1		GE	Cycle 2	
	COMBUSTION TURBINE AIR INLET FILTER	1		GE	Cycle 2	Pulse Air Self Cleaning with silencer.
	COMBUSTION TURBINE MECHANICAL PACKAGE	1		GE	Cycle 2	
	COMBUSTION TURBINE ELECTRICAL PACKAGE	1		GE	Cycle 2	
	CT AIR INLET EVAPORATIVE COOLER	1		GE	Cycle 2	Recirculation Type
	CT AIR INLET ANTI-ICIING SYSTEM	1		GE	Cycle 2	
	CT START UP SYSTEM	1		GE	Cycle 2	Static frequency converter system with turning gear
	COMPRESSOR WATER WASH SYSTEM	1		GE	Cycle 2	Washing water tank and pumps
	TURBINE CONTROL PANEL	1		GE	Cycle 2	
	GENERATOR PROTECTION PANEL	1		GE	Cycle 2	
	LUBE OIL SYSTEM	1		GE	Cycle 2	Lube oil reservoir, pumps, cooler, heater, vapor extractor, filter accumulator, PT control and regulating valves.
	CONTROL OIL SYSTEM	1		GE	Cycle 2	Control oil reservoir, pumps, cooler, heater, vapor extractor, filter accumulator, PT control and cleaner.
	GT FUEL GAS UNIT	1		GE	Cycle 2	Enclosed
	FUEL GAS PURGE AIR SYSTEM	1		GE	Cycle 2	Purge air unit and valves.

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	CASING COOLING AIR SYSTEM	1		GE	Cycle 2	Cooling fan
	VIBRATION CONTROL PANELS	1		GE	Cycle 2	
	CT CO2 FIRE PROTECTION SYSTEM	1		GE	Cycle 2	Tank and Control Panel
PROCESS AIR COMPRESSOR EQUIPMENT AND AUXILIARIES						
	AIR COMPRESSOR (MDT HP)	2	**CONFIGURATION:** 2 x 50% **CAPACITY:** 309 lbs/sec **RATED POWER:** 48.3 MW	Man Diesel and Turbo	Cycle 2	Man Diesel-Turbo Model RBZ71
	AIR COMPRESSOR (MDT LP)	2	**CONFIGURATION:** 2 x 50% **CAPACITY:** 309 lbs/sec **RATED POWER:** 44.3 MW	Man Diesel and Turbo	Cycle 2	Man Diesel-Turbo Model RIKT140
	AIR COMPRESSOR TURNING GEAR	2	**RATED POWER:** 20 HP	Man Diesel and Turbo	Cycle 2	
	AIR INLET ANTI-ICIING SYSTEM	2		Man Diesel and Turbo	Cycle 2	
	LUBE OIL SYSTEM	1		Man Diesel and Turbo	Cycle 2	Including pumps, reservoir, heater, filters, and coolers.
	LUBE OIL HEATERS	2	**RATED POWER:** 30 kW			
	LUBE OIL MIST SEPARATORS	3	**RATED POWER:** 2.5 kW			3 x 50%
	LUBE OIL CONDITIONER	1	**RATED POWER:** 1 kW			
	MAIN LUBE OIL PUMPS	2	**CONFIGURATION:** 2 x 100% **RATED POWER:** 150 HP			AC Powered
	BACKUP LUBE OIL PUMPS	1	**CONFIGURATION:** 1 x 100% **RATED POWER:** 80 HP			DC Powered
	CONTROL OIL SYSTEM JACKING OIL PUMPS	1	**RATED POWER:** 20 HP	Man Diesel and Turbo	Cycle 2	
	INTER/AFTER COOLERS w/ MOSITURE SEPARATORS	8		Man Diesel and Turbo	Cycle 2	4 per compressor
	COMPRESSOR LCI SOFT STARTER	1		Man Diesel and Turbo	Cycle 2	Single starter for both compressors
	AIR COMPRESSOR NOISE ENCLOSURE	4		EPCM	Cycle 2	
AIR TURBINE GENERATOR EQUIPMENT AND AUXILIARIES						
	AIR TURBINE GENERATOR	2	**OUTPUT:** 65 MW **GENERATOR:** 80 MVA **VOLTAGE:** 13.8 kV **MAX CO AT STACK:** 0.8 ppmvd CO	Man Diesel and Turbo	Cycle 2	MAN Diesel-Turbo DK100/220RA1, single casing, single flow axial turbine.
	AIR TURBINE TURNING GEAR	2	**RATED POWER:** 20 HP	Man Diesel and Turbo	Cycle 2	

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	LUBE OIL SYSTEM	2		Man Diesel and Turbo	Cycle 2	Including pumps, reservoir, heater, filters, and coolers.
	LUBE OIL HEATERS	2	**RATED POWER:** 30 kW			Per System
	LUBE OIL MIST SEPARATORS	3	**RATED POWER:** 2.5 kW			3 x 50%, Per System
	LUBE OIL CONDITIONER	1	**RATED POWER:** 1 kW			Per System
	MAIN LUBE OIL PUMPS	2	**CONFIGURATION:** 2 x 100% **RATED POWER:** 150 HP			AC Powered, Per System
	BACKUP LUBE OIL PUMPS	1	**CONFIGURATION:** 1 x 100% **RATED POWER:** 80 HP			DC Powered, Per System
	CONTROL OIL SYSTEM JACKING OIL PUMPS	1	**RATED POWER:** 20 HP	Man Diesel and Turbo	Cycle 2	Bottles, regulators, and instruments
	TURBINE NOISE ENCLOSURE	2		Man Diesel and Turbo	Cycle 2	
	EXIT AIR STACK	1	**STACK HEIGHT:** 50 ft	Man Diesel and Turbo	Cycle 2	
RECUPERATOR EQUIPMENT AND AUXILIARIES						
	COMBUSTION TURBINE WASTE HEAT RECUPERATOR	1	**PRESSURE:** 1150 psig **TEMPERATURE:** 940 deg F **AIR FLOW:** 2,125,800 lb/hr	RECUPERATOR SUPPLIER	Cycle 2	SCR and CO Catalyst.
	INLET DUCTWORK AND EXPANSION JOINT	1		RECUPERATOR SUPPLIER	Cycle 2	
	OUTLET DUCTWORK AND EXPANSION JOINT	1		RECUPERATOR SUPPLIER	Cycle 2	
	SCR SYSTEM	1	**MAX NOx AT STACK:** 2.0 ppmvd NOx	RECUPERATOR SUPPLIER	Cycle 2	Including ammonia vaporization and injection skid.
	TEMPERING AIR FANS	2	**RATED POWER:** 400 HP			2 x 100% per system
	AMMONIA VAPORIZER	1				1 per system
	DILUTION AIR BLOWERS	2	**RATED POWER:** 15 HP			2 x 100% per system
	CO CATALYST SYSTEM	1	**MAX CO AT STACK:** 2.0 ppmvd CO	RECUPERATOR SUPPLIER	Cycle 2	
	EXHAUST DUCT STACK	1	**STACK HEIGHT:** 190 ft **STACK DIAMETER:** 17 ft	RECUPERATOR SUPPLIER	Cycle 2	
	EXHAUST STACK DAMPER	1		RECUPERATOR SUPPLIER	Cycle 2	
COMPRESSED GAS						
	BULK NITROGEN STORAGE AND PIPING	1 LOT		EPCM	Cycle 2	Bottles, regulators, and instruments (Piping by EPC)

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
AMMONIA STORAGE AND HANDLING SYSTEM						
	AMMONIA HANDLING & UNLOADING SYSTEM	1	**DELIVERY:** 1 Unloading Station	EPCM	Cycle 2	Based on 19% Aqueous Ammonia
	AQUEOUS AMMONIA STORAGE TANK	1	**CAPACITY:** 10,000 Gallons	EPCM	Cycle 2	Shop fabricated, horizontal tank
	AMMONIA FORWARDING PUMPS	2	**CONFIGURATION:** 2 x 100% **CAPACITY:** 4 GPM **TOTAL HEAD:** 200 ft **RATED POWER:** 1.00 HP	EPCM	Cycle 2	Positive displacement pumps
CIRCULATING WATER PUMPS AND PIPING						
	CIRCULATING WATER PUMPS	2	**CONFIGURATION:** 2 x 50% **FLOW:** 30,000 GPM **TOTAL HEAD:** 60 ft **RATED POWER:** 600 HP	EPCM	Cycle 2	Vertical, wet pit, mix flow pump.
	AUXILIARY COOLING WATER PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 3,900 GPM **TOTAL HEAD:** 80 ft **RATED POWER:** 125 HP	EPCM	Cycle 2	Vertical, wet pit, mix flow pump.
COOLING TOWER						
	COOLING TOWER	1	**DUTY:** 600 MMBtu/hr **FLOW:** 60,000 GPM **# OF FANS:** 5 **RATED POWER:** 250 HP/fan	EPCM	Cycle 2	Plume Abatement Option
	COOLING TOWER TRASH SCREENS	2		EPCM	Cycle 2	To suit basin design
	CIRCULATING WATER FEED SYSTEM	1 LOT		EPCM	Cycle 2	Complete system with controls, pumps, and storage tanks.
	ACID METERING PUMPS AND STORAGE		**RATED POWER:** 1 HP			2 x 100% Pumps with storage tote
	SODIUM HYPOCHLORITE METERING PUMPS AND STORAGE		**RATED POWER:** 1 HP			2 x 100% Pumps with storage tote
	CORROSION INHIBITOR METERING PUMPS AND STORAGE		**RATED POWER:** 1 HP			2 x 100% Pumps with storage tote
	SODIUM BISULFITE METERING PUMPS AND STORAGE		**RATED POWER:** 1 HP			2 x 100% Pumps with storage tote
SERVICE / RAW WATER						
	RAW WATER SUPPLY PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 428 GPM **TOTAL HEAD:** 650 ft **RATED POWER:** 125 HP	EPCM	Cycle 2	Vertical, wet pit pump.

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	AIR BACKWASH BLOWER	2	**RATED POWER:** 20 HP	EPCM	Cycle 2	2 x 100% air blower. Power to be verified by supplier.
	SERVICE / FIRE WATER STORAGE TANK	1	**CAPACITY:** 700,000 gallons	EPCM	Cycle 2	Field erected, carbon steel 62 ft x 32 ft (D x H)
	SERVICE WATER PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 85 GPM **TOTAL HEAD:** 230 ft **RATED POWER:** 15.00 HP	EPCM	Cycle 2	Horizontal skid mounted centrifugal pumps
POTABLE WATER						
	POTABLIZATION SKID	1	**CAPACITY:** 10 gpm	Water Treatment Suppiler	Cycle 2	Activated carbon filter and sodium hypochlorite dosing. 2 x 100% pumps
	SODIUM HYPOCHLORITE PUMPS	2	**RATED POWER:** 1 HP			
	POTABLE WATER STORAGE TANK	1	**CAPACITY:** 14,400 gallons	EPCM	Cycle 2	Field erected, carbon steel 14 ft 4 in x 12 ft (D x H)
	POTABLE WATER PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 75 GPM **TOTAL HEAD:** 150 ft **RATED POWER:** 7.50 HP	EPCM	Cycle 2	Horizontal skid mounted centrifugal pumps
	EMERGENCY EYE-WASH STATIONS & SAFETY SHOWERS	3		EPCM	Cycle 2	For areas where chemical exposure is possible. Instantaneous water heaters included.
WATER TREAMENT						
	MULTIMEDIA FILTER SKID	2	**CONFIGURATION:** 2 x 100% **CAPACITY:** 45 GPM	Water Treatment Suppiler	Cycle 2	
	MULTIMEDIA FILTER BACKWASH PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 50 GPM **TOTAL HEAD:** 120 ft **RATED POWER:** 5 HP	Water Treatment Suppiler	Cycle 2	Pump size to be verified by supplier data
	AIR SCOUR BLOWER	1	**RATED POWER:** 10 HP	Water Treatment Suppiler	Cycle 2	1 x 100% air blower. Power to be verified by supplier.
WASTE WATER TREATMENT						
	CTG WATER WASH DRAIN TANK	1	**CAPACITY:** 1,600 gallons	EPCM	Cycle 2	Double wall, carbon steel.
	MECHANICAL EQUIPMENT BUILDING SUMP	1	**SIZE:** 3 x 10 ft (Dia x Height)	EPCM	Cycle 2	Reinforced concrete sump
	MECHANICAL EQUIPMENT BUILDING SUMP PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 100 gpm **TOTAL HEAD:** 75 ft **RATED POWER:** 7.5 HP	EPCM	Cycle 2	Submersible pumps, complete with controls.

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	WAREHOUSE / MAINTENANCE BUILDING SUMP	1	**SIZE:** 3 x 10 ft (Dia x Height)	EPCM	Cycle 2	Reinforced concrete sump with protective lining
	WAREHOUSE / MAINTENANCE BUILDING SUMP PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 100 gpm **TOTAL HEAD:** 75 ft **RATED POWER:** 7.5 HP	EPCM	Cycle 2	Submersible pumps, complete with controls.
	COOLING TOWER CHEMICAL BUILDING SUMP	1	**SIZE:** 3 x 10 ft (Dia x Height)	EPCM	Cycle 2	Reinforced concrete sump
	COOLING TOWER CHEMICAL BUILDING SUMP PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 100 gpm **TOTAL HEAD:** 75 ft **RATED POWER:** 7.5 HP	EPCM	Cycle 2	Submersible pumps, complete with controls.
	TURBINE/COMPRESSOR BUILDING SUMP	1	**SIZE:** 3 x 10 ft (Dia x Height)	EPCM	Cycle 2	Pre-cast concrete manhole
	TURBINE/COMPRESSOR BUILDING SUMP PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 100 gpm **TOTAL HEAD:** 75 ft **RATED POWER:** 7.5 HP	EPCM	Cycle 2	Sewage grinder pumps, complete with controls. Designed to handle sanitary waste.
	OIL/WATER SEPARATOR (API)	1	**CAPACITY:** 600 gpm	EPCM	Cycle 2	Horizontal, cylindrical, above ground, static separator.
	O/WS EFFLUENT TRANSFER PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 600 gpm **TOTAL HEAD:** 75 ft **RATED POWER:** 30 HP	EPCM	Cycle 2	Submersible pumps, complete with controls
	STORM WATER TRANSFER SUMP	1	**SIZE:** 3 x 10 ft (Dia x Height)	EPCM	Cycle 2	Pre-cast concrete manhole
	STORM WATER TRANSFER PUMPS	2	**CONFIGURATION:** 2 x 100% **FLOW:** 10 gpm **TOTAL HEAD:** 75 ft **RATED POWER:** 1 HP	EPCM	Cycle 2	Submersible pumps, complete with controls
	PACKAGED SANITARY SYSTEM SEWAGE GRINDER PUMPS	1	**CAPACITY:** 10 gpm **CONFIGURATION:** 2 x 100% **RATED POWER:** 7.5 HP	EPCM	Cycle 2	 Sewage grinder pumps, complete with controls. Designed to handle sanitary waste.

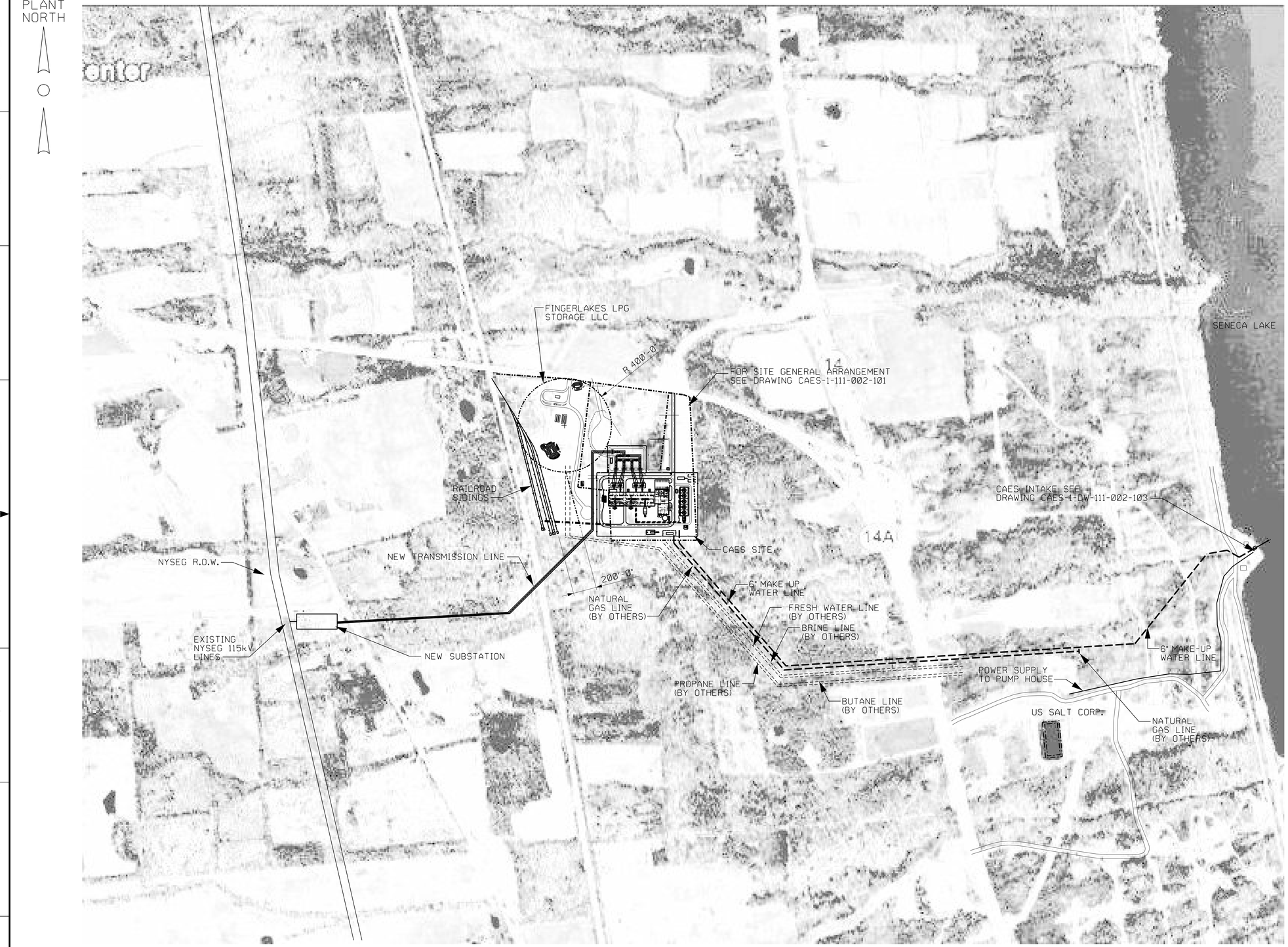
PLANT AIR EQUIPMENT						
	INSTRUMENT AIR DRYER	1	**FLOW:** 200 scfm	EPCM	Cycle 2	Dual tower, heatless regenerated desiccant dryers with pre and after filters
	WET AIR RECIEVER	1	**CAPACITY** 40 ft^3	EPCM	Cycle 2	Located directly upstream of dryers.
	TURBINE / COMPRESSOR AIR RECIEVER	1	**CAPACITY** 40 ft^3	EPCM	Cycle 2	Located in turbine / compressor building.

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
FUEL GAS EQUIPMENT						
	FUEL GAS ULTRASONIC FLOW METER	1		EPCM	Cycle 2	
	FUEL GAS CHROMATOGRAPH	1		EPCM	Cycle 2	
	FUEL GAS DEWPOINT HEATER	1	**DESIGN FLOW:** 31,800 lbs/hr	EPCM	Cycle 2	Natural gas fired.
	FUEL GAS REGULATION STATION	2	**CONFIGURATION:** 2 x 100% **DESIGN FLOW (CYCLE 2):** 50,000 lbs/hr	EPCM	Cycle 2	GT fuel gas supply
	FUEL GAS CONDITIONING SKID WITH FILTER / SEPARATOR VESSEL AND DRAIN TANK	1	**CONFIGURATION:** 1 x 100% **DESIGN FLOW (CYCLE 2):** 50,000 lbs/hr	EPCM	Cycle 2	
	FUEL GAS COALESCING FILTER SKID (FINAL FILTERS) w/ DRAIN TANK	2 Skids	**DESIGN FLOW:** 2 x 100% **DESIGN FLOW (CYCLE 2):** 50,000 lbs/hr	EPCM	Cycle 2	2 x 100% filters per skid. Vertical, carbon steel vessel per ASME Section VIII with stainless steel mesh pad, removal to 1µ. Skid is completely pre-piped.
FIRE PROTECTION						
	FIRE WATER PUMP	1	**CONFIGURATION:** 1 x 100% **FLOW:** 2,000 GPM **TOTAL HEAD:** 350 ft **RATED POWER:** 200 HP	EPCM	Cycle 2	Horizontal split case pump with diesel engine.
	FIRE WATER PUMP	1	**CONFIGURATION:** 1 x 100% **FLOW:** 2,000 GPM **TOTAL HEAD:** 350 ft **RATED POWER:** 200 HP	EPCM	Cycle 2	Horizontal split case pump with electric drive
	FIRE WATER JOCKEY PUMP	1	**CONFIGURATION:** 1 x 100% **FLOW:** 25 GPM **TOTAL HEAD:** 350 ft **RATED POWER:** 5 HP	EPCM	Cycle 2	Horizontal jockey pump
	FIRE EXTINGUISHERS	1 LOT		EPCM	Cycle 2	Per NFPA Standards
	FIRE EQUIPMENT ENCLOSURE	1	Electric heat, lightings, and ventilation.	EPCM	Cycle 2	Pre-Fabricated enclosure for firewater pumps and related equipment.
BUILDING HVAC AND VENTILATION						
	COMPLETE HVAC SYSTEM	2	**NUMBER OF BUILDINGS:** 1 **RATING:** 25 TON per system	EPCM	Cycle 2	Grade mounted, redundant systems for Administration Building / Visitors Center
	VENTILATION SYSTEMS	6	**NUMBER OF BUILDINGS:** 3 **FLOW:** 38000 CFM for 6 Fans **FLOW:** 13,000 CFM for 2 Fans **NUMBER OF LOUVERS:** 14 (10 ft h x 7 ft w)	EPCM	Cycle 2	For Mechanical Equipment Building, Maintenance Building, Turbine / Compressor Building.

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
	ELECTRIC UNIT HEATERS	18	**NUMBER OF BUILDINGS:** 3 kW per unit **POWER USAGE:** 50 KW per unit	EPCM	Cycle 2	For Mechanical Equipment Building, Maintenance Building, Turbine / Compressor Building.
TRANSFORMERS						
	GENERATOR STEP UP TRANSFORMER	1	**Rating:** 144/240 MVA 115-13.8 kV	EPCM	Cycle 2	GSU for 3 generators
	STATION AUXILLIARY TRANSFORMER	2	**Rating:** 78/130 MVA 115-13.8 kV	EPCM	Cycle 2	Compressor train transformers
	STATION AUXILLIARY TRANSFORMER	1	**Rating:** 7.5-9.375 MVA 115-13.8 kV	EPCM	Cycle 2	4.16kV loads
ISOLATED PHASE BUS DUCT						
	GENERATOR ISOLATED PHASE BUS DUCT	1 Lot	**Rating:** 12000 A 15 kV 150 KA	EPCM	Cycle 2	For generators to Step-up transformer
	GENERATOR ISOLATED PHASE BUS DUCT, HORIZONTAL 90 DEGREE	6	**Rating:** 12000 A 15 kV 150 KA	EPCM	Cycle 2	For generators to Step-up transformer
	GENERATOR ISOLATED PHASE BUS DUCT, VERTICAL 90 DEGREE	3	**Rating:** 12000 A 15 kV 150 KA	EPCM	Cycle 2	For generators to Step-up transformer
	GENERATOR ISOLATED PHASE BUS DUCT, HORIZONTAL TEE	6	**Rating:** 12000 A 15 kV 150 KA	EPCM	Cycle 2	For generators to Step-up transformer
NON-SEGREGATED PHASE BUS DUCT						
	NON SEGREGATED PHASE BUS DUCT OR CABLE BUS	1 Lot	**Rating:** 1200 A 15 kV 50 KA	EPCM	Cycle 2	For 4.16kV switchgear to transformer
	NON SEGREGATED PHASE BUS DUCT	2 Lots	**Rating:** 5000 A 15 kV 80 KA	EPCM	Cycle 2	For compressor trains to transformers
POWER DISTRIBUTION CENTERS						
	MAIN PDC	1 Lot		EPCM	Cycle 2	Includes all MV Switchgear 480v Transformers, LV Switchgear, MCCs, DC equipment, batteries, UPS equipment except that relating to the Cooling Tower.
	COOLING TOWER PDC	1 Lot		EPCM	Cycle 2	Includes all 480v Transformers, MCCs, DC equipment, UPS equipment relating to the Cooling Tower.

ITEM	EQUIPMENT SCOPE	QTY	CAPACITY BASIS / DATA	SCOPE	OPTION	REMARKS
MISCELLANEOUS						
	EMERGENCY NATURAL GAS GENERATOR	1	**RATED POWER:** 1500 kW	EPCM	Cycle 2	937.5 kVA
	OVERHEAD CRANE - TURBINE / COMPRESSOR BUILDING	1	**CAPACITY:** 80 ton	EPCM	Cycle 2	With a 15 ton auxiliary hook.
	HOIST - MECHANICAL EQUIPMENT BUILDING	1	**CAPACITY:** 5 ton	EPCM	Cycle 2	Monorail, underhung.
	ELEVATOR	1	**CAPACITY:** 2500 lbs **RATED POWER:** 25 HP	EPCM	Cycle 2	Office Elevator
CONTINUIOUS EMMISIONS MONITORING SYSTEM						
	CEMS, EQUIPMENT, ANALYZERS, SHELTER, SAMPLE LINES, PROBES, HMI'S, PLC'S, ETC.	1 LOT		EPCM	Cycle 2	CEMS, equipment, analyzers, shelter, sample lines, probes, HMI's, PLC's, ect.

DISTRIBUTED CONTROL SYSTEM						
	COMPLETE DISTRIBUTED CONTROL SYSTEM FOR THE BALANCE OF PLANT EQUIPMENT	1 LOT		EPCM	Cycle 2	



REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC.	LEAD ENGINEER	PROJ ENGR MANAGER	PROJECT MANAGER
C	11 03 11	GENERAL REVISION ISSUED FOR REVIEW AND COMMENT	JEV		JEV	HGE			MH
B	08 29 11	GENERAL REVISION ISSUED FOR REVIEW AND COMMENT	JEV		JEV	HGE			MH
A	07 12 11	INITIAL ISSUE FOR REVIEW AND COMMENT	JEV		JEV	HGE			MH

PRELIMINARY STATUS — DATE
LDE H.G. EISENBISE 07-12-11
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE
LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: JEV	
CHECKED BY:	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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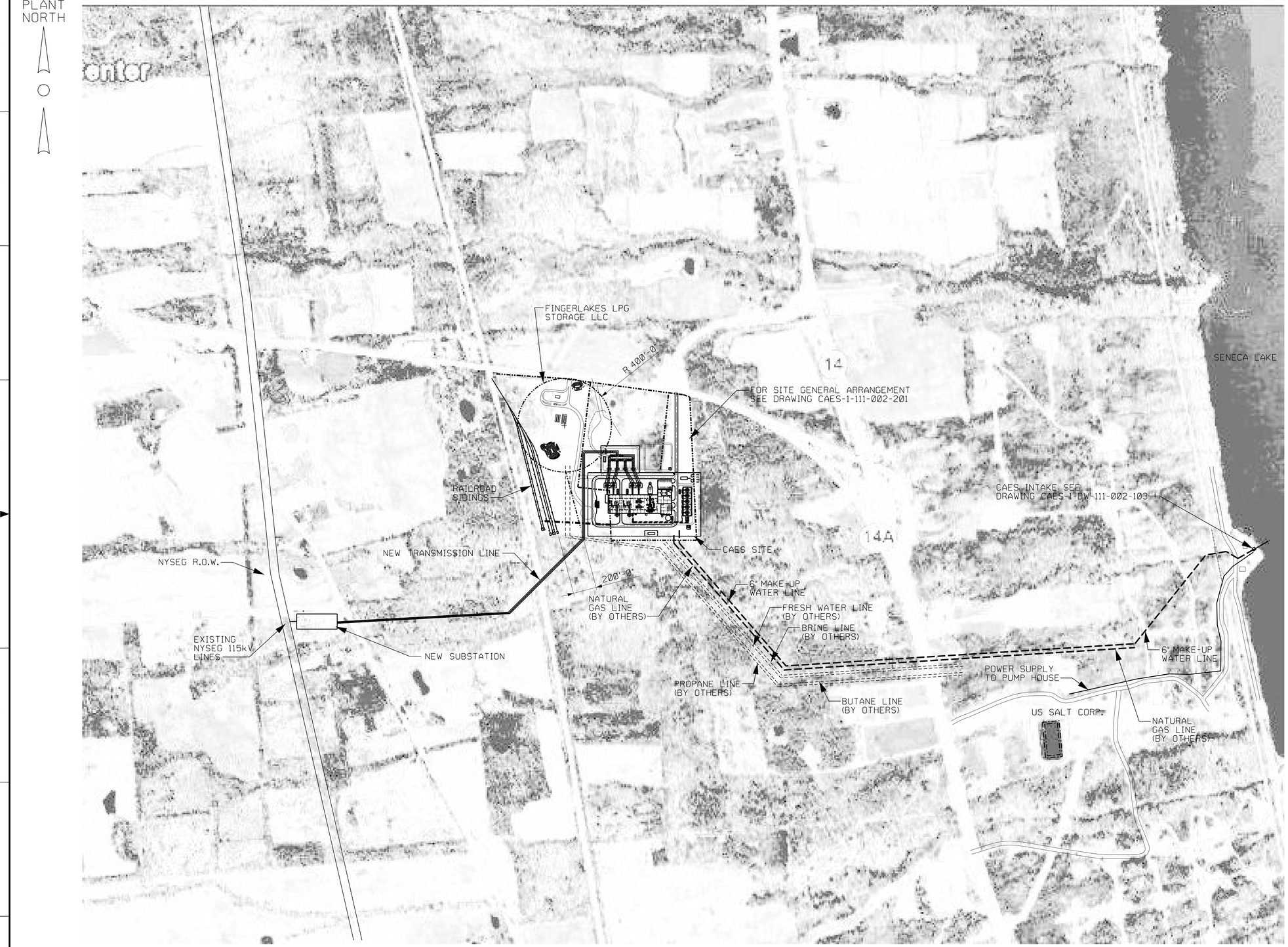
CLIENT/PROJECT TITLE

NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

GENERAL ARRANGEMENT
CYCLE 1
AREA PLAN

SCALE: 1"=400'
DRAWING SIZE: ARCH D (36" x 24")
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REV: C

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SCALE: 1" = 400'

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A	07 12 11	INITIAL ISSUE FOR REVIEW AND COMMENT	JEV		JEV	HGE			MH

PRELIMINARY STATUS — DATE — REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.
LDE H.G. EISENBISE 07-12-11

APPROVED STATUS — DATE — REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.
LDE

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: JEV	
CHECKED BY:	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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CLIENT/PROJECT TITLE

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SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

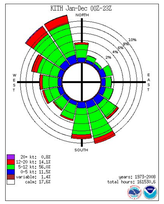
GENERAL ARRANGEMENT
CYCLE 2
AREA PLAN

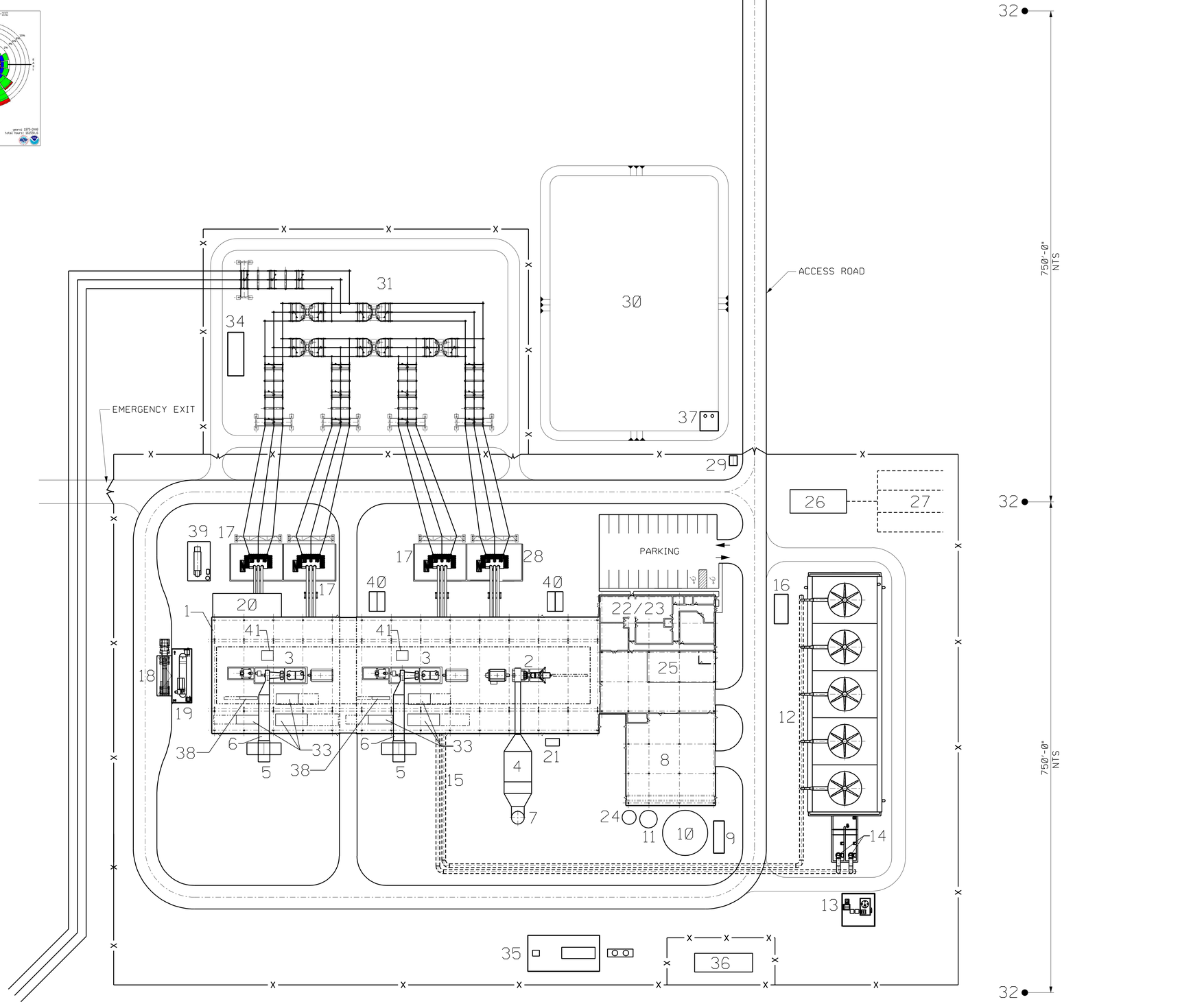
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PLANT NORTH





50 0 50 100 150

SCALE: 1" = 50'

PLANT DESCRIPTION

1 TURBINE/COMPRESSOR BUILDING
2 EXPANDER
3 COMPRESSOR
4 RECUPERATOR
5 AIR INLET FILTERS
6 AIR INLET DUCT
7 STACK
8 MECHANICAL EQUIPMENT BLDG.
9 FIRE WATER PUMP HOUSE
10 SERVICE/FIRE WATER TANK
11 DEMIN WATER TANK
12 COOLING TOWER
13 COOLING TOWER CHEMICAL BLDG.
14 CIRC WATER PUMP
15 CIRC WATER PIPING
16 COOLING TOWER PDC
17 TRANSFORMER
18 AMMONIA UNLOADING
19 AMMONIA STORAGE TANK
20 ELECTRICAL PDC
21 OIL WATER SEPARATOR
22 ADMIN/VISITORS CENTER (2nd FLOOR)
23 ADMIN/MAINTENANCE (1st FLOOR)
24 POTABLE WATER TANK
25 MEZZANINE STORAGE
26 SEWAGE SYSTEM
27 LEACH FIELD
28 STEP UP TRANSFORMER
29 GUARD HOUSE
30 STORM WATER POND
31 SWITCHYARD
32 WELL HEAD
33 INTERCOOLER
34 SWITCHYARD CONTROL BUILDING
35 GAS COMPRESSOR
36 GAS METERING
37 STORM WATER TRANSFER PUMP HOUSE
38 AFTER COOLER
39 GAS FIRED GENERATOR
40 VARIABLE FREQUENCY DRIVE
41 LUBE OIL SKID

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC.	LEAD ELECTRICAL ENGINEER	PROJ. ENGR MANAGER	PROJECT MANAGER
E	10/26/11	REV PER LATEST INFORMATION ISSUED FOR REVIEW & COMMENT	JEV		JEV	HGE			MH
D	10/12/11	REV PER LATEST INFORMATION ISSUED FOR REVIEW & COMMENT	JEV		JEV	HGE			MH
C	09/22/11	REVISED SWITCHYARD ISSUED FOR REVIEW & COMMENT	JEV		JEV	HGE			MH
B	09/19/11	REV PER LATEST INFORMATION FOR REVIEW AND COMMENT	JEV		JEV	HGE			MH
A	07/13/11	INITIAL ISSUE FOR REVIEW AND COMMENT	JEV		JEV	HGE			MH

PRELIMINARY STATUS — DATE — REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.
LDE H.G.EISENBISE 07-13-11

APPROVED STATUS — DATE — REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED 'HOLD' RETAINS PRELIMINARY STATUS.
LDE

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: JEV	
CHECKED BY:	
LEAD DESIGNER: J.E. VEEN	
ENGINEER/TECH SPECIALIST: H.G.EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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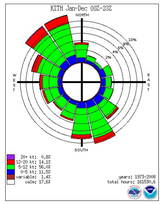
CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

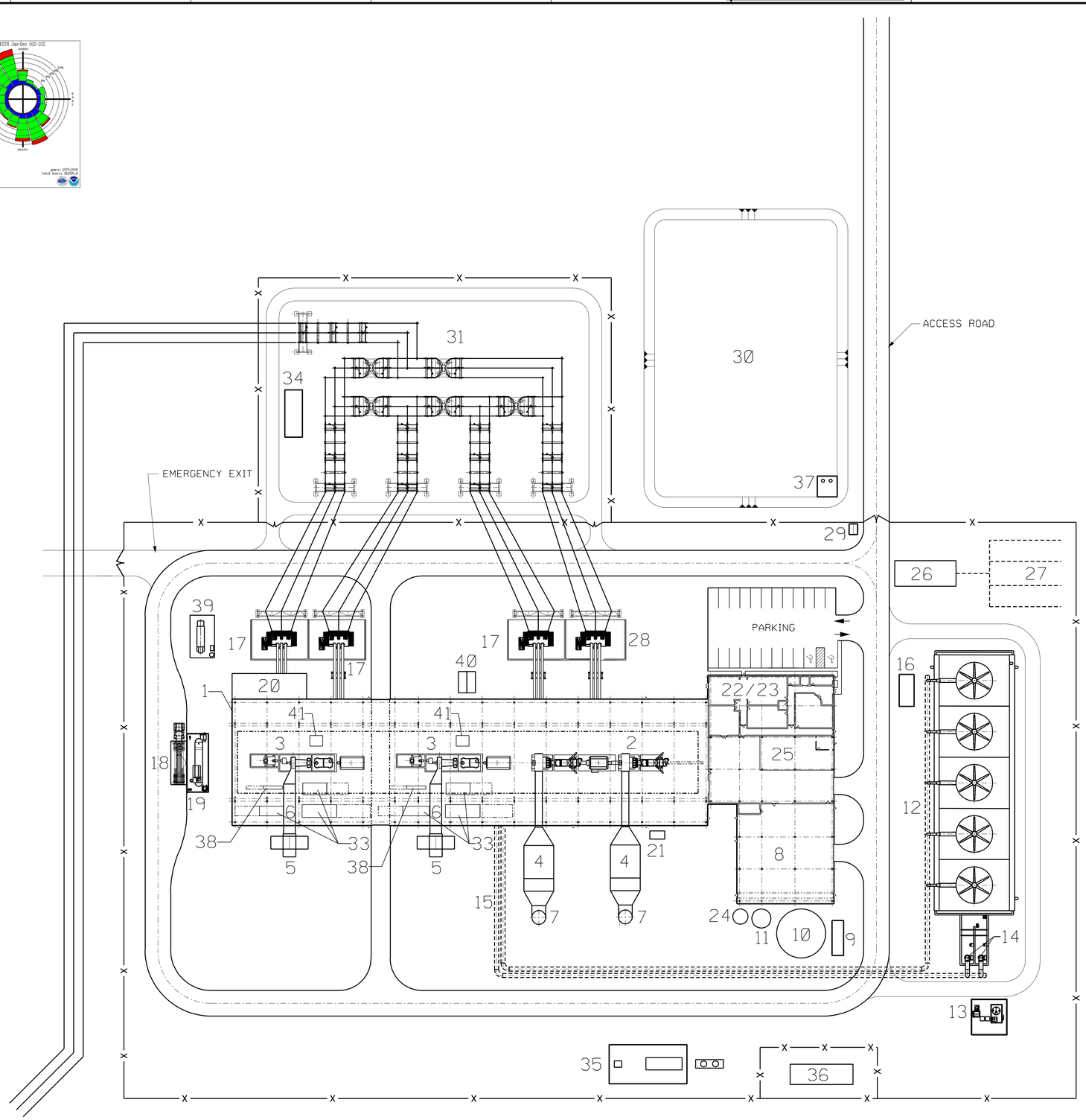
GENERAL ARRANGEMENT
CYCLE 1
SITE PLAN

SCALE: 1"=50' | DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-111-002-101 | REV: E

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PLANT NORTH





SCALE: 1" = 50'

50 0 50 100 150

PLANT DESCRIPTION

1 TURBINE/COMPRESSOR BUILDING
2 EXPANDER
3 COMPRESSOR
4 RECUPERATOR
5 AIR INLET FILTERS
6 AIR INLET DUCT
7 STACK
8 MECHANICAL EQUIPMENT BLDG.
9 FIRE WATER PUMP HOUSE
10 SERVICE/FIRE WATER TANK
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12 COOLING TOWER
13 COOLING TOWER CHEMICAL BLDG.
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25 MEZZANINE STORAGE
26 SEWAGE SYSTEM
27 LEACH FIELD
28 STEP UP TRANSFORMER
29 GUARD HOUSE
30 STORM WATER POND
31 SWITCHYARD
32 NOT USED
33 INTERCOOLER
34 SWITCHYARD CONTROL BUILDING
35 GAS COMPRESSOR
36 GAS METERING
37 STORM WATER TRANSFER PUMP HOUSE
38 AFTER COOLER
39 GAS FIRED GENERATOR
40 VARIABLE FREQUENCY DRIVE
41 LUBE OIL SKID

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC.	LEAD ENGINEER	PROJ. ENGR. MANAGER	PROJECT MANAGER
B	11	REVISED COMPRESSORS	JEV		JEV	HGE			MH
A	11/17/11	INITIAL ISSUE FOR REVIEW AND COMMENT	JEV		JEV	HGE			MH

PRELIMINARY STATUS — DATE
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APPROVED STATUS — DATE
LDE
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DRAWN BY: JEV	
CHECKED BY:	
LEAD DESIGNER: J.E. VEEN	
ENGINEER/TECH SPECIALIST: H.G.EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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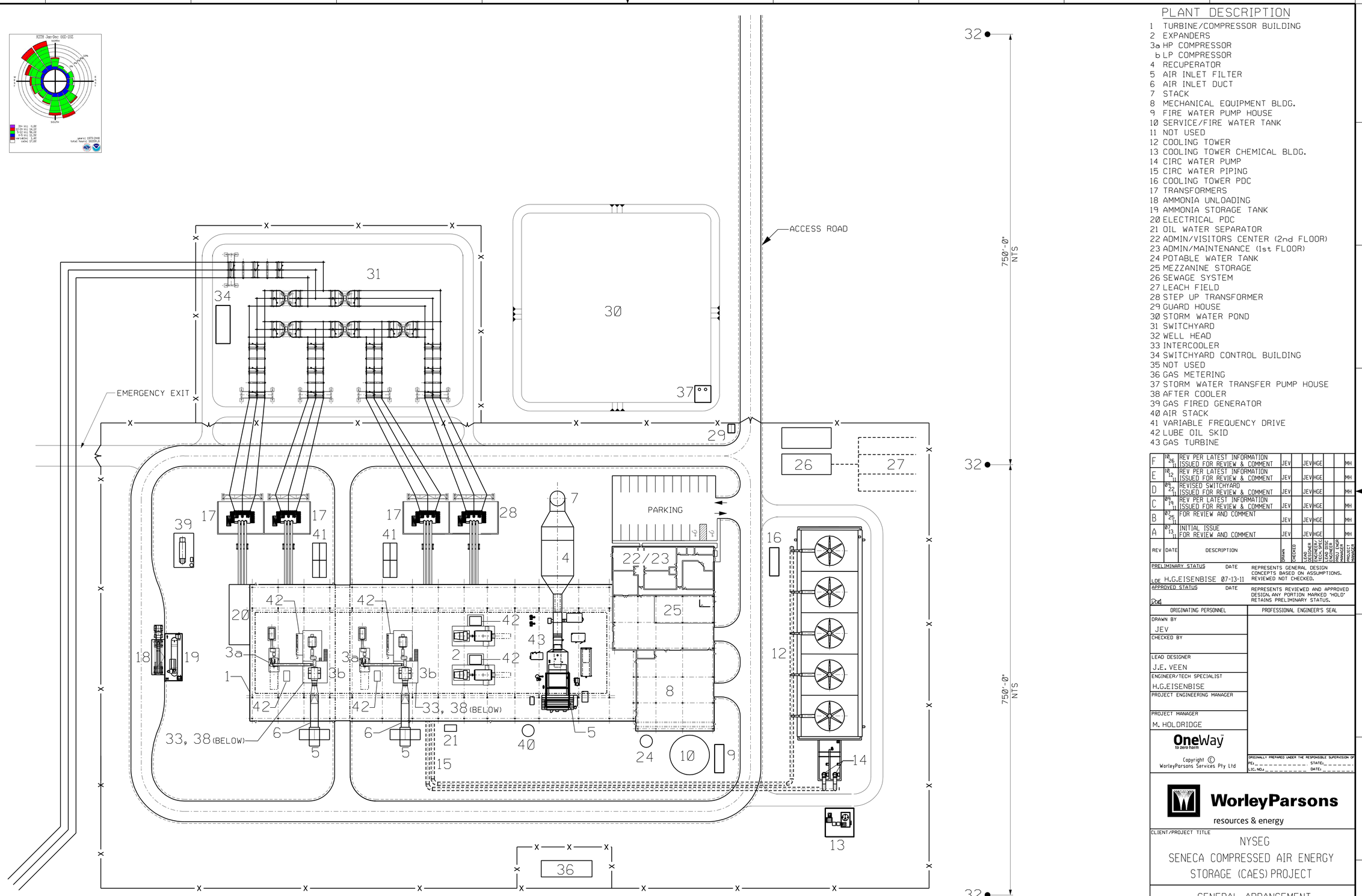
CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

GENERAL ARRANGEMENT
CYCLE 1A
SITE PLAN

SCALE: 1"=50'
DRAWING SIZE: ARCH D (36" x 24")
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REV: B

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PLANT NORTH



PLANT DESCRIPTION

1 TURBINE/COMPRESSOR BUILDING
2 EXPANDERS
3a HP COMPRESSOR
b LP COMPRESSOR
4 RECUPERATOR
5 AIR INLET FILTER
6 AIR INLET DUCT
7 STACK
8 MECHANICAL EQUIPMENT BLDG.
9 FIRE WATER PUMP HOUSE
10 SERVICE/FIRE WATER TANK
11 NOT USED
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13 COOLING TOWER CHEMICAL BLDG.
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34 SWITCHYARD CONTROL BUILDING
35 NOT USED
36 GAS METERING
37 STORM WATER TRANSFER PUMP HOUSE
38 AFTER COOLER
39 GAS FIRED GENERATOR
40 AIR STACK
41 VARIABLE FREQUENCY DRIVE
42 LUBE OIL SKID
43 GAS TURBINE

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC	PROJ. ENGR MANAGER	PROJECT MANAGER
F	10_26_11	REV PER LATEST INFORMATION ISSUED FOR REVIEW & COMMENT	JEV		JEV	HGE		MH
E	10_12_11	REV PER LATEST INFORMATION ISSUED FOR REVIEW & COMMENT	JEV		JEV	HGE		MH
D	09_22_11	REVISED SWITCHYARD ISSUED FOR REVIEW & COMMENT	JEV		JEV	HGE		MH
C	09_19_11	REV PER LATEST INFORMATION ISSUED FOR REVIEW & COMMENT	JEV		JEV	HGE		MH
B	07_25_11	FOR REVIEW AND COMMENT	JEV		JEV	HGE		MH
A	07_13_11	INITIAL ISSUE FOR REVIEW AND COMMENT	JEV		JEV	HGE		MH

PRELIMINARY STATUS — DATE — REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.
LDE H.G.EISENBISE 07-13-11
APPROVED STATUS — DATE — REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.
Pad

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: JEV	
CHECKED BY:	
LEAD DESIGNER: J.E. VEEN	
ENGINEER/TECH SPECIALIST: H.G.EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF: PE: _____ STATE: _____ LIC. NO.: _____ DATE: _____

WorleyParsons resources & energy

CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

GENERAL ARRANGEMENT
CYCLE 2
SITE PLAN

SCALE 1"=50' | DRAWING SIZE ARCH D (36" x 24")

WORLEYPARSONS DWG. NO. CAES-1-DW-111-002-201 | REV F

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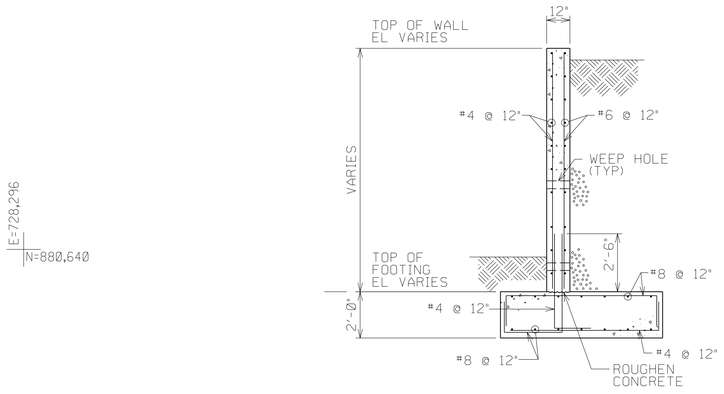


LEGEND:

- PROPERTY BOUNDARY
- PROPOSED FENCE
- OFFSET FROM R.O.W.
- NYSEG RIGHT OF WAY
- OFFSET FROM CREEK
- GRADE CONTOUR LINE (1160)
- RETAINING WALL
- ● 1140 PROPOSED GRADE SPOT ELEVATIONS
- ▫ CATCH BASIN

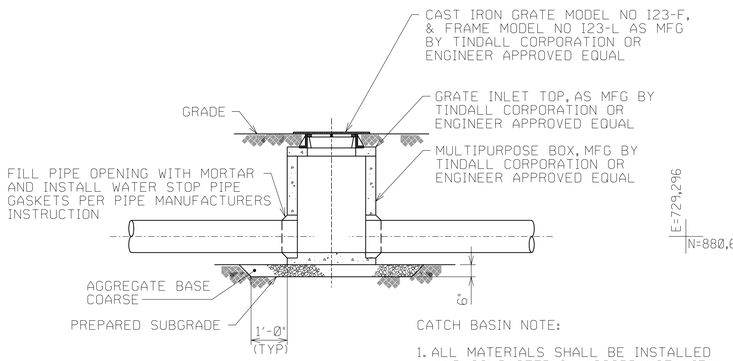
NOTE:

1. GRADE CONTOUR LINE; CREEK BOUNDARY AND WIDTH ARE APPROXIMATE.
2. COORDINATES ARE REFERENCED FROM TOWN OF READING TAX MAP #43.00 (POINT LOCATIONS ARE APPROXIMATE).
3. ALL ROADS ARE TO BE 16' WIDE.
4. CLOUDED AREA SHOWS CAPACITOR BANKS AND BUS ARRANGEMENT IF REQUIRED.



TYPICAL RETAINING WALL SECTION DETAIL

SCALE: 3/4" = 1'-0"

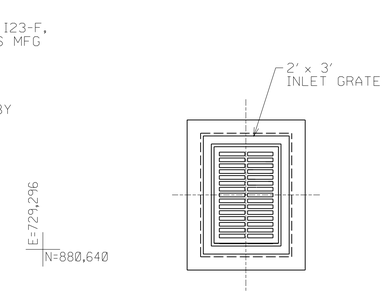


ELEVATION - CATCH BASIN

N.T.S

CATCH BASIN NOTE:

1. ALL MATERIALS SHALL BE INSTALLED AND COMPACTED IN ACCORDANCE WITH THE TECHNICAL SPECIFICATIONS.



PLAN - CATCH BASIN

N.T.S

PRELIMINARY DRAWING

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	LEAD DESIGNER	ENGINEER	MANAGER	PROJECT MANAGER
A	09/28/11	INITIAL ISSUE FOR REVIEW & COMMENT	DP		MA	BJW	BJW	WJB		MH

PRELIMINARY STATUS — LDE S. UNGER — DATE 08-02-11 — REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — LDE — DATE — REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: D. PRESSEY	
CHECKED BY:	
LEAD DESIGNER: M.APEWAJOYE	
ENGINEER/TECH SPECIALIST: S. UNGER	
PROJECT ENGINEERING MANAGER: W. BILENKI	
PROJECT MANAGER: M. HOLDRIDGE	

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ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF PE:_____ STATE:_____ LIC. NO.:_____ DATE:_____

WorleyParsons resources & energy

CLIENT/PROJECT TITLE

NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

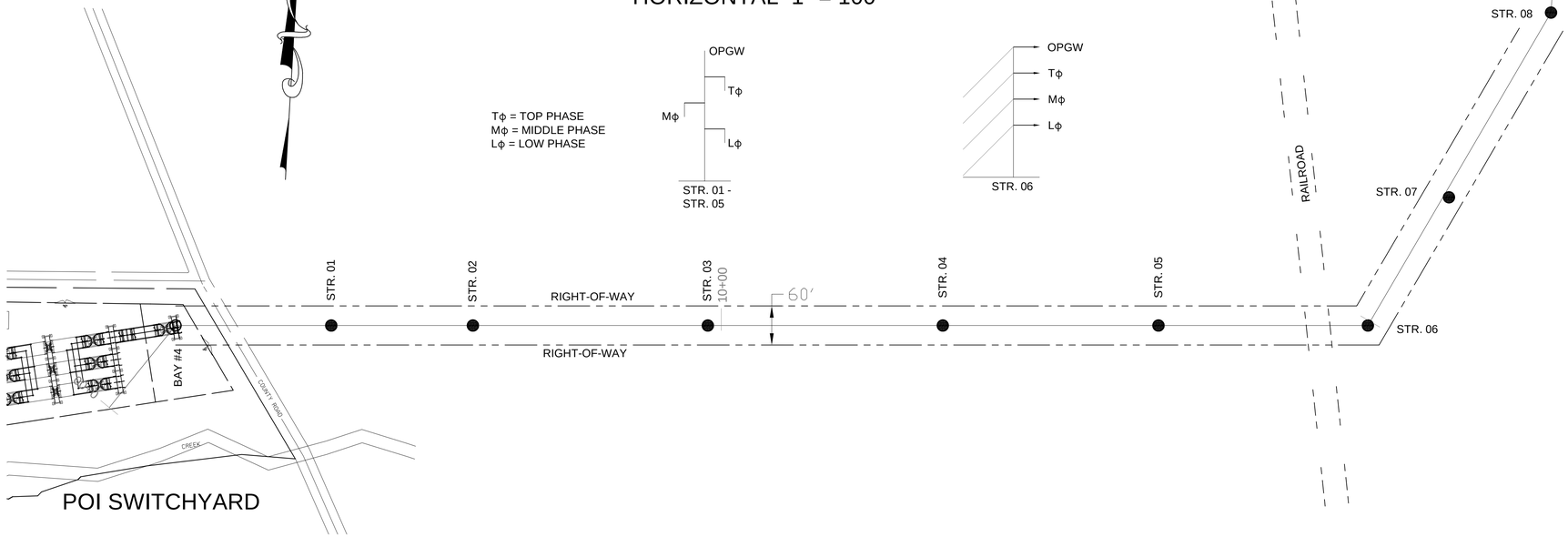
PROPERTY SITE LAYOUT GRADING PLAN

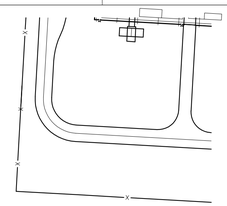
SCALE 1"=40'-0" — DRAWING SIZE ARCH D (36" x 24")

WORLEYPARSONS DWG. NO. CAES-1-DW-024-101-001 — REV A

PLAN SCALE
HORIZONTAL 1" = 100'

Tϕ = TOP PHASE
Mϕ = MIDDLE PHASE
Lϕ = LOW PHASE





GENERAL NOTES

PROJECT DESCRIPTION

NEW 115kV TRANSMISSION FROM READING CENTER SWITCHYARD TO NEW SENECA COMPRESSED AIR ENERGY STORAGE FACILITY.

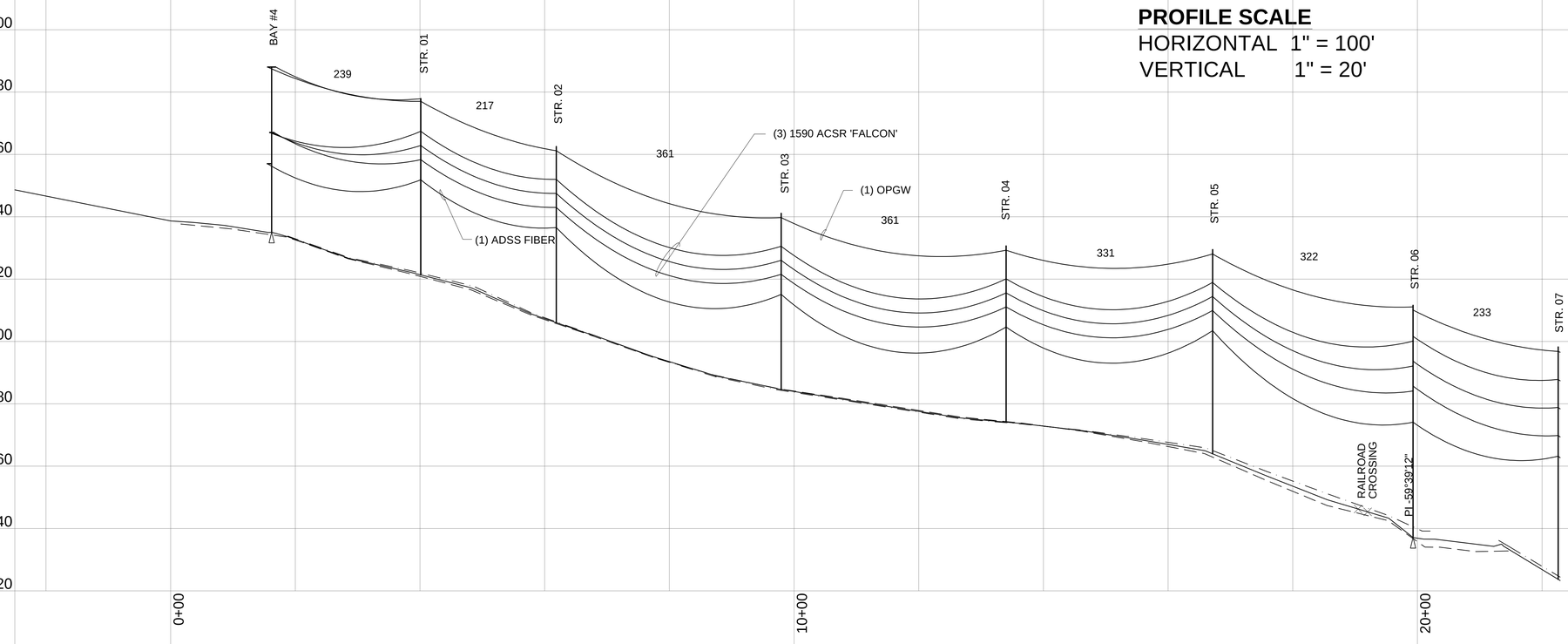
DESIGN CRITERIA

VOLTAGE 115kV
MVA 240 MVA
AMPACITY 1205 AMPERES STEADY STATE

SCOPE

SET TWELVE (12) NEW WOOD TRANSMISSION POLES AND RUN NEW (1) OPGW - OPTICAL GROUND WIRE, 115kV (3) ACSR - PHASE CONDUCTOR AND (1) ADSS - FIBER.

PROFILE SCALE
HORIZONTAL 1" = 100'
VERTICAL 1" = 20'



REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC	LEAD ENGINEER	PROJECT MANAGER

PRELIMINARY STATUS LDE	DATE 09/23/11	REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.
APPROVED STATUS LDE	DATE	REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY R. COBY	
CHECKED BY	
LEAD DESIGNER	
ENGINEER/TECH SPECIALIST R. COBY	
PROJECT ENGINEERING MANAGER W. BILENKI	
PROJECT MANAGER	

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ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF
PE: _____ STATE: _____
LIC. NO: _____ DATE: _____

WorleyParsons
resources & energy

CLIENT/PROJECT TITLE

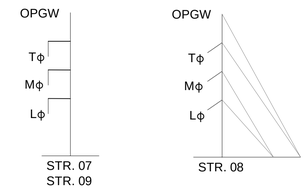
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

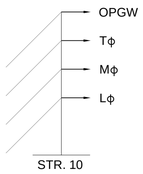
PLAN & PROFILE
CAES TRANSMISSION
115kV CIRCUIT

SCALE	DRAWING SIZE
As Noted	ARCH D (36" x 24")

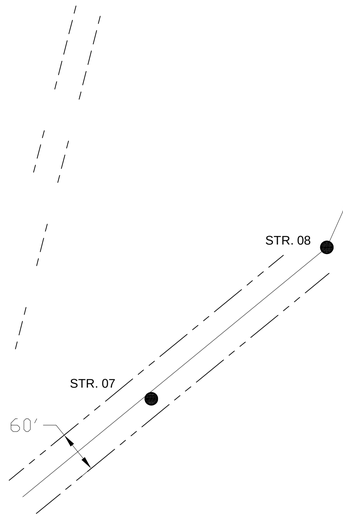
WORLEYPARSONS DWG. NO.	REV
CAES-1-DW-662-002-002	A

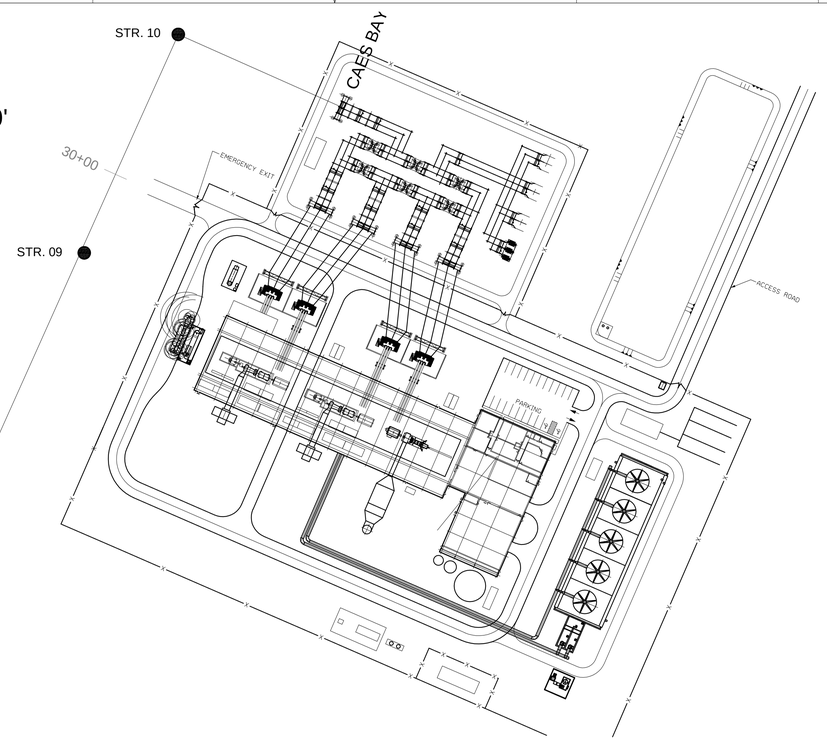
CAES-01-DW-662-002-002.dwg
04-OCT-2011 21:15





PLAN SCALE
HORIZONTAL 1" = 100'







GENERAL NOTES

PROJECT DESCRIPTION

NEW 115kV TRANSMISSION FROM READING CENTER SWITCHYARD TO NEW SENECA COMPRESSED AIR ENERGY STORAGE FACILITY.

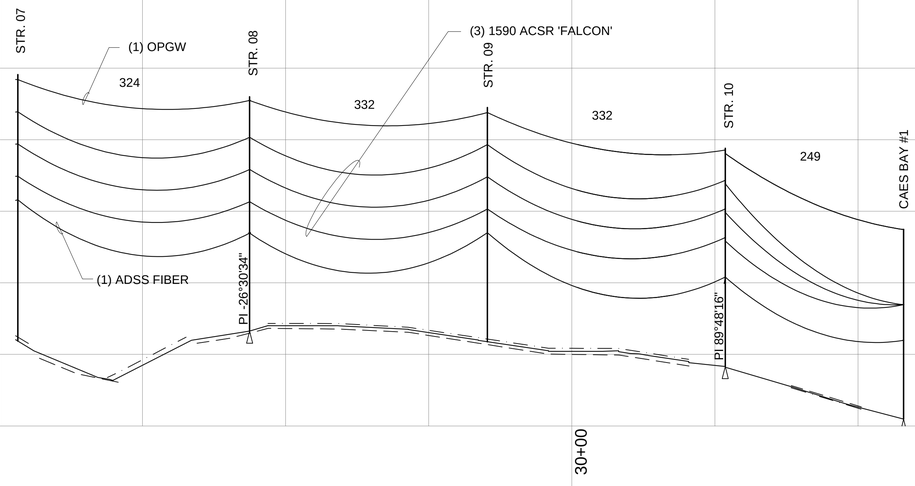
DESIGN CRITERIA

VOLTAGE 115kV
MVA 240 MVA
AMPACITY 1205 AMPERES STEADY STATE

SCOPE

SET TWELVE (12) NEW WOOD TRANSMISSION POLES AND RUN NEW (1) OPGW - OPTICAL GROUND WIRE, 115kV (3) ACSR - PHASE CONDUCTOR AND (1) ADSS - FIBER.

PROFILE SCALE
HORIZONTAL 1" = 100'
VERTICAL 1" = 20'



REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC	LEAD ENGINEER	PROJECT ENGINEER	PROJECT MANAGER

PRELIMINARY STATUS — DATE 09/23/11 — LDE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL

DRAWN BY: R. COBY
CHECKED BY:
LEAD DESIGNER:
ENGINEER/TECH SPECIALIST: R. COBY
PROJECT ENGINEERING MANAGER: W. BILENKI
PROJECT MANAGER:

PROFESSIONAL ENGINEER'S SEAL

ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF
PE: _____ STATE: _____
LIC. NO: _____ DATE: _____

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CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PLAN & PROFILE
CAES TRANSMISSION
115kV CIRCUIT

SCALE As Noted
DRAWING SIZE ARCH D (36" x 24")
WORLEYPARSONS DWG. NO. CAES-1-DW-662-002-002
REV A

CAES-01-DW-662-002-002.dwg
04-OCT-2011 21:16



NOTE:

1. GRADE CONTOUR LINE; CREEK BOUNDARY AND WIDTH ARE APPROXIMATE.
2. COOORDINATES ARE REFRENCED FROM TOWN OF READING TAX MAP #43.00 (POINT LOCATIONS ARE APPROXIMATE).
3. CLOUDED AREA SHOWS CAPACITOR BANKS AND BUS ARRANGEMENT IF REQUIRED.
4. TRANSMISSION LINE CONDUCTOR SIZE IS TO BE 1590 KCMIL ACSR, 54/19 STRANDING

REFRENCE DRAWINGS

1. ONE LINE DIAGRAM PLANT SWITCHYARD ---- DWG.# CAES-1-DW-662-206-001
2. ONE LINE DIAGRAM INTERCONNECT SWITCHYARD ---- DWG.# CAES-1-DW-662-206-002
3. GENERAL ARRANGEMENT INTERCONNECT SWITCHYARD BUS PLAN ---- DWG.# CAES-1-DW-662-747-001
4. ELECTRICAL EQUIPMENT INTERCONNECT ELEVATIONS ---- DWG.# CAES-1-DW-662-747-002
5. ELECTRICAL EQUIPMENT PLANT SWITCHYARD ELEVATIONS ---- DWG.# CAES-1-DW-662-747-004
6. PROPERTY SITE LAYOUT INTERCONNECT SWITCHYARD PLAN ---- DWG.# CAES-1-DW-662-002-004
7. PROPERTY SITE LAYOUT GRADING PLAN - INTERCONNECT SWITCHYARD ---- DWG.# CAES-1-DW-024-101-001

PRELIMINARY DRAWING

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER/ ENGINEER/ TECH SPEC	ENGINEER/ TECH SPEC	PROJECT ENGINEERING MANAGER	PROJECT MANAGER
A	09/28/11	INITIAL ISSUE FOR REVIEW & COMMENT	MA		MA	BJW	BJW	WJB	MH

PRELIMINARY STATUS — DATE — INFORMATION ONLY - NOT TO BE USED FOR CONSTRUCTION.
LDE B. WILLIAMS 08-02-11

APPROVED STATUS — DATE — REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.
LDE

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: M. APEWAJOYE	
CHECKED BY:	
LEAD DESIGNER: M. APEWAJOYE	
ENGINEER/TECH SPECIALIST: B. WILLIAMS	
PROJECT ENGINEERING MANAGER: W. BILENKI	
PROJECT MANAGER: M. HOLDRIDGE	

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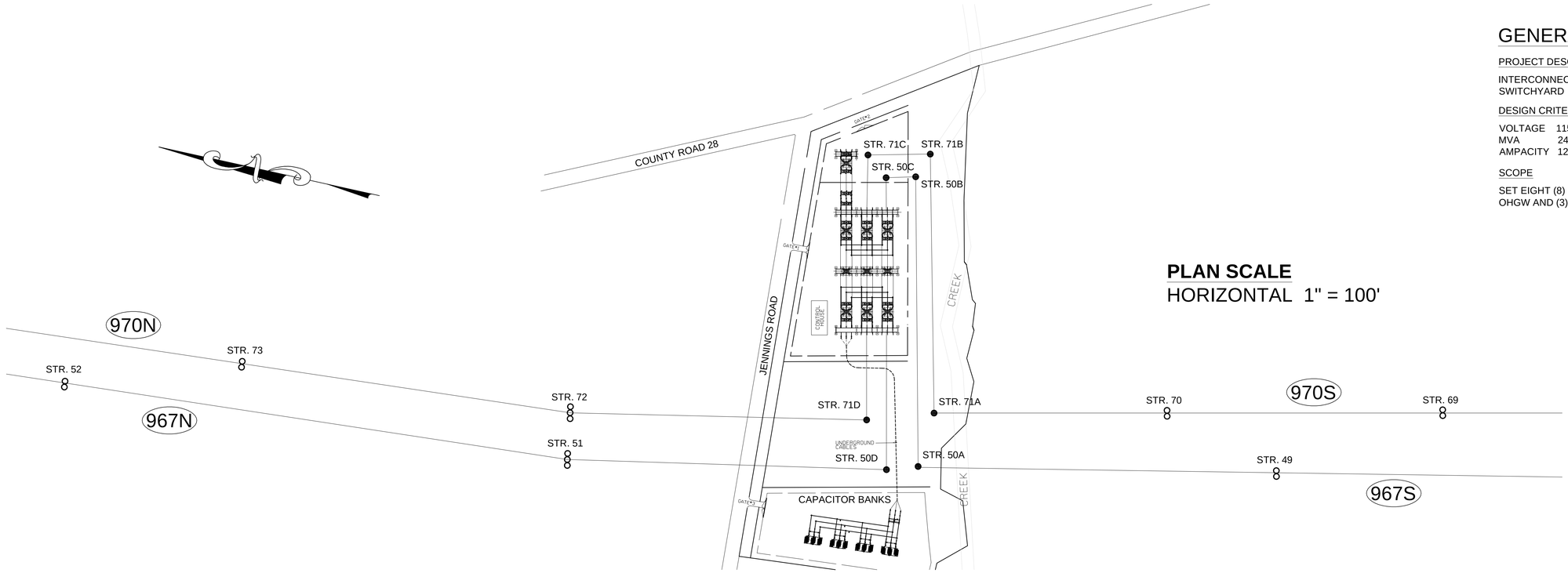
ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF
PE:_____ STATE:_____
LIC. NO.:_____ DATE:_____

WorleyParsons resources & energy

CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PROPERTY SITE LAYOUT
INTERCONNECT SWITCHYARD
PLAN

SCALE 1"=40'-0" | DRAWING SIZE ANSI E (44" x 34")
WORLEYPARSONS DWG. NO. CAES-1-DW-662-002-004 | REV A



PLAN SCALE
HORIZONTAL 1" = 100'

GENERAL NOTES

PROJECT DESCRIPTION

INTERCONNECT 115kV LINES 967 & 970 TO NEW READING CENTER SWITCHYARD

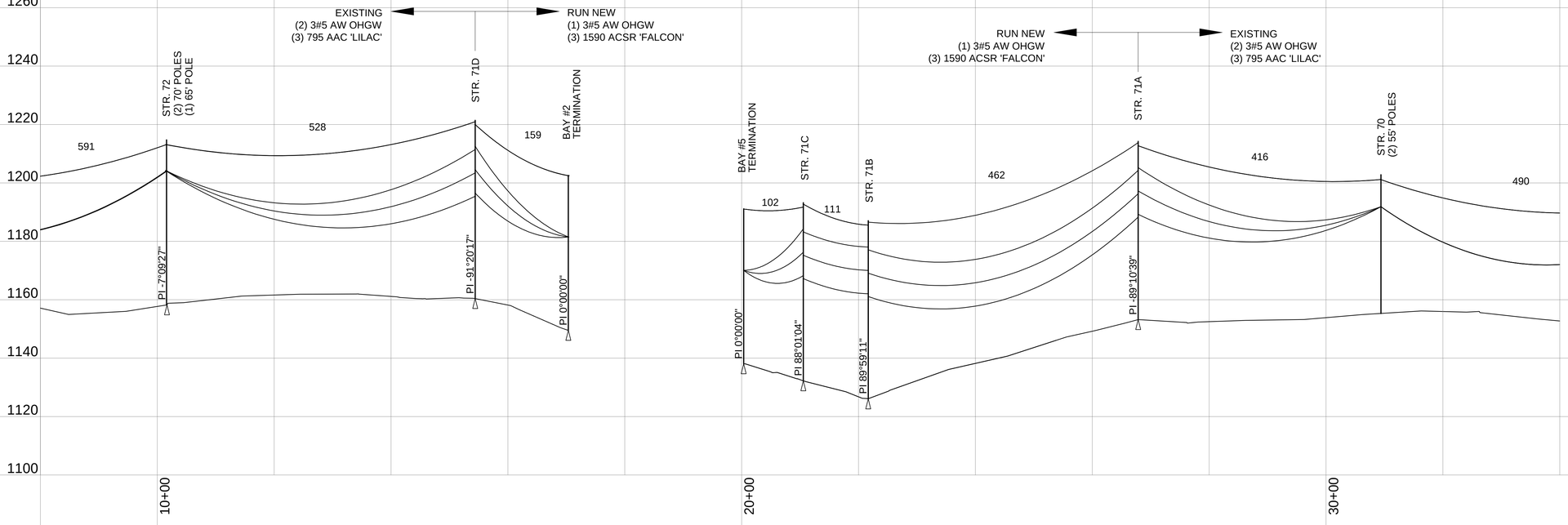
DESIGN CRITERIA

VOLTAGE 115kV
MVA 240 MVA
AMPACITY 1205 AMPERES STEADY STATE

SCOPE

SET EIGHT (8) NEW WOOD TRANSMISSION POLES AND RUN (1) OHGW AND (3) ACSR PHASE CONDUCTORS

PROFILE SCALE
HORIZONTAL 1" = 100'
VERTICAL 1" = 20'



REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC	LEAD ENGINEER	PROJECT MANAGER

PRELIMINARY STATUS — DATE 09/23/11 — LDE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL

DRAWN BY: R. COBY
CHECKED BY:
LEAD DESIGNER:
ENGINEER/TECH SPECIALIST: R. COBY
PROJECT ENGINEERING MANAGER: W. BILENKI
PROJECT MANAGER:

PROFESSIONAL ENGINEER'S SEAL

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ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF
PE: _____ STATE: _____
LIC. NO: _____ DATE: _____

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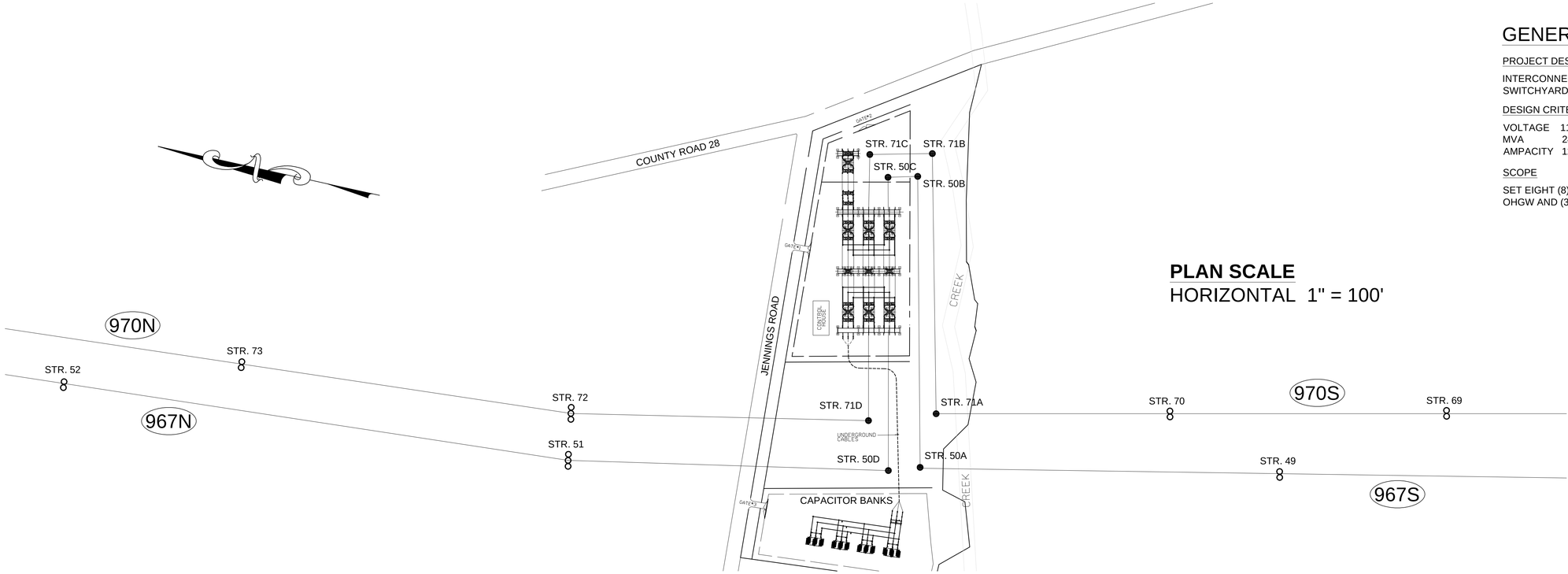
CLIENT/PROJECT TITLE

NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

GENERAL ARRANGEMENT
115kV INTERCONNECT
CIRCUIT I.D. 970

SCALE As Noted
DRAWING SIZE ARCH D (36" x 24")
WORLEYPARSONS DWG. NO. CAES-1-DW-662-002-001
REV A

CAES-01-DW-662-002-001.dwg
04-OCT-2011 09:57



PLAN SCALE
HORIZONTAL 1" = 100'

GENERAL NOTES

PROJECT DESCRIPTION

INTERCONNECT 115kV LINES 967 & 970 TO NEW READING CENTER SWITCHYARD

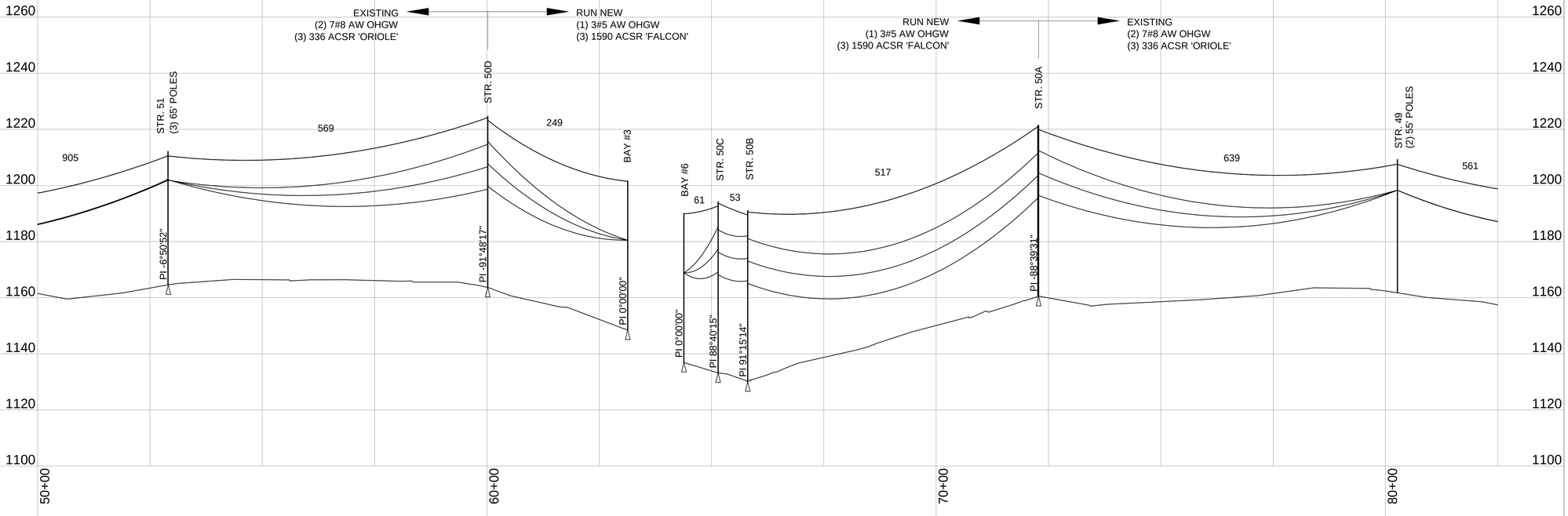
DESIGN CRITERIA

VOLTAGE 115kV
MVA 240 MVA
AMPACITY 1205 AMPERES STEADY STATE

SCOPE

SET EIGHT (8) NEW WOOD TRANSMISSION POLES AND RUN (1) OHGW AND (3) ACSR PHASE CONDUCTORS

PROFILE SCALE
HORIZONTAL 1" = 100'
VERTICAL 1" = 20'



REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC	ENGINEER	PROJECTION MANAGER	PROJECT MANAGER

PRELIMINARY STATUS — DATE 09/23/11 — LDE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL

DRAWN BY: R. COBY
CHECKED BY:
LEAD DESIGNER:
ENGINEER/TECH SPECIALIST: R. COBY
PROJECT ENGINEERING MANAGER: W. BILENKI
PROJECT MANAGER:

PROFESSIONAL ENGINEER'S SEAL

ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF
PE: _____ STATE: _____
LIC. NO: _____ DATE: _____

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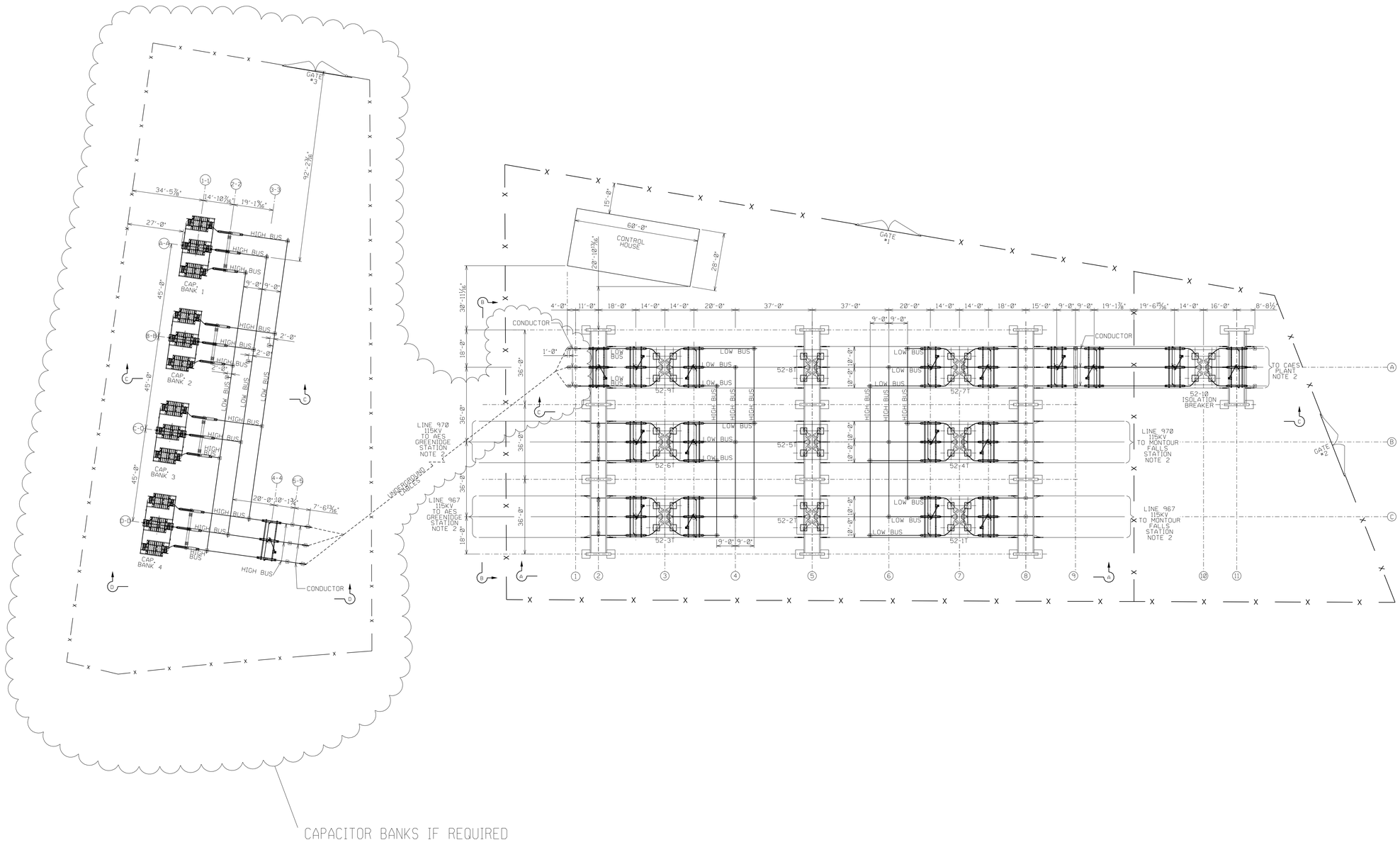
CLIENT/PROJECT TITLE

NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

GENERAL ARRANGEMENT
115kV INTERCONNECT
CIRCUIT I.D. 967

SCALE: As Noted
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-662-002-001
REV: A

CAES-01-DW-662-002-001.dwg
04-OCT-2011 - 23:58



REFRENCE DRAWINGS

1. ONE LINE DIAGRAM PLANT SWITCHYARD _____ DWG.# CAES-1-DW-662-206-001
2. ONE LINE DIAGRAM INTERCONNECT SWITCHYARD _____ DWG.# CAES-1-DW-662-206-002
3. GENERAL ARRANGEMENT PLANT SWITCHYARD BUS PLAN _____ DWG.# CAES-1-DW-662-747-003
4. ELECTRICAL EQUIPMENT INTERCONNECT SWITCHYARD ELEVATIONS _____ DWG.# CAES-1-DW-662-747-002
5. ELECTRICAL EQUIPMENT PLANT SWITCHYARD ELEVATIONS _____ DWG.# CAES-1-DW-662-747-024
6. PROPERTY SITE LAYOUT INTERCONNECT SWITCHYARD PLAN _____ DWG.# CAES-1-DW-662-002-024
7. PROPERTY SITE LAYOUT GRADING PLAN - INTERCONNECT SWITCHYARD _____ DWG.# CAES-1-DW-024-101-001

NOTE

1. CLOUDED AREA SHOWS CAPACITOR BANKS AND BUS ARRANGEMENT IF REQUIRED.
2. TRANSMISSION LINE CONDUCTOR SIZE IS TO BE 1590 KCMIL ACSR, 54/19 STRANDING

PRELIMINARY DRAWING

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/TECH SPECIALIST	LEAD DISCIPLINE ENGINEER	PROJECT ENGINEERING MANAGER	PROJECT MANAGER
A	09/28/11	INITIAL ISSUE FOR REVIEW & COMMENT	MA		MA	BJW	WJB	JB	MH

PRELIMINARY STATUS — DATE — INFORMATION ONLY - NOT TO BE USED FOR CONSTRUCTION.
LDE B. WILLIAMS 08-02-11
APPROVED STATUS — DATE — REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.
LDE

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: M. APEWAJOYE	
CHECKED BY:	
LEAD DESIGNER: M. APEWAJOYE	
ENGINEER/TECH SPECIALIST: B. WILLIAMS	
PROJECT ENGINEERING MANAGER: W. BILENKI	
PROJECT MANAGER: M. HOLDRIDGE	

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ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF
PE(s) _____ STATE(s) _____
LIC.NO(s) _____ DATE(s) _____

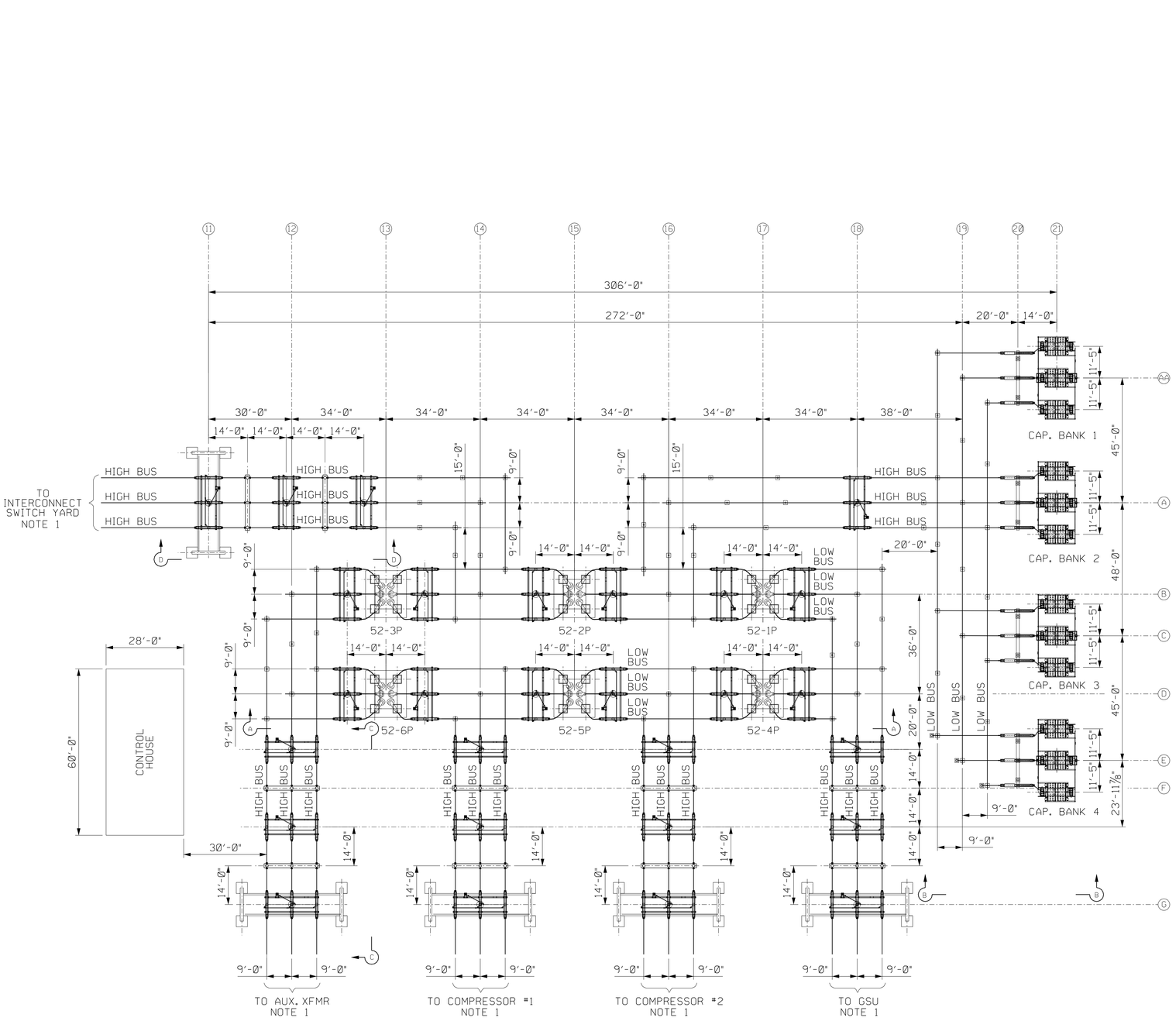
WorleyParsons
resources & energy

CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

GENERAL ARRANGEMENT INTERCONNECT SWITCHYARD BUS PLAN

SCALE 1"=20'-0" | DRAWING SIZE ANSI E (44" x 34")

WORLEYPARSONS DWG. NO. CAES-1-DW-662-747-001 | REV A



PRELIMINARY DRAWING

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	PROJECT ENGINEER	PROJECT MANAGER
A	09 28 11	INITIAL ISSUE FOR REVIEW & COMMENT	MAC		MA	BJW	BJW	WJB	MH

PRELIMINARY STATUS LDE B. WILLIAMS	DATE 09/21/11
	INFORMATION ONLY - NOT TO BE USED FOR CONSTRUCTION.
APPROVED STATUS LDE	DATE
	REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY M. CLEMENT	
CHECKED BY	
LEAD DESIGNER M. APEWAJOYE	
ENGINEER/TECH SPECIALIST B. WILLIAMS	
PROJECT ENGINEERING MANAGER W. BILENKI	
PROJECT MANAGER M. HOLDRIDGE	

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LIC. NO.: _____ DATE: _____

WorleyParsons
resources & energy

CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

GENERAL ARRANGEMENT
PLANT SWITCHYARD
BUS PLAN

SCALE	DRAWING SIZE
1" = 20'	ARCH D (36" x 24")

WORLEYPARSONS DWG. NO. CAES-1-DW-662-747-003 | REV A

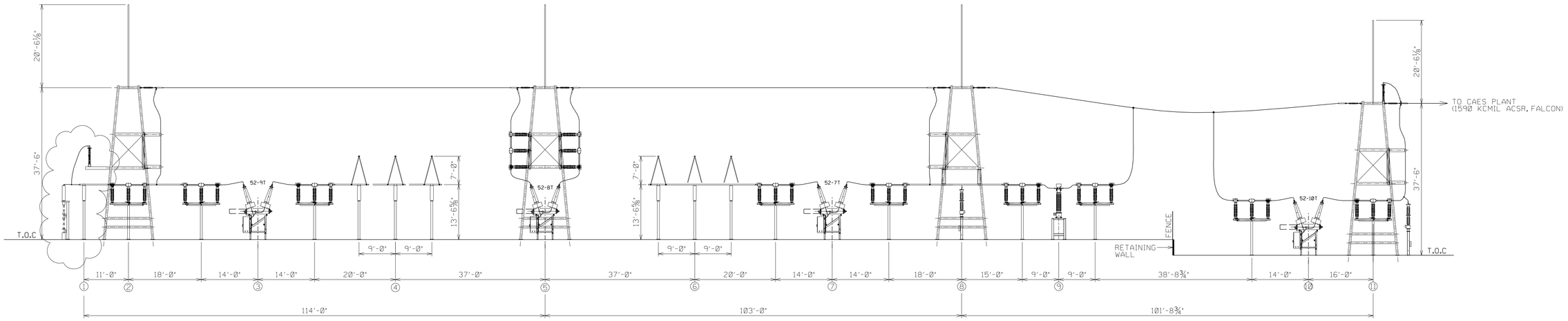
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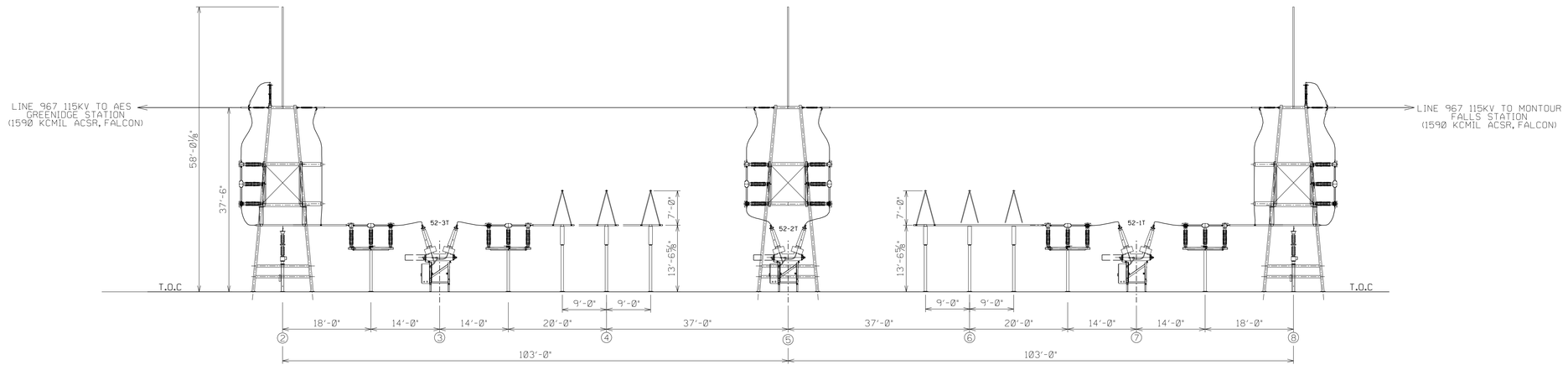
1. TRANSMISSION LINE CONDUCTOR SIZE IS TO BE 1590 KCMIL ACSR, 54/19 STRANDING.

REFRENCE DRAWINGS

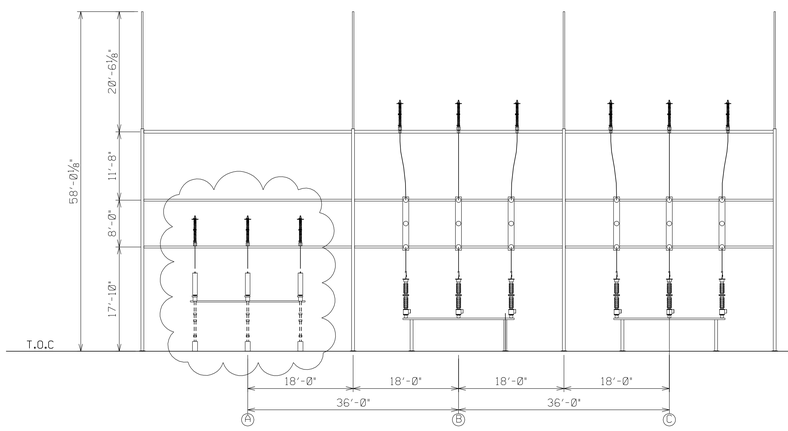
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2. ONE LINE DIAGRAM INTERCONNECT SWITCHYARD ..... DWG.# CAES-1-DW-662-206-002
3. GENERAL ARRANGEMENT PLANT SWITCHYARD BUS PLAN ..... DWG.# CAES-1-DW-662-747-003
4. ELECTRICAL EQUIPMENT INTERCONNECT SWITCHYARD ELEVATIONS ..... DWG.# CAES-1-DW-662-747-002
5. ELECTRICAL EQUIPMENT PLANT SWITCHYARD ELEVATIONS ..... DWG.# CAES-1-DW-662-747-004
6. PROPERTY SITE LAYOUT INTERCONNECT SWITCHYARD PLAN ..... DWG.# CAES-1-DW-662-002-004
7. PROPERTY SITE LAYOUT GRADING PLAN INTERCONNECT SWITCHYARD ..... DWG.# CAES-1-DW-024-101-001



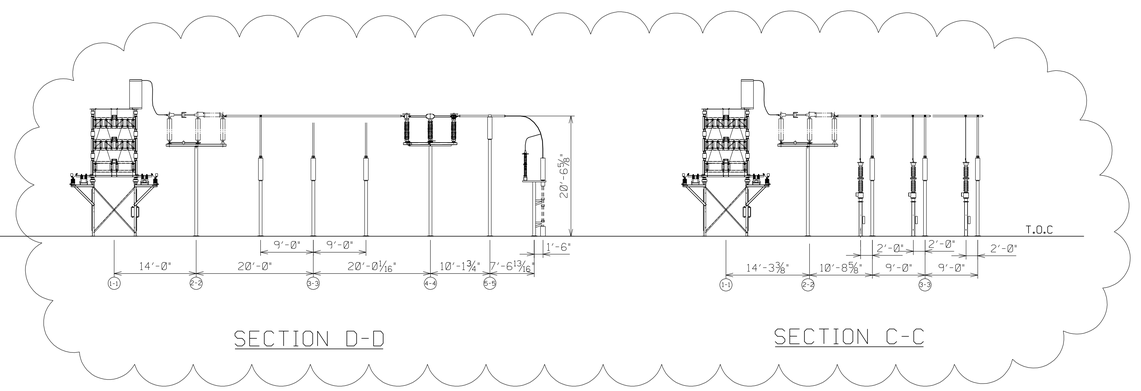
SECTION C-C



SECTION A-A



SECTION B-B



SECTION D-D

SECTION C-C

REFRENCE DRAWINGS

1. ONE LINE DIAGRAM PLANT SWITCHYARD_____DWG.# CAES-1-DW-662-206-001
2. ONE LINE DIAGRAM INTERCONNECT SWITCHYARD_____DWG.# CAES-1-DW-662-206-002
3. GENERAL ARRANGEMENT INTERCONNECT SWITCHYARD BUS PLAN_____DWG.# CAES-1-DW-662-747-001
4. GENERAL ARRANGEMENT PLANT SWITCHYARD BUS PLAN_____DWG.# CAES-1-DW-662-747-003
5. ELECTRICAL EQUIPMENT PLANT SWITCHYARD ELEVATIONS_____DWG.# CAES-1-DW-662-747-004
6. PROPERTY SITE LAYOUT INTERCONNECT SWITCHYARD PLAN_____DWG.# CAES-1-DW-662-002-004
7. PROPERTY SITE LAYOUT GRADING PLAN - INTERCONNECT SWITCHYARD_____DWG.# CAES-1-DW-024-101-001

NOTE

CLOUDED AREA AND SECTIONS SHOWS CAPACITOR BANKS AND BUS ARRANGEMENT IF REQUIRED.

PRELIMINARY DRAWING

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC	LEAD STRUC ENGINEER	PROJECT ENGINEERING MANAGER	PROJECT MANAGER
A	09/28/11	INITIAL ISSUE FOR REVIEW & COMMENT	MA		MA	BJW	BJW	WJB	MH

PRELIMINARY STATUS — DATE
LDE B. WILLIAMS 08-02-11
INFORMATION ONLY - NOT TO BE USED FOR CONSTRUCTION.

APPROVED STATUS — DATE
LDE
REPRESENTS REVIEWED AND APPROVED DESIGN, ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: M. APEWAJOYE	
CHECKED BY:	
LEAD DESIGNER: M. APEWAJOYE	
ENGINEER/TECH SPECIALIST: B. WILLIAMS	
PROJECT ENGINEERING MANAGER: W. BILENKI	
PROJECT MANAGER: M. HOLDRIDGE	

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PE's _____ STATE's _____
LIC. NO.s _____ DATE: _____

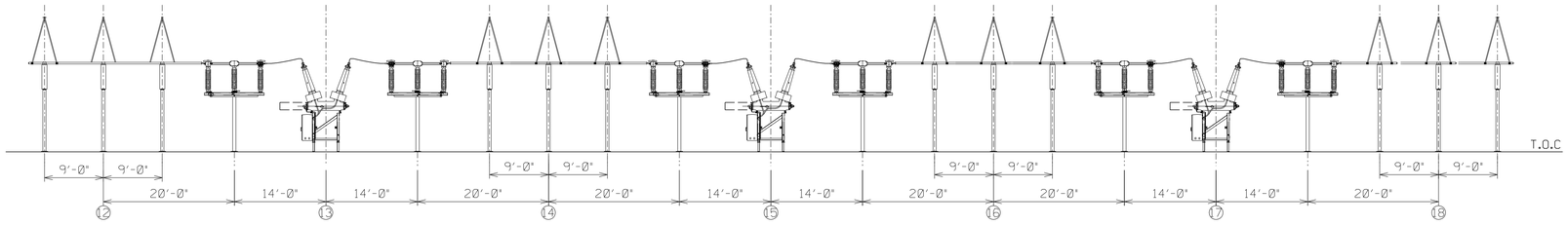
WorleyParsons
resources & energy

CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

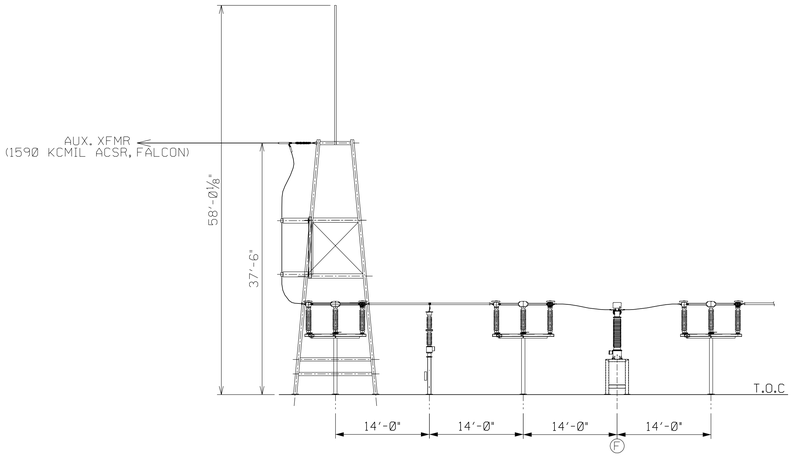
ELECTRICAL EQUIPMENT INTERCONNECT SWITCHYARD ELEVATIONS

SCALE 1"=10'-0" | DRAWING SIZE ANSI E (44" x 34")

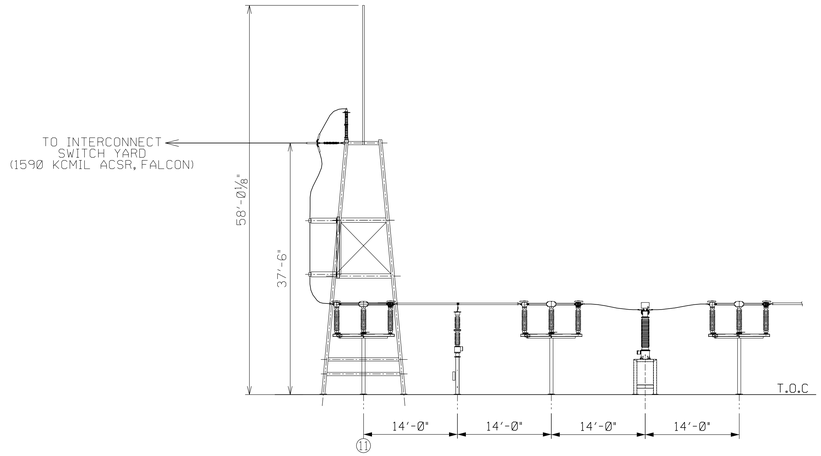
WORLEYPARSONS DWG. NO. CAES-1-DW-662-747-002 | REV A



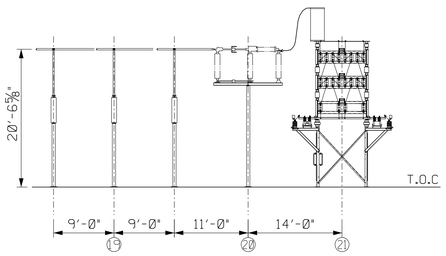
SECTION A-A



SECTION C-C



SECTION D-D



SECTION B-B

REFRENCE DRAWINGS

1. ONE LINE DIAGRAM PLANT SWITCHYARD ..... DWG.# CAES-1-DW-662-206-001
2. ONE LINE DIAGRAM INTERCONNECT SWITCHYARD ..... DWG.# CAES-1-DW-662-206-002
3. GENERAL ARRANGEMENT INTERCONNECT SWITCHYARD BUS PLAN ..... DWG.# CAES-1-DW-662-747-001
4. GENERAL ARRANGEMENT PLANT SWITCHYARD BUS PLAN ..... DWG.# CAES-1-DW-662-747-003
5. ELECTRICAL EQUIPMENT PLANT SWITCHYARD ELEVATIONS ..... DWG.# CAES-1-DW-662-747-004
6. PROPERTY SITE LAYOUT INTERCONNECT SWITCHYARD PLAN ..... DWG.# CAES-1-DW-662-002-004
7. PROPERTY SITE LAYOUT GRADING PLAN INTERCONNECT SWITCHYARD ..... DWG.# CAES-1-DW-024-101-001

PRELIMINARY DRAWING

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/TECH SPEC	LEAD ENGINEER	PROJECT ENGINEER	PROJECT MANAGER
A	09/20/11	INITIAL ISSUE FOR REVIEW & COMMENT	DP		MA	BJW	BJW	WJB	MH

PRELIMINARY STATUS — DATE
LDE B. WILLIAMS
INFORMATION ONLY - NOT TO BE USED FOR CONSTRUCTION.

APPROVED STATUS — DATE
LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: D. PRESSEY	
CHECKED BY:	
LEAD DESIGNER: M. APEWAJOYE	
ENGINEER/TECH SPECIALIST: B. WILLIAMS	
PROJECT ENGINEERING MANAGER: W. BILENKI	
PROJECT MANAGER: M. HOLDRIDGE	

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PE:_____ STATE:_____
LIC.NO.:_____ DATE:_____

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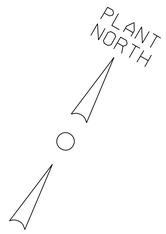
CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

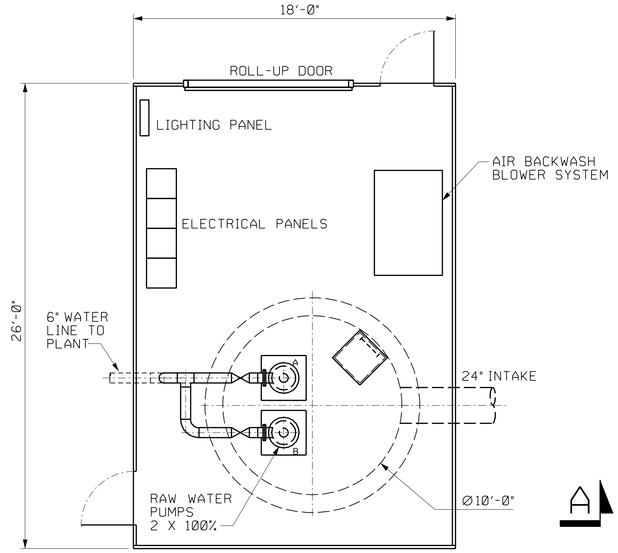
ELECTRICAL EQUIPMENT
PLANT SWITCH YARD
ELEVATIONS

SCALE 3/32" = 1' | DRAWING SIZE ARCH D (36" x 24")

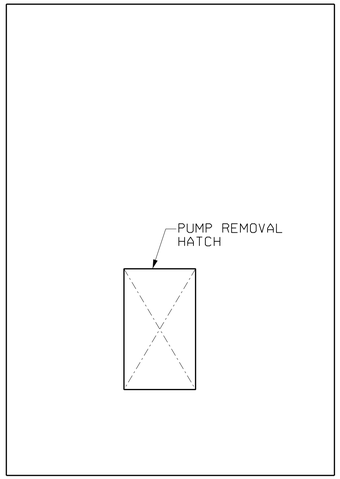
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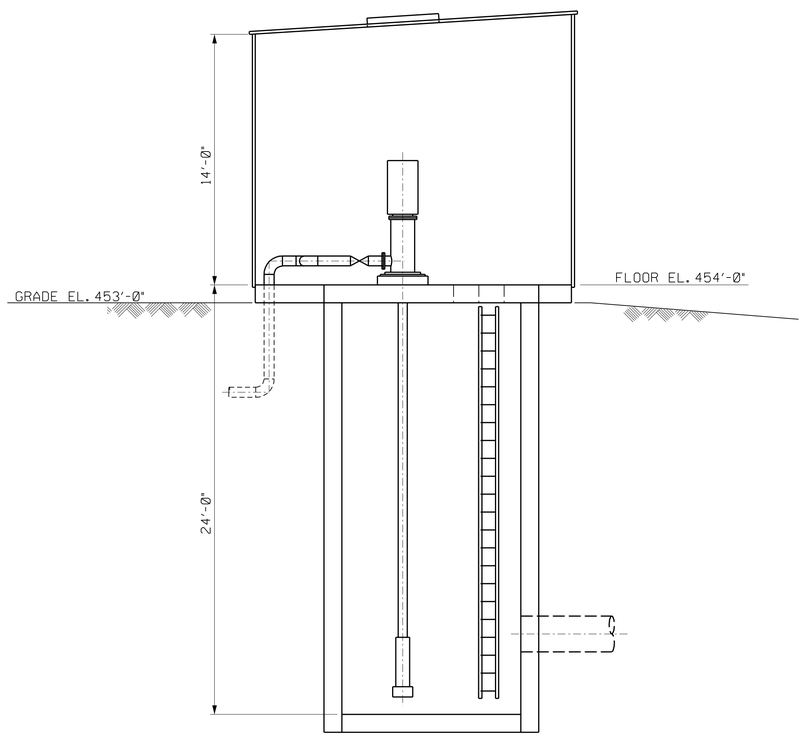




FLOOR PLAN



ROOF PLAN



SECTION A-A

SCALE: 1/4" = 1'

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	PROJ. ENGR. MANAGER	PROJECT MANAGER
A	08-29-11	INITIAL ISSUE FOR REVIEW AND COMMENT	JEV			HGE		MH

PRELIMINARY STATUS — DATE — LDE H.G. EISENBISE
INFORMATION ONLY - NOT TO BE USED FOR CONSTRUCTION.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: JEV	
CHECKED BY:	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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LIC. NO.:_____ DATE:_____

WorleyParsons
resources & energy

CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

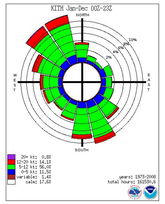
GENERAL ARRANGEMENT
RAW WATER PUMPHOUSE

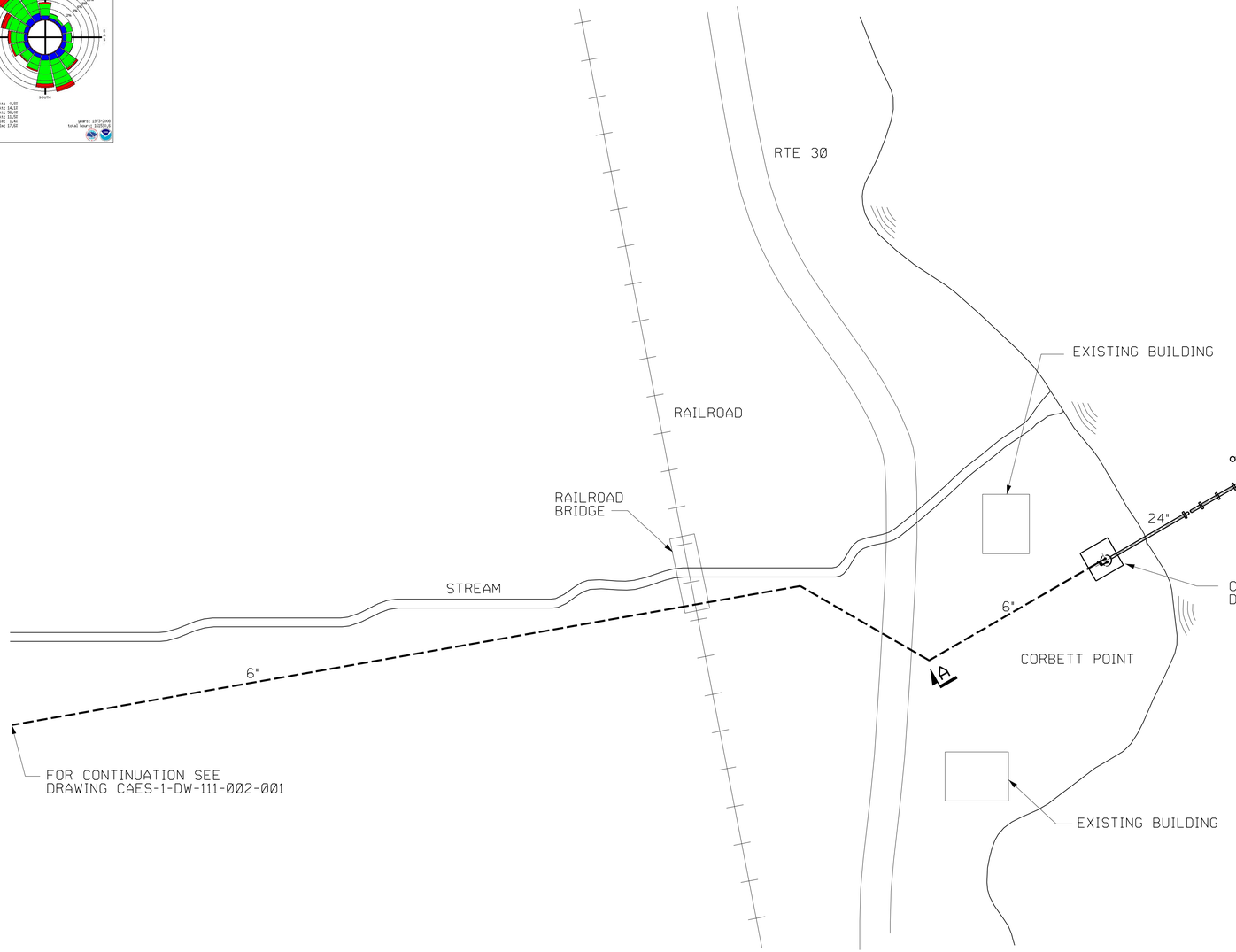
SCALE 1/4"=1' | DRAWING SIZE ARCH D (36" x 24")

WORLEYPARSONS DWG. NO. CAES-1-DW-177-002-101 | REV A

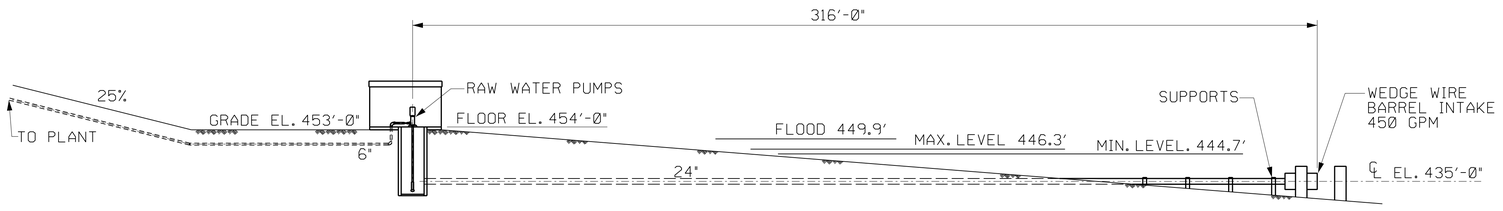
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PLANT NORTH





PLAN
SCALE: 1"=60'



SECTION A-A
SCALE: 1"=30'

30 0 30 60 90
SCALE: 1" = 30'

60 0 60 120 180
SCALE: 1" = 60'

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	LEAD DISC. ENGINEER	PROJ. ENGR. MANAGER	PROJECT MANAGER
A	08.29.11	INITIAL ISSUE FOR REVIEW AND COMMENT	JEV		JEV	HGE			MH

PRELIMINARY STATUS — DATE — LDE H.G.EISENBISE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: JEV	
CHECKED BY:	
LEAD DESIGNER: J.E. VEEN	
ENGINEER/TECH SPECIALIST: H.G.EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF
PE: _____ STATE: _____
LIC. NO.: _____ DATE: _____

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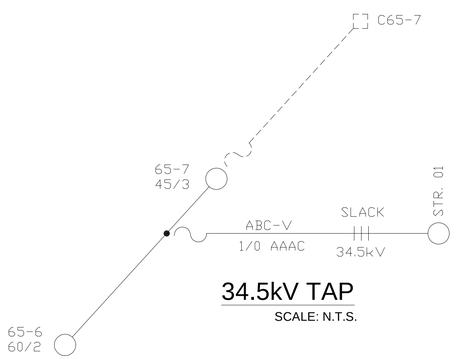
CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

GENERAL ARRANGEMENT
INTAKE PUMP HOUSE
SITE PLAN

SCALE: AS NOTED
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-111-002-103
REV: A

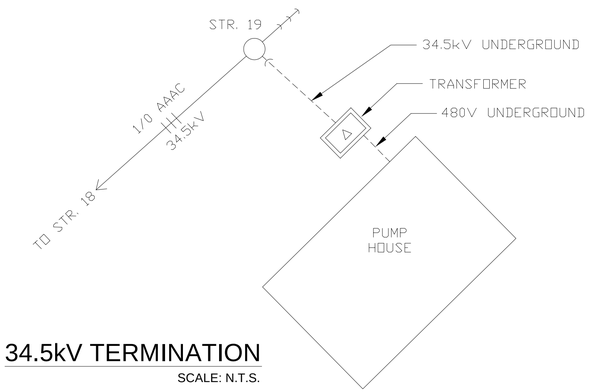
MM 8576 (2007/08) cad-dgn-111-002-103.dgn





34.5kV TAP

SCALE: N.T.S.



34.5kV TERMINATION

SCALE: N.T.S.

GENERAL NOTES

PROJECT DESCRIPTION

NEW 34.5kV FEEDER FOR CAES NATURAL WATER PUMPING PLANT. FEEDER WILL BE LOCATED JUST TO THE NORTH OF ACCESS ROAD

DESIGN CRITERIA

VOLTAGE 34.5kV

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC	ENGINEER	PROJECT MANAGER

PRELIMINARY STATUS LDE	DATE 09/23/11	REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.
APPROVED STATUS LDE	DATE	REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY R. COBY	
CHECKED BY	
LEAD DESIGNER	
ENGINEER/TECH SPECIALIST R. COBY	
PROJECT ENGINEERING MANAGER W. BILENKI	
PROJECT MANAGER	

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PE: _____ STATE: _____
LIC. NO: _____ DATE: _____

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CLIENT/PROJECT TITLE

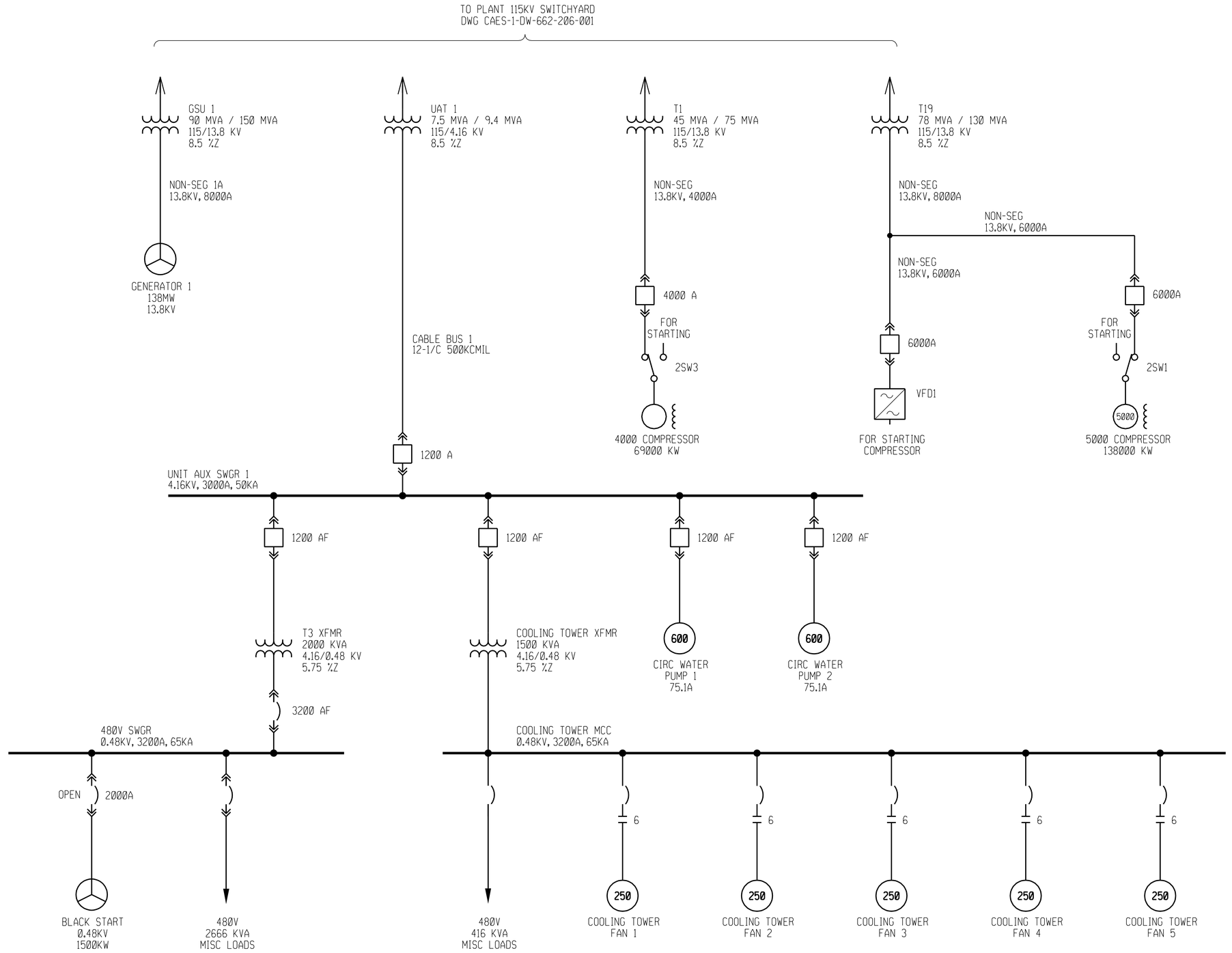
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

GENERAL ARRANGEMENT
34.5kV Feeder
NATURAL WATER PUMPING PLANT

SCALE	DRAWING SIZE
As Noted	ARCH D (36" x 24")

WORLEYPARSONS DWG. NO.	REV
CAES-1-DW-623-002-001	A

CAES-1-DW-623-002-001.dwg
04-27-2011 2:09



REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	LEAD DISCIPLINE ENGINEER	PROJ. ENGR. MANAGER	PROJECT MANAGER
A	10/19/11	INITIAL ISSUE	TAR		BEV	SRB	SRB		MH

PRELIMINARY STATUS — DATE
LDE S. BARKER 10/19/11
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE
LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAR	ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF: PE: _____ STATE: _____ LIC. NO.: _____ DATE: _____
CHECKED BY:	
LEAD DESIGNER: B. VOIGT	
ENGINEER/TECH SPECIALIST: S. BARKER	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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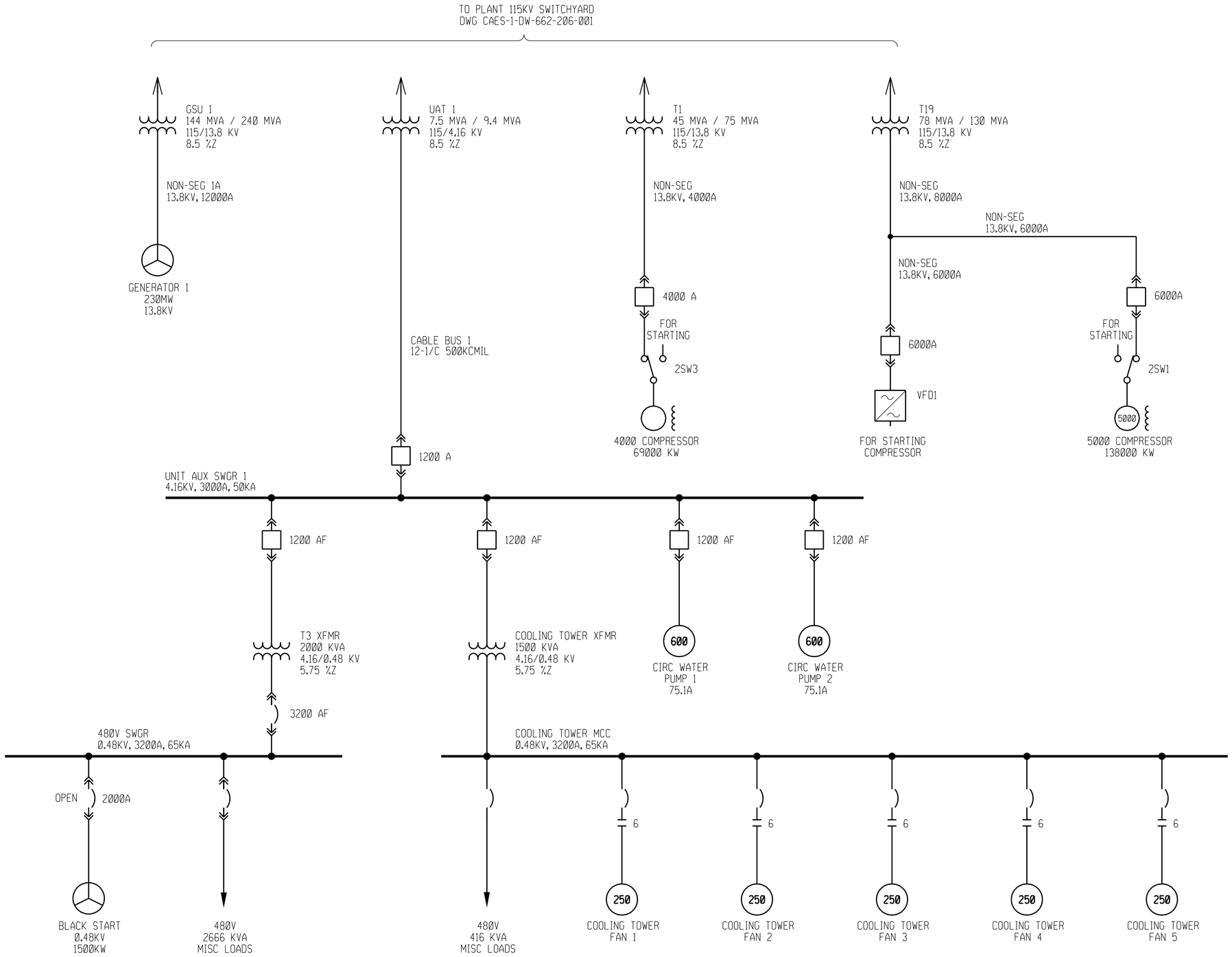
WorleyParsons
resources & energy

CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

ONE LINE DIAGRAM
PLANT CYCLE 1

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-601-206-001
REV: A

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REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	PROJ. ENGR. MANAGER	PROJECT MANAGER
A	12/09/11	INITIAL ISSUE	LJJ		BEV	SRB	SRB	MH

PRELIMINARY STATUS — DATE
LDE S. BARKER 12/07/11
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE
LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: LJJ	ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF: PE: _____ STATE: _____ LIC. NO.: _____ DATE: _____
CHECKED BY:	
LEAD DESIGNER: B. VOIGT	
ENGINEER/TECH SPECIALIST: S. BARKER	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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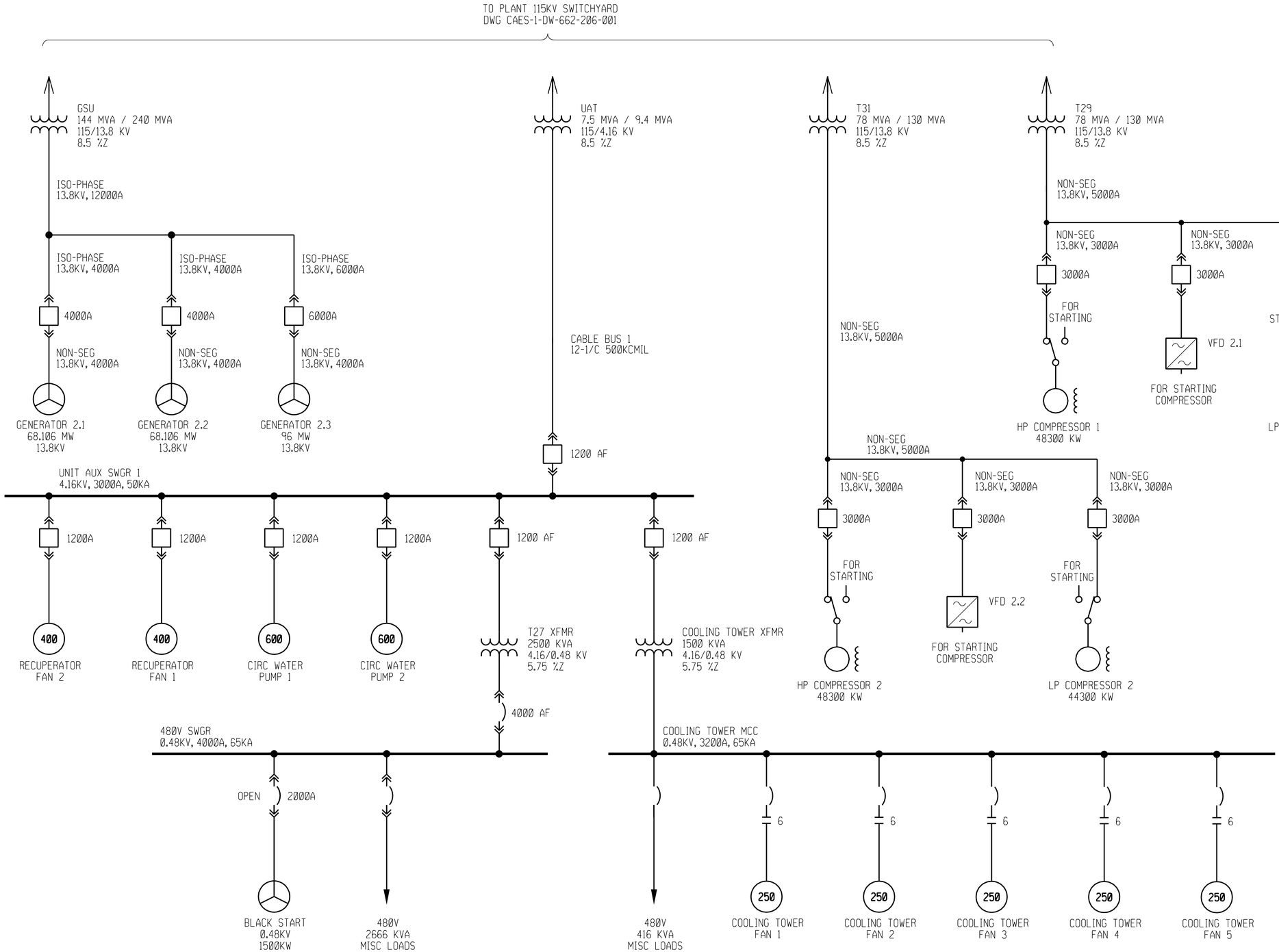
WorleyParsons
resources & energy

CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

ONE LINE DIAGRAM
PLANT CYCLE 1A

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-601-206-004
REV: A

\\caes-1-dw-601-206-004.dgn
12/7/2011 12:27:12 PM



REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER / TECH. SPECIALIST	PROJECT ENGINEER	PROJECT MANAGER
D	10/25/11	ISSUED FOR INFORMATION	TAR		BEV	SRB	SRB		MH
C	10/20/11	ISSUED FOR INFORMATION	TAR		BEV	SRB	SRB		MH
B	10/20/11	REVISE AS INDICATED	TAR		BEV	SRB	SRB		MH
A	10/19/11	INITIAL ISSUE	TAR		BEV	SRB	SRB		MH

PRELIMINARY STATUS — DATE — REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.
LDE S. BARKER 10/19/11

APPROVED STATUS — DATE — REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED 'HOLD' RETAINS PRELIMINARY STATUS.
LDE

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAR	
CHECKED BY:	
LEAD DESIGNER: B. VOIGT	
ENGINEER/TECH SPECIALIST: S. BARKER	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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PE: _____ STATE: _____
LIC. NO.: _____ DATE: _____

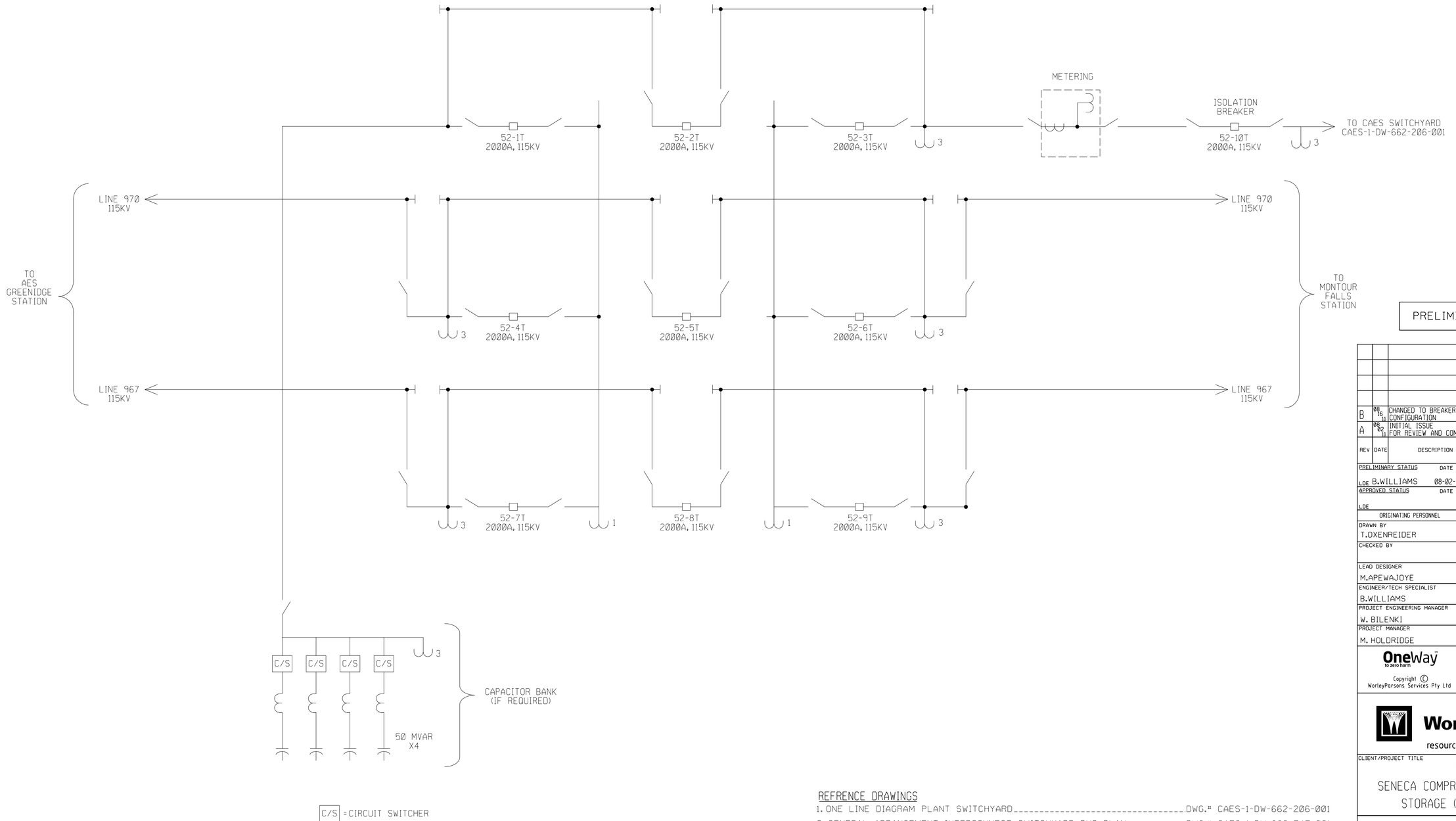
WorleyParsons
resources & energy

CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

ONE LINE DIAGRAM
PLANT CYCLE 2

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-601-206-002
REV: D

10/25/2011 2:34:14 PM
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PRELIMINARY DRAWING

REFRENCE DRAWINGS

1. ONE LINE DIAGRAM PLANT SWITCHYARD _____ DWG.# CAES-1-DW-662-206-001
2. GENERAL ARRANGEMENT INTERCONNECT SWITCHYARD BUS PLAN _____ DWG.# CAES-1-DW-662-747-001
3. ELECTRICAL EQUIPMENT INTERCONNECT ELEVATIONS _____ DWG.# CAES-1-DW-662-747-002
4. GENERAL ARRANGMENT PLANT SWITCHYARD BUS PLAN _____ DWG.# CAES-1-DW-662-747-003
5. ELECTRICAL EQUIPMENT PLANT SWITCHYARD ELEVATIONS _____ DWG.# CAES-1-DW-662-747-004
6. PROPERTY SITE LAYOUT INTERCONNECT SWITCHYARD PLAN _____ DWG.# CAES-1-DW-662-002-004
7. PROPERTY SITE LAYOUT GRADING PLAN - INTERCONNECT SWITCHYARD _____ DWG.# CAES-1-DW-024-101-001

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC.	ENGINEER	PROJECT ENGINEER MANAGER	PROJECT MANAGER
B	08-16-11	CHANGED TO BREAKER-AND-A-HALF CONFIGURATION	TO		MOA	BJW	BJW	WJB	MH
A	08-02-11	INITIAL ISSUE FOR REVIEW AND COMMENT	TO		MOA	BJW	BJW	WJB	MH

PRELIMINARY STATUS — DATE — REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.
LDE B.WILLIAMS 08-02-11

APPROVED STATUS — DATE — REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.
LDE

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: T.OXENREIDER	
CHECKED BY:	
LEAD DESIGNER: M.APEWAJOYE	
ENGINEER/TECH SPECIALIST: B.WILLIAMS	
PROJECT ENGINEERING MANAGER: W. BILENKI	
PROJECT MANAGER: M. HOLDRIDGE	

OneWay™ to zero harm

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PE:_____ STATE:_____
LIC. NO.:_____ DATE:_____

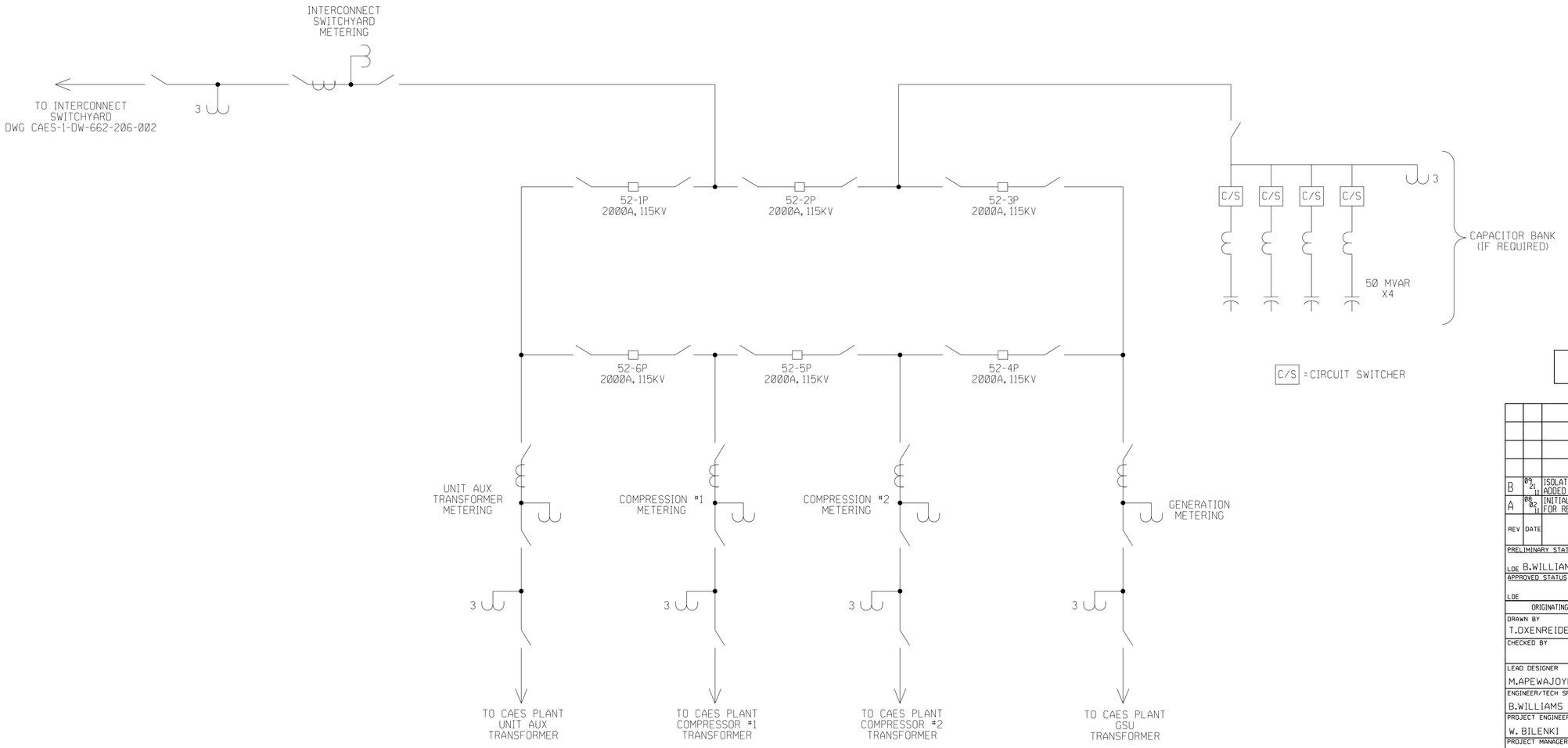
WorleyParsons
resources & energy

CLIENT/PROJECT TITLE

NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

ONE LINE DIAGRAM
INTERCONNECT SWITCHYARD

SCALE: NTS
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-662-206-002
REV: B



PRELIMINARY DRAWING

REFRENCE DRAWINGS

1. ONE LINE DIAGRAM INTERCONNECT SWITCHYARD ____ DWG.# CAES-1-DW-662-206-002
2. GENERAL ARRANGEMENT INTERCONNECT SWITCHYARD BUS PLAN ____ DWG.# CAES-1-DW-662-747-001
3. ELECTRICAL EQUIPMENT INTERCONNECT ELEVATIONS ____ DWG.# CAES-1-DW-662-747-002
4. GENERAL ARRANGMENT PLANT SWITCHYARD BUS PLAN ____ DWG.# CAES-1-DW-662-747-003
5. ELECTRICAL EQUIPMENT PLANT SWITCHYARD ELEVATIONS ____ DWG.# CAES-1-DW-662-747-004
6. PROPERTY SITE LAYOUT INTERCONNECT SWITCHYARD PLAN ____ DWG.# CAES-1-DW-662-002-004
7. PROPERTY SITE LAYOUT GRADING PLAN - INTERCONNECT SWITCHYARD ____ DWG.# CAES-1-DW-024-101-001

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD ENGINEER	ENGINEER/ TECH SPECIALIST	PROJECT ENGINEER	PROJECT MANAGER
B	09.21.11	ISOLATION BKR MOVED TO THIS DWG. ADDED SECOND COMPRESSION FEED	TO		MOA	BJW	BJW	WJB	MH
A	08.02.11	INITIAL ISSUE FOR REVIEW AND COMMENT	TO		MOA	BJW	BJW	WJB	MH

PRELIMINARY STATUS — DATE
LDE B.WILLIAMS — 08-02-11
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE
LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: T.OXENREIDER	
CHECKED BY:	
LEAD DESIGNER: M.APEWAJOYE	
ENGINEER/TECH SPECIALIST: B.WILLIAMS	
PROJECT ENGINEERING MANAGER: W. BILENKI	
PROJECT MANAGER: M. HOLDRIDGE	

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PE:_____ STATE:_____
LIC. NO.:_____ DATE:_____

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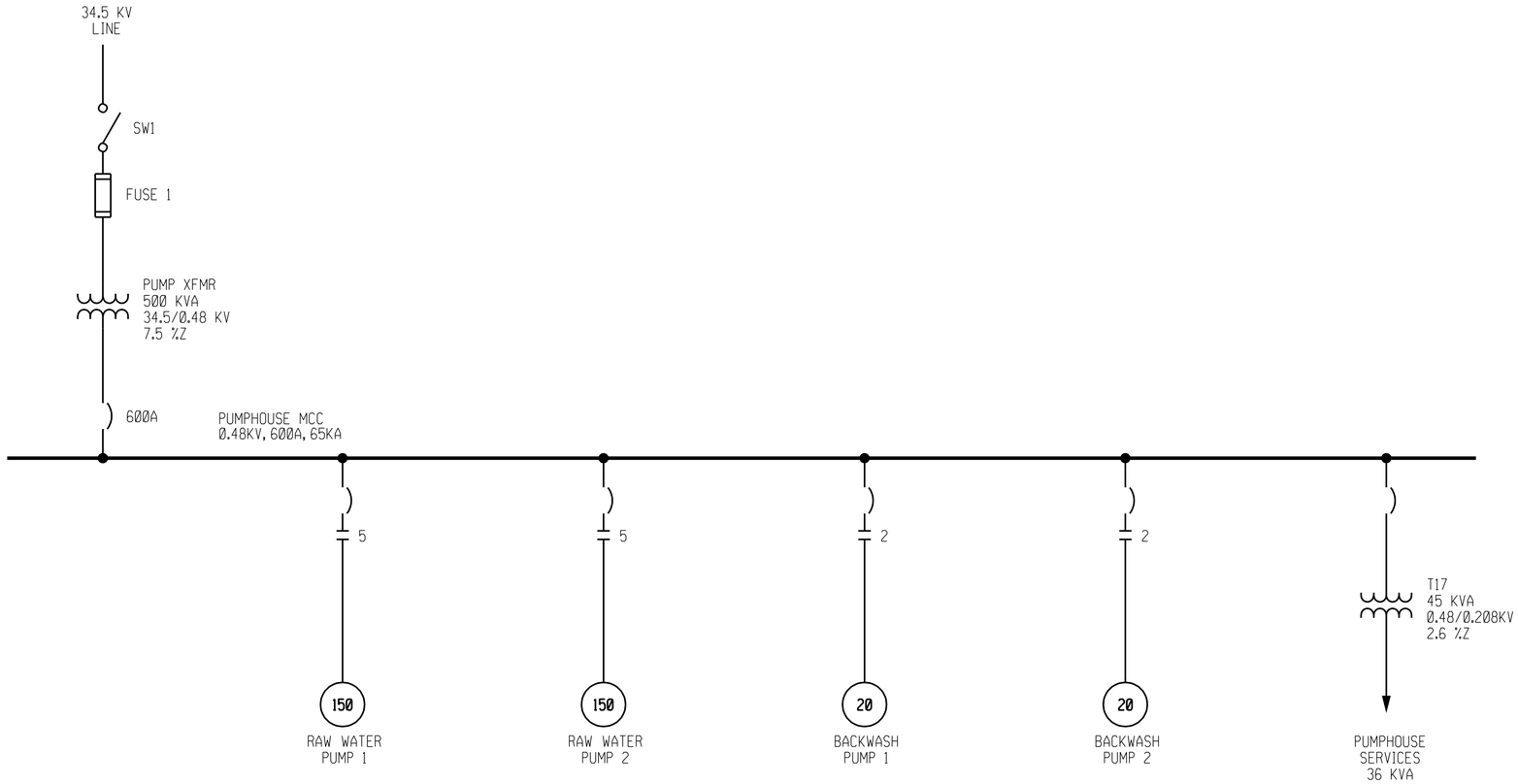
CLIENT/PROJECT TITLE

NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

ONE LINE DIAGRAM
PLANT SWITCHYARD

SCALE: NTS
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-662-206-001
REV: B

\\NYSEG\CAES-1-DW-662-206-001
9/26/2011 08:12:59 AM



REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	PROJECT ENGINEER	PROJECT MANAGER
A	10/19/11	INITIAL ISSUE	TAR		BEV	SRB	SRB		MH

PRELIMINARY STATUS — DATE — REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.
LDE S. BARKER 10/19/11

APPROVED STATUS — DATE — REPRESENTS REVIEWED AND APPROVED DESIGN, ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.
LDE

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAR	
CHECKED BY:	
LEAD DESIGNER: B. VOIGT	
ENGINEER/TECH SPECIALIST: S. BARKER	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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LIC. NO.: _____ DATE: _____

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CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

ONE LINE DIAGRAM
CYCLE 1 & 2 PUMPHOUSE AREA

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CEAS-I-DW-601-206-003
REV: A

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VESSELS AND STORAGE

CONE ROOF TANK -TNK-

EXTERNAL FLOATING ROOF TANK -TNK-

OPEN TOP TANK -TNK-

TANK WITH DIAPHRAGM -TNK-

DOME ROOF TANK TNK--

DOUBLE WALL, DOME ROOF TANK TNK--

INTERNAL FLOATING ROOF TANK -TNK-

LARGE, 1-CHAMBER, 2:1 HEADS VERTICAL DRUM -VSL-

LARGE, 1-CHAMBER, 2:1 HEADS HORIZONTAL DRUM -VSL-

PRESSURIZED GAS BOTTLE -GBM-

FLAT ROOF TANK -TNK-

PACKED COLUMN DEAERATOR -DEA-

PACKED COLUMN DEAERATOR -DEA-

BOTTLE GAS STORAGE RACK -GBM-

CURBED AREA

BOTTLED GAS STORAGE TRAILER -GBM-

SIZE REDUCTION

MEDIUM CRUSHER -CRH-

CONE CRUSHER -CRH-

ROLL CRUSHER -CRH-

BALL MILL -PVZ-

PULVERIZER -PVZ-

EXCHANGERS AND COOLERS

SPIRAL HEAT EXCHANGER -HX-

AIR COOLED SURFACE CONDENSER -CND-

COOLING TOWER -CTW-

HYPERBOLIC COOLING TOWER -CTW-

SPRAY COOLER -CLR-

SOLID WASTE INCINERATOR -SWI-

CONDENSER CREATED W/ SURFACE CONDENSER -CND-

CONDENSER CREATED W/ SURFACE CONDENSER -CND-

PLATE HEAT EXCHANGER -HX-

GENERIC 1 SHELL AND TUBE HEAT EXCHANGER -HX-

KETTLE SHELL AND TUBE HEAT EXCHANGER -HX-

GENERIC 1 SHELL AND TUBE HEAT EXCHANGER -HX-

GENERIC 1 SHELL AND TUBE HEAT EXCHANGER -HX-

GENERIC 1 SHELL AND TUBE HEAT EXCHANGER -HX-

FINNED TUBE HEAT EXCHANGER -HX-

BAYONET HEATER -HX-

ELECTRICAL BAYONET HEATER -HX-

ROTARY PREHEATER -HX-

FAN COOLED HEAT EXCHANGER -HX-

HOR SURGE TANK W/ HOR DEAERATOR -DEA-

HOR SURGE TANK W/ VERT DEAERATOR -DEA-

SINGLE EFFECT EVAPORATOR -EVP-

PUMPS

HORIZONTAL CENTRIFUGAL PUMP -P-

LIQUID RING VACUUM PUMP -P-

CENTRIFUGAL SUMP PUMP -P-

WET PIT PUMP -P-

VERTICAL CAN PUMP -P-

POSITIVE DISPLACEMENT PUMP -P-

PROPORTIONING PUMP -P-

HAND PUMP -P-

DIAPHRAGM PUMP -P-

CIRCULATING WATER PUMP -P-

SEWAGE GEAR PUMP/COMMINUTOR -CMR-

POSITIVE DISPLACEMENT PUMP -P-

VANE PUMP -P-

COMPRESSORS

CENTRIFUGAL COMPRESSOR -CMP-

ROTARY COMPRESSOR -CMP-

RECIPROCATING COMPRESSOR -CMP-

LIQUID SEAL COMPRESSOR -CMP-

MULTI-STAGE TURBO COMPRESSOR -CMP-

BLOWERS

CENTRIFUGAL BLOWER -BL-

AXIAL FAN -FAN-

PROPELLER FAN -FAN-

ROTARY LOBE BLOWER -BL-

FILTERS

CARTRIDGE FILTER -FLT-

BED FILTER -FLT-

SEPARATION

THERMAL DRYER -DRY-

DESSICANT DRYER -DRY-

SEPARATION

TRAVELING SCREEN -TRS-

INTAKE SCREEN -SCN-

DEWATERING SCREEN -SCN-

FLOCCULATOR/CLARIFIER -CLF-

RAKE THICKENER -CLF-

SETTLING POND -STP-

SPRAY POND -SYP-

CENTRIFUGE -CET-

FILTER PRESS -FLT-

ROTARY VACUUM FILTER -FLT-

SINGLE-STAGE CYCLONE -SEP-

SKIMMER -SKM-

WASTE WATER SEPARATOR -OWS-

LIQUID SEPARATOR -SEP-

DUST COLLECTOR -CO-

CONDENSER BALL TUBE CLEANING STRAINER -STR-

EQUIPMENT TAGGING

218-TNK-0003

- 218 — SEQUENCE NUMBER
- TNK — SERIES NUMBER
- 0003 — EQUIPMENT TYPE
- WBS NUMBER

TURBINES/GENERATORS/ DRIVERS

STEAM TURBINE -ST-

DOUBLE FLOW STEAM TURBINE -ST-

ELECTRIC GENERATOR

ELECTRIC MOTOR

DIESEL ENGINE

GAS ENGINE

VARIABLE SPEED DRIVE VDR

MISCELLANEOUS

PROPELLER AGITATOR -MIX-

COMPOSITE SAMPLER -SAM-

TRASH RAKE -TRE-

EQUIPMENT TYPE/DESCRIPTION

EQUIPMENT TYPE	DESCRIPTION
AIX	EXCHANGER, ANION
BL	BLOWER
BLR	BOILER
BNR	BURNER
BRS	BAR SCREEN
CCL	COIL, COOLING
CET	CENTRIFUGE
CIX	EXCHANGER, CATION
CLF	CLARIFIER
CMP	COMPRESSOR
CMR	COMMINUTOR
CND	CONDENSER
CO	COLLECTOR
CRH	CRUSHER
CTB	CONSTANT TEMPERATURE BATH
CTW	COOLING TOWER
DEA	DEAERATOR
DG	DIESEL GENERATOR
DGS	DEGASIFIER
DMZ	DEMINERALIZER
DRM	DRUM
DRY	DRYER
DSH	DESUPERHEATER
EDU	EDUCTOR, MIXING
EJR	EJECTOR EDUCTOR
ES	EMERGENCY SHOWER
ESW	EMERGENCY SHOWER AND EYE WASH
EW	EYE WASH
EVP	EVAPORATOR
FAN	FAN
FCH	FOAM CHAMBER
FDM	FILTER DEMINERALIZER
FEX	FIRE EXTINGUISHER
FHT	FEEDWATER HEATER
FLT	FILTER
GBM	GAS CYLINDERS AND/OR MANIFOLD
HCL	COIL, HEATING
HST	HOIST
HT	HEATER
HX	HEAT EXCHANGER
IGN	IGNITER
INJ	INJECTOR (SPRAY NOZZLE)
LFS	LIFT STATION
LMS	LIME SLAKER
MBX	EXCHANGER, MIXED BED
MIX	MIXER/BLENDER
OWS	OIL WATER SEPARATOR PUMP
PCP	PRECIPITATOR
POV	POWER ROOF VENTILATOR
PVZ	PULVERIZER (BALL MILL)
RCV	RECEIVER
ROU	REVERSE OSMOSIS UNIT
RVR	RESERVOIR
SAM	SAMPLER
SBL	SOOT BLOWER
SCN	SCREEN
SEP	SEPARATOR
SG	STEAM GENERATOR
SIL	SILENCER
SKD	EQUIPMENT SKID (DEFINED BY COMMON BASEPLATE)
SKM	SKIMMER
SPF	SPECTACLE FLANGE
SPL	PANEL, SAMPLE
ST	STEAM TURBINE
STP	SETTLING POND
STU	SEWAGE TREATMENT UNIT
SWI	SOLID WASTE INCINERATOR
SYP	SPRAY POND
TG	TURBINE GENERATOR
TGR	TURNING GEAR
TNK	TANK
TRE	TRASH RAKE
TRS	TRAVELING SCREEN
VDR	VARIABLE SPEED DRIVE
VP	VACUUM PUMP
VSL	VESSEL, PRESSURE

NOTES:

1. FOR GENERAL NOTES, ABBREVIATIONS AND SYMBOLS SEE DRAWINGS CAES-1-DW-012-302-001, 002 AND 003.

PRELIMINARY DESIGN

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	TECH. SPEC. ENGINEER	PROJ. ENGR MANAGER	PROJECT MANAGER
A		ISSUED FOR REVIEW COMMENT	TAD	HGE		HGE	HGE	MH

PRELIMINARY STATUS — DATE — LDE — REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE — REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED 'HOLD' RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAD	
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

Zero Harm — Leadership, No Incidents, Safe Behavior

ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF
PE: _____ STATE: _____
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WorleyParsons
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CLIENT/PROJECT TITLE

NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PIPING & INSTRUMENTATION DIAGRAM
LEGENDS AND SYMBOLS
EQUIPMENT SYMBOLS

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-012-302-003
REV: A

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EQ TYPE	DESCRIPTION
AE	PRIMARY ELEMENT, ANALYSIS
AI	INDICATOR, ANALYSIS
AIS	INDICATING SWITCH, ANALYSIS
AIT	INDICATING TRANSMITTER, ANALYSIS
AP	TEST POINT, ANALYSIS
AS	SWITCH, ANALYSIS
AT	TRANSMITTER, ANALYSIS
BE	PRIMARY ELEMENT, BURNER
BI	INDICATOR, BURNER
BIS	INDICATING SWITCH, BURNER
BIT	INDICATING TRANSMITTER, BURNER
BP	TEST POINT, BURNER
BT	TRANSMITTER, BURNER
BW	PROBE, BURNER
CDR	CONTROL DRIVE
FCV	CONTROL VALVE, FLOW
FE	PRIMARY ELEMENT, FLOW
FG	GAUGE GLASS, FLOW
FI	INDICATOR, FLOW
FIS	INDICATING SWITCH, FLOW
FIT	INDICATING TRANSMITTER, FLOW
FP	TEST POINT, FLOW
FS	SWITCH, FLOW
FT	TRANSMITTER, FLOW
FY	SOLENOID, FLOW
HCV	HYDRAULIC CONTROL VALVE
HS	SWITCH, HAND
LCV	CONTROL VALVE, LEVEL
LE	PRIMARY ELEMENT, LEVEL
LG	GAUGE GLASS, LEVEL
LI	INDICATOR, LEVEL
LIS	INDICATING SWITCH, LEVEL
LIT	INDICATING TRANSMITTER, LEVEL
LRV	REGULATING VALVE, LEVEL (SELF ACTUATING)
LS	SWITCH, LEVEL
LT	TRANSMITTER, LEVEL
LY	SOLENOID, LEVEL
MI	INDICATOR, MOISTURE (HUMIDITY)
MIS	INDICATING SWITCH, MOISTURE (HUMIDITY)
MS	SWITCH, MOISTURE (HUMIDITY)
MT	TRANSMITTER, MOISTURE (HUMIDITY)
PCV	CONTROL VALVE, PRESSURE
PDCV	CONTROL VALVE, PRESSURE DIFF.
PDI	INDICATOR, PRESSURE DIFF.
PDIS	INDICATING SWITCH, PRESSURE DIFF.
PDIT	INDICATING TRANSMITTER, PRESSURE DIFF.
PDRV	REGULATING VALVE, PRESSURE DIFF. (SELF ACTUATING)
PDS	SWITCH, PRESSURE DIFF.
PDT	TRANSMITTER, PRESSURE DIFF.
PE	PRIMARY ELEMENT, PRESSURE
PI	INDICATOR, PRESSURE
PIS	INDICATING SWITCH, PRESSURE
PIT	INDICATING TRANSMITTER, PRESSURE
PP	TEST POINT, PRESSURE
PRV	REGULATING VALVE, PRESSURE (SELF ACTUATING)
PS	SWITCH, PRESSURE
PSV	SAFETY VALVE, PRESSURE (RELIEF)
PT	TRANSMITTER, PRESSURE
PY	SOLENOID, PRESSURE
SCV	CONTROL VALVE, SPEED/FREQ.
SE	PRIMARY ELEMENT, SPEED/FREQ.
SI	INDICATOR, SPEED/FREQ.
SIS	INDICATING SWITCH, SPEED/FREQ.
SIT	INDICATING TRANSMITTER, SPEED/FREQ.
SS	SWITCH, SPEED/FREQ.
SV	VALVE, SOLENOID (ALL TYPES)
TCV	CONTROL VALVE, TEMPERATURE
TE	PRIMARY ELEMENT, TEMPERATURE
THS	THERMOSTAT
TI	INDICATOR, TEMPERATURE
TIS	INDICATING SWITCH, TEMPERATURE
TIT	INDICATING TRANSMITTER, TEMPERATURE
TP	TEST POINT, TEMPERATURE
TRV	REGULATING VALVE, TEMP. (SELF ACTUATING)
TS	SWITCH, TEMPERATURE
TT	TRANSMITTER, TEMPERATURE
TW	PROBE, TEMPERATURE (THERMOWELL)
TY	SOLENOID, TEMPERATURE
VE	PRIMARY ELEMENT, VIBRATION
VI	INDICATOR, VIBRATION
VIT	INDICATING TRANSMITTER, VIBRATION
VS	SWITCH, VIBRATION
VT	TRANSMITTER, VIBRATION
VY	VIBRATION PROXIMITOR
WE	PRIMARY ELEMENT, WEIGHT/FORCE
WI	INDICATOR, WEIGHT/FORCE
WIS	INDICATING SWITCH, WEIGHT/FORCE
WIT	INDICATING TRANSMITTER, WEIGHT/FORCE
WS	SWITCH, WEIGHT/FORCE
WT	TRANSMITTER, WEIGHT/FORCE
XE	SPECIAL ANALYSIS INSTRUMENT
XI	INDICATOR, SPECIAL
XS	SWITCH, SPECIAL
XT	TRANSMITTER, MISCELLANEOUS
ZE	PRIMARY ELEMENT, POSITION/DIMENSION
ZI	INDICATOR, POSITION/DIMENSION
ZIS	INDICATING SWITCH, POSITION/DIMENSION
ZIT	INDICATING TRANSMITTER, POSITION/DIMENSION
ZS	SWITCH, POSITION/DIMENSION
ZT	TRANSMITTER, POSITION/DIMENSION

NOTE: 1. THIS TABLE IS NOT ALL-INCLUSIVE.
2. 'A' IS USED FOR ANALYTICAL VARIABLES NOT LISTED IN THE TABLE.
EXAMPLE: O, H, CO, NO, CO, SO, pH, SMOKE, SP COND, CAT COND.

• MODIFIED FROM ISA 5.1
•• LETTER A (ALARM-THE ANNUNCIATING DEVICE) MAY BA USED IN THE SAME FASHION AS LETTER S (SWITCH-THE ACTUATING DEVICE).
••• THE LETTERS H AND L MAY BE OMITTED IN THE UNDEFINED CASE.
ALL AUTOMATIC BLOCK VALVES NO MATTER THE CONTROL MEASURED VARIABLE WILL CARRY AN INSTRUMENT CODE OF "ABV"
ALL HYDRAULIC BLOCK VALVES NO MATTER THE CONTROL MEASURED VARIABLE WILL CARRY AN INSTRUMENT CODE OF "HBV"
ALL MOTOR OPERATED BLOCK VALVES NO MATTER THE CONTROL MEASURED VARIABLE WILL CARRY AN INSTRUMENT CODE OF "MBV"

GENERAL INSTRUMENTS

DISCRETE SINGLE-FUNCT INSTR, FIELD MOUNTED INSTRUMENT FOR SINGLE MEASURED VARIABLE AND ANY NUMBER OF FUNCTIONS. INSTRUMENT IS LOCALLY MOUNTED 704057

DISCRETE SINGLE-FUNCT INSTR, FIELD MOUNTED INSTRUMENT IS MOUNTED BEHIND A PANEL. 704D70

DISCRETE SINGLE-FUNCT INSTR, FIELD MOUNTED INSTRUMENT IS MOUNTED ON A MAIN CONTROL PANEL. 704D65

DISCRETE SINGLE-FUNCT INSTR, FIELD MOUNTED INSTRUMENT IS MOUNTED ON A LOCAL PANEL. 704D85

SIGNAL LINES

CONNECTION TO PROCESS
PNEUMATIC SIGNAL
ELECTRIC SIGNAL
CAPILLARY TUBING (FILLED SYSTEM)
HYDRAULIC SIGNAL
ELECTROMAGNETIC OR SONIC SIGNAL (WITHOUT WIRING OR TUBING)
MECHANICAL LINK SIGNAL
DCS SOFTWARE LINK

SENSORS - FLOW

ORIFICE PLATE & FLANGES 7P3C05
ORIF PLATE, FLANGES & METER RUN 7P3C06
FLOW NOZZLE 7P3C19
FLOW NOZZLE FABRICATED METER RUN 7P3C9B
VENTURI 7P3C13
VENTURI FABRICATED METER RUN 7P3C9A
IN-LINE AVERAGING PITOT TUBE 7P3C16
VORTEX FLOW INSTR 7P3C37
FLUME 7P3C44
WEIR 7P3C46
IN-LINE PROPELLER FLOW INSTR 7P3C35
BALLOON INSTR 7P3C01
VAR AREA FLOW INSTR 7P3C22
STRAIGHTENING VANE 7P3C50

SELF-ACTIVATED DEVICES-PRESSURE

SELF CONTAINED PRESS RED REG 7P1E33
PRESS RED REG W/EXT TAP 7P1E34
DIFF PRESS RED REG W/INT & EXT TAPS 7P1E42
SELF CONTAINED BACKPRESS REG 7P1E38
BACKPRESS REG W/EXT TAP 7P1E39

SELF - ACTIVATED DEVICES - FLOW

FLOW REGULATOR 7P3C01

SENSORS - ANALYSIS

BALLOON INSTR THROUGH-FLOW TYPE 7P3C01
DISCRETE SINGLE-FUNCT INSTR, FIELD MOUNTED 704D57

CONTROL VALVES

PNEUMATIC DIAPHRAGM GATE CONTROL VALVE 7P1E01
PNEUMATIC DIAPHRAGM GLOBE CONTROL VALVE 7P1E15
PNEUMATIC DIAPHRAGM BUTTERFLY CONTROL VALVE 7P1E17
PNEUMATIC DIAPHRAGM BALL METAL SEAT CONTROL VALVE 7P1E13
ELECTRO OR PNEUMATIC HYDRAULIC
PNEUMATIC CYLINDER GATE CONTROL VALVE 7P1E01
PNEUMATIC CYLINDER BUTTERFLY CONTROL VALVE 7P1E17
PNEUMATIC CYLINDER GLOBE CONTROL VALVE 7P1E15
PNEUMATIC CYLINDER BALL METAL SEAT CONTROL VALVE 7P1E13
ROTARY MOTOR GLOBE CONTROL VALVE 7P1E15
ROTARY MOTOR GATE CONTROL VALVE 7P1E01
ROTARY MOTOR BUTTERFLY CONTROL VALVE 7P1E17
ROTARY MOTOR BALL METAL SEAT CONTROL VALVE 7P1E13
ANGLE PRESS RELIEF VALVE 7P2C01
PRESS/VAC RELIEF VALVE 7P2C12
PRESS RELIEF RUPTURE DISC 7P2C16

INSTRUMENT TAGGING

TEXT LOCATION AROUND INSTRUMENT "BALLOON" SHALL BE STANDARDIZED AS SHOWN IN THE SKETCH BELOW:

J1 J2 J3 J4 J5

J1 - SYSTEM DESIGNATION (WBS CODE)
J2 - INSTRUMENT TYPE (ISA CODE)
J3 - SERIAL NUMBER & ALPHABET
J4 - INSTRUMENT TYPE IF NEEDED (REMARK 1)
J5 - REMARK 2

VALVE BODY WITH ACTUATOR (TYPICAL)

TEMPERATURE REGULATOR FIELD - SYSTEM TYPE

VALVE BODIES & FAILURE MODES

TWO-WAY (TYPICAL GLOBE SHOWN)
THREE-WAY
FOUR-WAY

FO - INDICATES FAIL OPEN
FC - INDICATES FAIL CLOSED
FL - INDICATES FAIL LOCKED (POSITION DOES NOT CHANGE)
FI - INDICATES FAIL INTERMEDIATE

PRESSURE TRANSMITTERS

REMOTE MOUNT

USE SINGLE FUNCTION INSTRUMENT BUBBLE

REMOTE MOUNT W/DIAPHRAGM SEAL

USE SINGLE FUNCTION INSTRUMENT BUBBLE

DIRECT MOUNT

USE IMPLIED SINGLE FUNCTION INSTRUMENT BUBBLE

REMARK 1 AND REMARK 2 ARE NOT REQUIRED UNLESS NOTED BY ENGINEER

PRESSURE GAUGE OR SWITCH

USE SINGLE FUNCTION INSTRUMENT BUBBLE.

REMOTE MOUNT AND DIRECT MOUNT ARE IDENTICAL

THERMOMETERS/THERMOWELLS

SIZE WILL BE DETERMINED BY THE PROCESS SYSTEM

REMARK 1 WILL BE BLANK IF "SW" AND WILL BE "NPT" IF THREADED

FILLED SYSTEM

HAND - ACTUATED DEVICES

TWO-WAY HAND CONTROL VALVE IN PROCESS LINE

FLOW METERS

VENTURI

FLOW METER IS FLANGED OR BUTT WELDED SPOOL PIECE WITH 0.75" SOCKOLETS PROVIDED AT EACH TAP LOCATION

NOZZLE

FLOW METER IS FLANGED OR BUTT WELDED SPOOL PIECE WITH 0.75" SOCKOLETS PROVIDED AT EACH TAP LOCATION

ORIFICE PLATE REMOTE MOUNT

ORIFICE PLATE DIRECT MOUNT

ORIFICE FLANGE TAPS AND ROOT VALVE SIZE IS BASED ON PIPE LINE SPEC

AVERAGING PITOT

NOMINAL CONNECTION SIZE MAY VARY

STEAM CONDITIONING VALVES

ANGLE STEAM CONDITIONING VALVE 7P1E47
STEAM CONDITIONING VALVE 7P1E49
STEAM ATOMIZED DESUPERHEATER 7P1E9B

LEVEL SWITCHES

FLOAT

MOTOR OPERATED VALVE

ALL MBV SHALL INCLUDE INTEGRAL MOTOR STARTER, LOCAL/REMOTE CONTROL SWITCH AND LOCAL OPEN/CLOSE PUSHBUTTONS UNLESS OTHERWISE NOTED IN THE REMARKS. THE FOLLOWING DCS I/O POINTS WILL APPLY TO EACH MBV UNLESS NOTED IN THE REMARKS:

OPEN COMMAND	DCS DIGITAL OUTPUT
CLOSE COMMAND	DCS DIGITAL OUTPUT
OPEN LIMIT	DCS DIGITAL INPUT
CLOSE LIMIT	DCS DIGITAL INPUT
IN REMOTE MODE	DCS DIGITAL INPUT

AIR OPERATED ON/OFF VALVE

ALL ABV VALVES SHALL INCLUDE A SOLENIOD VALVE AND OPEN AND CLOSE LIMIT SWITCHES UNLESS OTHERWISE NOTED IN THE REMARK. THE FOLLOWING DCS I/O POINTS WILL APPLY TO EACH ABV UNLESS OTHERWISE NOTED IN THE REMARKS:

CLOSE COMMAND	DCS DIGITAL OUTPUT
OPEN LIMIT	DCS DIGITAL INPUT
CLOSED LIMIT	DCS DIGITAL INPUT

• NOTE THAT REMARK 1 IS "FC" FOR FAIL CLOSED ABV TO CREATE A DIFFERENT MACRO NAME THAT WILL CREATE AN 'OPEN COMMAND' DCS DIGITAL OUTPUT IN IDM INSTEAD OF A 'CLOSE COMMAND'.

LEVEL TRANSMITTERS

DISPLACEMENT

DIFFERENTIAL PRESSURE TYPE

ULTRASONIC

LEVEL GAUGES

NOTES:

1. FOR GENERAL NOTES, ABBREVIATIONS AND SYMBOLS SEE DRAWINGS CAES-1-DW-012-302-001, 002 AND 003.
2. SYSTEM PBS DESIGNATOR FOR VALVES AND PIPING SPECIALTIES ARE THE SAME AS THE ASSOCIATED PIPE DESIGNATION.
3. ALL EQUIPMENT, VALVES, AND SPECIALTY ITEM TAG NUMBERS ARE PREFIXED WITH CAES-1-EQ (SYSTEM PBS DESIGNATOR) UNLESS OTHERWISE NOTED.
4. ALL LOCAL VENTS AND DRAINS TO HAVE A 4" LONG NIPPLE THREADED ONE END TERMINATED LOCALLY UNLESS OTHERWISE NOTED.
5. ALL INSTRUMENT ROOT VALVES ARE 0.75" AND VENTS AND DRAINS ARE 1" UNLESS OTHERWISE NOTED. ALL FLOW ELEMENT ROOT VALVES ARE 0.5" UNLESS OTHERWISE NOTED.
6. THE FOLLOWING TERMS MAY BE PLACED OUTSIDE THE INSTRUMENT BUBBLE OF A LOOP TO DENOTE THE SPECIFIC VARIABLES USING THE REMARKS 1 LABEL.

CC - CATION CONDUCTIVITY	DO2 - DISSOLVED OXYGEN
CL - CHLORIDE	O2 - GASEOUS OXYGEN
CO - CARBON MONOXIDE	PH - PH
COMB - COMBUSTIBLE	SC - SPECIFIC CONDUCTIVITY
H - DISSOLVED HYDROGEN	SIO2 - SILICA
H2 - GASEOUS HYDROGEN	SMOKE - SMOKE DENSITY
NA - SODIUM	SO2 - SULPHUR DIOXIDE
N2H4 - HYDRAZINE	TRB - TURBIDITY
NOX - NITROGEN OXIDE	CL2 - CHLORINE
LS - LOCAL SAMPLE	

7. THIS TYPE OF INSTRUMENT MAY BE NAMED OUTSIDE THE INSTRUMENT CIRCLE, e.g. MAGNETIC FLOW METER, MASS FLOW METER, FLOW SIGHT GLASS.
8. ALL MOTOR OPERATED VALVES AND PNEUMATIC ON/OFF VALVES ARE SUPPLIED WITH OPEN AND CLOSE LIMIT SWITCHES, HOWEVER, THESE LIMIT SWITCHES ARE NOT SHOWN ON THE P&ID. POSITION LIMITS SWITCHES ON MODULATING CONTROL VALVES ARE NOT PROVIDED UNLESS NOTED OTHERWISE.
9. A HAND CONTROL VALVE HCV IS A HAND-ACTIVATED VALVE THAT EITHER MODULATES A PROCESS STREAM OR IS USED AS AN INSTRUMENT DEVICE.

PRELIMINARY DESIGN

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD ENGINEER	ENGINEER	TECH. SPECIALIST	LEAD ENGINEER	PROJ. ENGR. MANAGER	PROJECT MANAGER
A		ISSUED FOR REVIEW COMMENT	TAD	HGE			HGE	HGE		MH

PRELIMINARY STATUS — DATE — REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.
LDE
APPROVED STATUS — DATE — REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.
LDE

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAD	
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

Zero Harm — Leadership No Incidents Safe Behavior

ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF
PE1 _____ STATE _____
LIC. NO.1 _____ DATE1 _____

WorleyParsons
resources & energy

CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PIPING & INSTRUMENTATION DIAGRAM
LEGENDS AND SYMBOLS
INSTRUMENT SYMBOLS

SCALE	DRAWING SIZE
NONE	ARCH D (36" x 24")

WORLEYPARSONS DWG. NO.	REV
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PIPING VALVES

GATE VALVE	BV--	
GLOBE VALVE	BV--	
BALL VALVE	BV--	
BUTTERFLY VALVE	BV--	
CHECK VALVE	UV--	
WAFER CHECK VALVE	UV--	
Y STOP CHECK VALVE	UV--	
STOP CHECK VALVE	UV--	
TILTING DISK CHECK VALVE	UV--	
ANGLE CHECK VALVE	UV--	
KNIFE GATE VALVE	BV--	
PLUG VALVE	BV--	
3-WAY PLUG VALVE	DV--	
4-WAY PLUG VALVE	DV--	
3-WAY BALL VALVE	DV--	
VENT WITH 4" LONG NIPPLE THREADED ONE END	BV--	
DRAIN WITH 4" LONG NIPPLE THREADED ONE END	BV--	

VENT AND DRAIN VALVES HAVE A DEFAULT SIZE OF 1". DEFAULT IS SOCKET WELD BOTH ENDS. SIZE WILL NOT BE NOTED ON THE DRAWING UNLESS OTHER THAN DEFAULT VALUE. THE FOLLOWING ARE THE DIFFERENT VENT DRAIN VALVE BODY TYPES:

GATE, GLOBE W/ PLUG, BALL W/ PLUG, BALL, GLOBE W/ FLANGE, BALL W/ FLANGE, GLOBE, GATE W/ FLANGE, PLUG

3-WAY VALVE	DV--	
PINCH VALVE	BV--	
DIAPHRAGM VALVE	BV--	
NEEDLE VALVE	BV--	
Y GLOBE VALVE	BV--	
ANGLE VALVE	BV--	
HOSE VALVE	BV--	
ANGLE HOSE VALVE	BV--	
AUTOMATIC RECIRCULATION VALVE	ARV--	
ANGLE STOP CHECK VALVE	UV--	
FOOT VALVE	BV--	
NON-RETURN VALVE	AUV--	
FUSIBLE LINK VALVE	FLV--	
ANTI WHIP VALVE	AHC--	

THE FOLLOWING ARE THE INSTRUMENT ROOT VALVE BODY TYPES AND THEY HAVE A DEFAULT SIZE OF 0.75". SIZE WILL NOT BE NOTED ON THE DRAWING UNLESS OTHER THAN THE DEFAULT VALUE:

GATE, BALL, GLOBE, NEEDLE

MISCELLANEOUS

CONCENTRIC REDUCER		
ECCENTRIC REDUCER		
WELD CAP		
PLUG		
SCREWED CAP		
HOSE CONNECTION		
QUICK DISCONNECT	QD--	
REMOVABLE SPOOL		
BLIND FLANGE		
OPEN SPECTACLE BLIND	SPF--	
CLOSED SPECTACLE BLIND	SPF--	
INSULATING FLANGE		
DIELECTRIC UNION		
BREATHER		
LOOP SEAL		
GOOSE NECK VENT		
NOTE NUMBER		
OPEN DRAIN		
TARGET PLATE		

PIPING VALVE OPTIONS

VENTED BALL, POST INDICATOR, PISTON CHECK, FTE, LUG TYPE (THREADED BODY), HOR CHK, FULL PORT, VITON SEAT, VERT CHK, RFFE, VITON SEAT, WAFER

PIPING VALVE OPENING ACTIONS

NORMALLY OPEN, NORMALLY CLOSED (NC), LOCKED CLOSED (LC), LOCKED OPEN (LO)

PIPING SPECIALTY ITEMS

GENERIC COMPONENT	
Y-TYPE STRAINER	STR--
SINGLE BASKET STRAINER	STR--
DUPLEX STRAINER	STR--
FLAT PLATE STRAINER	STR--
CONE STRAINER	STR--
TEMPORARY STRAINER	STR--
T-TYPE STRAINER	STR--
STEAM TRAP	TRP--
FLOAT STEAM TRAP	TRP--
INVERTED BUCKET STEAM TRAP	TRP--
THERMOSTATIC STEAM TRAP	TRP--
THERMODYNAMIC STEAM TRAP	TRP--
IMPULSE STEAM TRAP	TRP--
RESTRICTION ORIFICE	FO--
PLUG RESISTANT ORIFICE	PRO--
PLUG RESISTANT ORIFICE	PRO--
MULTI-STAGE ORIFICE	ORF--
FILTER	FLT--
FLAME ARRESTOR	ARR--
SPRAY NOZZLE	INJ--
BACKFLOW PREVENTER	BFP--
EXPANSION JOINT	EXJ--
FREE VENT W/SCREEN	SCN--
VENT SILENCER	SIL--
IN-LINE SILENCER	SIL--
SURGE ARRESTOR	SAR--
EJECTOR/EDUCTOR	EJR--
AIR FILTER	FLT--
AIR VENT	AV--
AUTO AIR RELIEF VALVE & VAC BREAK	VBK--
PRIMING VENT VALVE	VV--
IN-LINE MIXER	MIX--
FLEXIBLE HOSE	FHS--
SAMPLE COOLER	CLR--
DRIP PAN	DPN--
CALIBRATION COLUMN	CAL--
EXHAUST HEAD	EHD--
SAFETY VALVE VENT SEAL	RVS--
CONSERVATION VENT	CVN--

ATTRIBUTE BREAKS

GROUP BREAK: INDICATES A CHANGE IN ALL LINE ATTRIBUTES INCLUDING: SYSTEM NUMBER, LINE NUMBER, MATERIAL CLASS, INSULATION CODE, DESIGN PRESSURE/TEMPERATURE, OPERATING PRESSURE/TEMPERATURE, FLOW RATE, TEST PRESSURE

ATTRIBUTE BREAK: INDICATES A CHANGE ONLY IN LINE ATTRIBUTES ATTACHED TO THE BREAK. SEE BELOW FOR ATTRIBUTE SYMBOLOGY.

• BECAUSE FLOWRATES SHOWN ARE MAXIMUM, LISTED FLOWS MAY NOT RESULT IN A MASS BALANCE AT THE JUNCTION.

BREAK DESIGNATION	BREAK SYMBOL	SEGMENT SYMBOL	COMPONENT SYMBOL
NOMINAL DIAMETER		6"	6"
PIPING MATERIAL CLASS		12A1S	
SUPPLY RESPONSIBILITY		BY V	• BY V
INSULATION CLASS		HC	
DESIGN RESPONSIBILITY		BY INSTRUMENTS	
CONSTRUCTION STATUS		EXISTING	NEW
OPERATING PRESS/TEMP		999/999	
DESIGN PRESS/TEMP		999/999	
•MAXIMUM FLOW RATE		999 gpm / 999 lb/h	

FIRE PROTECTION AND SAFETY

POST INDICATOR VALVE	PIV--
DRY PIPE SPRINKLER VALVE	DPV--
DELUGE VALVE	DEV--
PREACTION VALVE	PAV--
ALARM CHECK VALVE	UV--
FIRE HYDRANT	HYD--
3-WAY FIRE HYDRANT	HYD--
FIRE HYDRANT W/MONITOR NOZZLE	HYD--
STANDPIPE	
FIRE MONITOR NOZZLE	MNZ--
FOAM MONITOR NOZZLE	MNZ--
ELEVATED FIRE MONITOR NOZZLE	MNZ--
REMOTELY OPERATED FIRE MONITOR NOZZLE	MNZ--
ELEVATED FOAM MONITOR NOZZLE	MNZ--
REMOTELY OPERATED FOAM MONITOR NOZZLE	MNZ--
TAMPER SWITCH VALVE	BV--
EYE WASH	EW--
SAFETY SHOWER AND EYE WASH	ESW--
SAFETY SHOWER	ES--
FIRE DEPT CONNECTION	
PRE-ACTION SPRINKLER	SPR--
SPRAY SPRINKLER	SPR--
WET SPRINKLER	SPR--
AUTOMATICALLY ACTIVATED SPRINKLER SYSTEM	SPR--
DRY DELUGE OPEN HEAD	
SPRINKLER	SPR--
HOSE REEL	HSS--
HOSE HOUSE	HSH--
HOSE RACK STATION	HSS--
FOAM CHAMBER	FCH--
BALL DRIP VALVE	BDV--

PROCESS PIPING

MAIN PROCESS FLOW PIPING
SECONDARY PROCESS FLOW PIPING
FLOW DIRECTION
HEAT TRACING
EXISTING PROCESS FLOW PIPING
FUTURE PROCESS FLOW PIPING
LINE SLOPE (8FT 1.000" SLOPE)

VENDOR PACKAGE

ALL EQUIPMENT, PIPE AND INSTRUMENTS INSIDE PACKAGE BREAK WILL BE SUPPLIED BY VENDOR

PACKAGE NO
PACKAGE NAME

SUPPLY RESPONSIBILITY
BY CONTRACTOR : WORLEYPARSONS (DEFAULT)
BY V : VENDOR

VALVE AND SPECIALTIES CODE

CODE	DESCRIPTION
ABV	AIR OPERATED BLOCK VALVE
ADV	PNEUMATIC DIVERTER VALVE (3 OR 4 WAY)
AHC	AIR HOSE CHECK VALVE (ANTI-WHIP VALVE)
ARR	ARRESTOR, FLAME
ARV	AUTOMATIC RECIRCULATION VALVE
AUV	NON-RETURN VALVE
BDV	BALL DRIP VALVE
BFP	BACKFLOW PREVENTER
BV	BLOCK VALVE
CAL	CALIBRATION COLUMN
CLR	SAMPLE COOLER
CVN	CONSERVATION VENT
DEV	DELUGE VALVE
DPN	DRIP PAN
DPV	DRY PIPE SPRINKLER VALVE
DV	DIVERTER VALVE
EJR	EJECTOR
ES	EMERGENCY SHOWER
ESW	EMERGENCY SHOWER AND EYE WASH
EW	EYE WASH
EXJ	EXPANSION JOINT
FCH	FOAM CHAMBER
FHS	FLEX HOSE
FLT	FILTER
FLV	FUSIBLE LINK VALVE
FO	FLOW RESTRICTION ORIFICE
HSH	HOSE HOUSE
HSS	STATION, HOSE (REEL)
HYD	HYDRANT
INJ	INJECTOR (SPRAY NOZZLE)
MBV	MOTOR OPERATED BLOCK VALVE
MNZ	MONITOR NOZZLE
MON	MONITOR (INCLUDES TV)
ORF	ORIFICE
PAV	PRE-ACTION VALVE
PBV	PISTON OPERATED BLOCK VALVE
PIV	POST INDICATOR VALVE
PRO	PLUG RESISTANT ORIFICE
PSV	SAFETY RELIEF VALVE
QD	QUICK DISCONNECT
RPD	RUPTURE DISK
RVS	RELIEF VALVE VENT SEAL
SAR	SURGE ARRESTOR
SCN	SCREEN
SIL	SILENCER
SPR	SPRINKLER
STR	STRAINER
SV	SOLENOID VALVE
TRP	TRAP
UV	CHECK VALVE
VBK	VACUUM BREAKER
VV	VENT VALVE

PIPING MATERIAL SPEC DESIGNATIONS

SPEC	CLASS	MATERIAL
12E61S	125	CAST IRON SEWAGE
12F53S	125	DUCTILE IRON, FIRE PROTECTION
12F55S	125	DUCTILE IRON, CIRCULATING WATER
12J16S	125	FRP, CIRCULATING WATER
12J4S	125	CPVC, SODIUM HYPOCHLORITE
12J8S	125	POLYETHYLENE-SDR 11 WATER, DRAINS
15A1S	150	CARBON STEEL, WATER, DRAINS, NITROGEN, AMMONIA
15A6S	150	CARBON STEEL, FUEL GAS, LUBE OIL
15A41S	150	CARBON STEEL, FIRE PROTECTION
15A42S	150	CARBON STEEL, FIRE PROTECTION
15D1S	150	STAINLESS STEEL 304
15D2S	150	ALLOY 20
15D7S	150	STAINLESS STEEL 304, PRESS FIT
15M6IS	150	COPPER, POTABLE
60A4S	600	CARBON STEEL, FUEL GAS
60D4S	600	STAINLESS STEEL 304 FLUE GAS
90A1S	900	CARBON STEEL, COMPRESSED AIR
150D1S	1500	STAINLESS STEEL, LOW PRESSURE, COMP

SYSTEM DESIGNATORS

PBS	DESCRIPTION
201	RECUPERATOR
311	CUMBUSTION TURBINE
411	EXPANDER TURBINE
461	CIRCULATING WATER
463	CIRCULATING WATER CHEMICAL TREATMENT
511	RAW WATER SUPPLY
512	RAW WATER TREATMENT (PRETREATMENT)
513	WATER TREATMENT (DEMINERALIZER)
521	PLANT EQUIPMENT DRAINS
525	PLANT SERVICE WATER SYSTEM
526	WASTE WATER TREATMENT
541	AMMONIA
543	COMPRESSED AIR
544	INSTRUMENT AIR
546	NITROGEN SYSTEM
561	FUEL GAS HANDLING
571	FLOOR AND ROOF DRAINS
572	PLANT FIRE PROTECTION
573	PLANT HVAC
577	POTABLE WATER
578	SANITARY DRAINS
579	SEWAGE TREATMENT

DRAWING NUMBERING

XXXX-X-DW-020-302-XXX
- UNIQUE IDENTIFIER
- DOC. SUB TYPE = 302 FOR P&IDS
- PBS = SYSTEM DESIGNATOR
- DW = DRAWING
- X = UNIT NUMBER
- XXXX = PROJECT IDENTIFIER

OFF-SHEET CONNECTORS

DRAWING CONNECTOR
UNIQUE CONNECTOR NUMBER
SERVICE DESCRIPTION
XXXXXXXXXXXXXXXXXXX
9999/XXX-302-XXX
XXXXXXXXXXXXXXXXXXXXXXXX
DESCRIPTION
DRAWING NUMBER (PBS)001 (SHEET NUMBER) OR VENDOR DRAWING NUMBER
TIE-IN NO
XXX
TIE-IN LABEL
TIE-IN MARKER

UNIT CONNECTOR TO SHOW CONNECTION TO VENDOR SUPPLIED DRAWING OR CLIENT BATTERY LIMITS
XXXXXXXXXXXXXXXXXXX
9999/XXX-XXX-XXX
XXXXXXXXXXXXXXXXXXXXXXXX

PIPE DESIGNATION

NOMINAL PIPE SIZE
SYSTEM PBS DESIGNATOR
PIPE LINE SERIES NUMBER
PIPE LINE TYPE
SEQUENCE NUMBER
PIPING LINE SPECIFICATION
INSULATION CODE
20"-218-1001-12A1S-N
OPERATING TEMPERATURE
OPERATING PRESSURE
DESIGN TEMPERATURE
DESIGN PRESSURE
MAXIMUM FLOW RATE

PIPING ELEMENT/VALVE TAGGING

VALVE/SPECIALTIES CODE
SERIES NUMBER
PIPE LINE SERIES NUMBER
OPTIONAL SUFFIX
OPTIONAL SUFFIX
PIPING COMPONENT NUMBER LABEL
BV-1001-1
6T2G01
V-21
GENERIC PIPING COMPONENT NUMBER LABEL
6T2G88
BULK VALVE TAG NUMBER (NUMBER IDENTIFIES SPECIFIC VALVE SIZE, TYPE, MATERIAL AND PRESSURE CLASS).

INSULATION CODE

AC	ACOUSTIC CONTROL
AS	ANTI SWEAT
HC	HEAT CONSERVATION
PF	FREEZE PROTECTION
PP	PERSONNEL PROTECTION
N	NONE

PRELIMINARY DESIGN

NOTES:

1. FOR GENERAL NOTES, ABBREVIATIONS AND SYMBOLS SEE DRAWINGS CAES-1-DW-012-302-001, 002 AND 003.
2. SYSTEM CODE FOR VALVES AND PIPING SPECIALTIES ARE THE SAME AS THE ASSOCIATED PIPE DESIGNATION.
3. ALL EQUIPMENT, VALVES, AND SPECIALTY ITEM TAG NUMBERS ARE PREFIXED WITH CAES-1-EQ UNLESS OTHERWISE NOTED.
4. ALL LOCAL VENTS AND DRAINS TO HAVE A 4" LONG NIPPLE THREADED ONE END TERMINATED LOCALLY UNLESS OTHERWISE NOTED.
5. ALL INSTRUMENT ROOT VALVES ARE 0.75" AND VENTS AND DRAINS ARE 1" UNLESS OTHERWISE NOTED. ALL FLOW ELEMENT ROOT VALVES ARE 0.5" UNLESS OTHERWISE NOTED.

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPECIALIST	LEAD DISCIPLINE ENGINEER	PROJECT ENGINEER	PROJECT MANAGER
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH

PRELIMINARY STATUS — DATE — REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED. — LDE

APPROVED STATUS — DATE — REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS. — LDE

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAD	ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF: PE:, STATE:, LIC. NO.#, DATE:
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

Zero Harm — Leadership, No Incidents, Safe Behavior

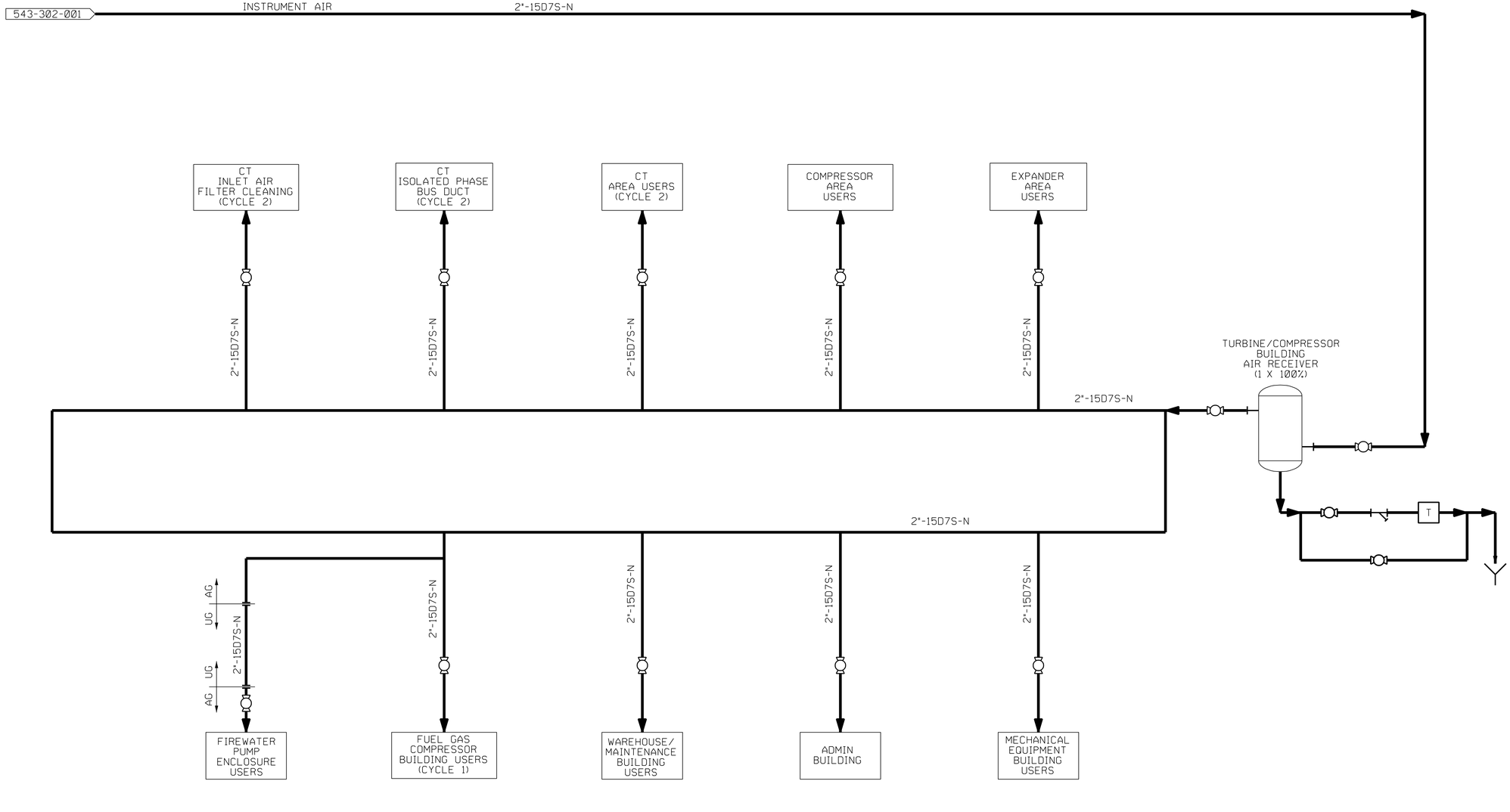
WorleyParsons — resources & energy

CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PIPING & INSTRUMENTATION DIAGRAM
LEGENDS AND SYMBOLS
PIPING SYMBOLS

SCALE: NONE | DRAWING SIZE: ARCH D (36" x 24") | WORLEYPARSONS DWG. NO.: CAES-1-DW-012-302-001 | REV: A

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PRELIMINARY DESIGN

NOTES:

1. FOR GENERAL NOTES, ABBREVIATIONS AND SYMBOLS SEE DRAWINGS CAES-1-DW-012-302-001, 002 AND 003.
2. LINE SIZES ARE FOR INFORMATION ONLY AND MAY CHANGE DURING FINAL DESIGN.

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	ENG. MGR.	PROJ. ENGR. MANAGER	PROJECT MANAGER
B	08 16 11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH

PRELIMINARY STATUS — DATE — LDE — REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE — REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAD	
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

OneWay to zero harm

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ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF PE: _____ STATE: _____ LIC. NO.: _____ DATE: _____

WorleyParsons resources & energy

CLIENT/PROJECT TITLE

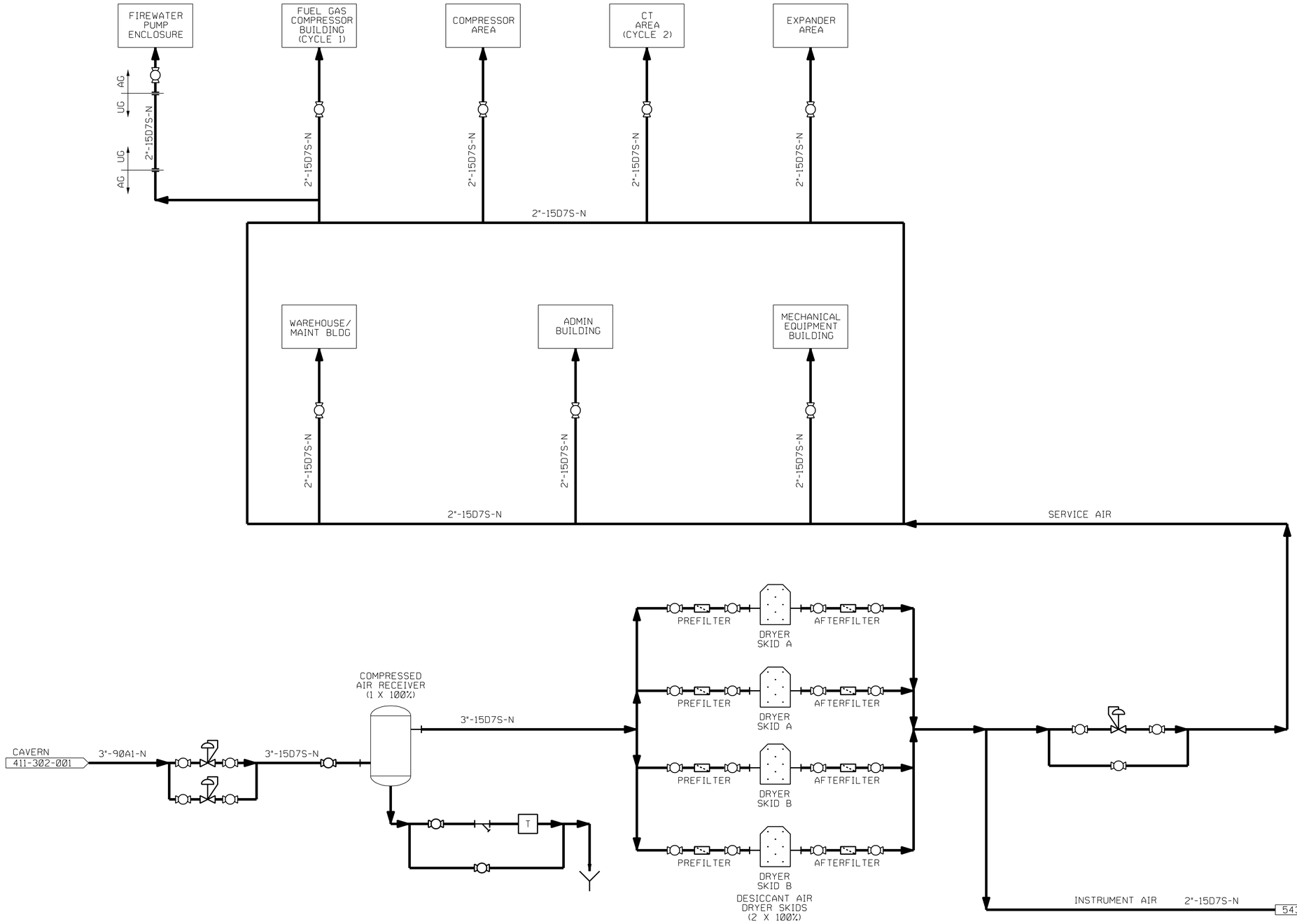
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PIPING & INSTRUMENTATION DIAGRAM
COMPRESSED AIR SYSTEMS

SCALE	DRAWING SIZE
NONE	ARCH D (36" x 24")

WORLEYPARSONS DWG. NO.	REV
CAES-1-DW-543-302-002	B

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NOTES:

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REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	LEAD ENGINEER	PROJ. ENGR MANAGER	PROJECT MANAGER
B	08 16 11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH

PRELIMINARY STATUS — DATE — LDE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAD	ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF PE: _____ STATE: _____ LIC. NO.: _____ DATE: _____
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

OneWay to zero harm

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CLIENT/PROJECT TITLE

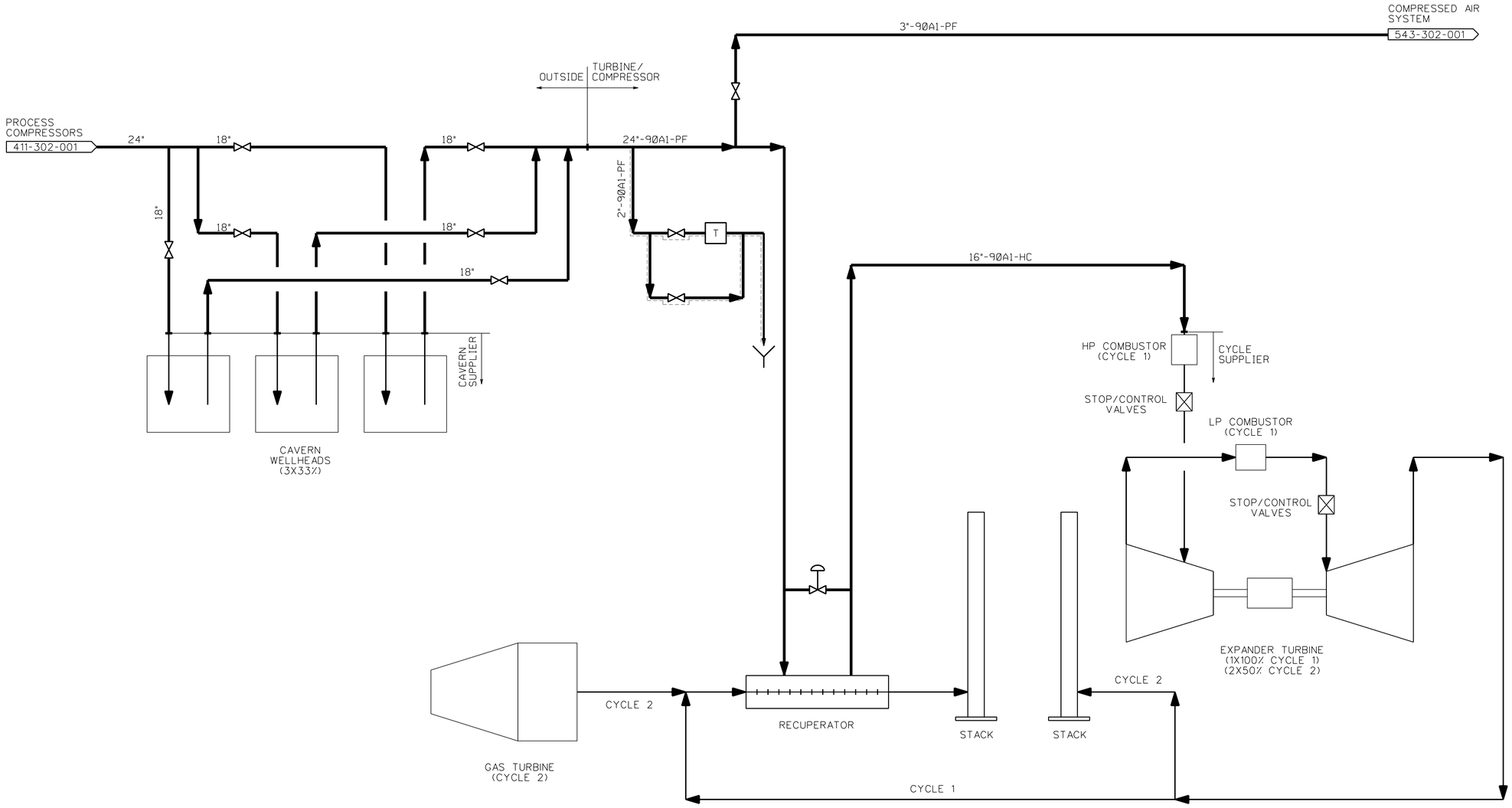
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PIPING & INSTRUMENTATION DIAGRAM
COMPRESSED AIR SYSTEMS

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-543-302-001
REV: B

PRELIMINARY DESIGN

...\caes-1-dw-543-302-001.dgn
8/16/2011 11:01:50 AM



PRELIMINARY DESIGN

NOTES:

1. FOR GENERAL NOTES, ABBREVIATIONS AND SYMBOLS SEE DRAWINGS CAES-1-DW-012-302-001, 002 AND 003.
2. LINE SIZES ARE FOR INFORMATION ONLY AND MAY CHANGE DURING FINAL DESIGN.

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER/ ENGINEER/ TECH SPEC ENGINEER	PROJ ENGR MANAGER	PROJECT MANAGER
B	10, 11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH

PRELIMINARY STATUS — DATE — LDE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAD	
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF
PE: _____ STATE: _____
LIC. NO.: _____ DATE: _____

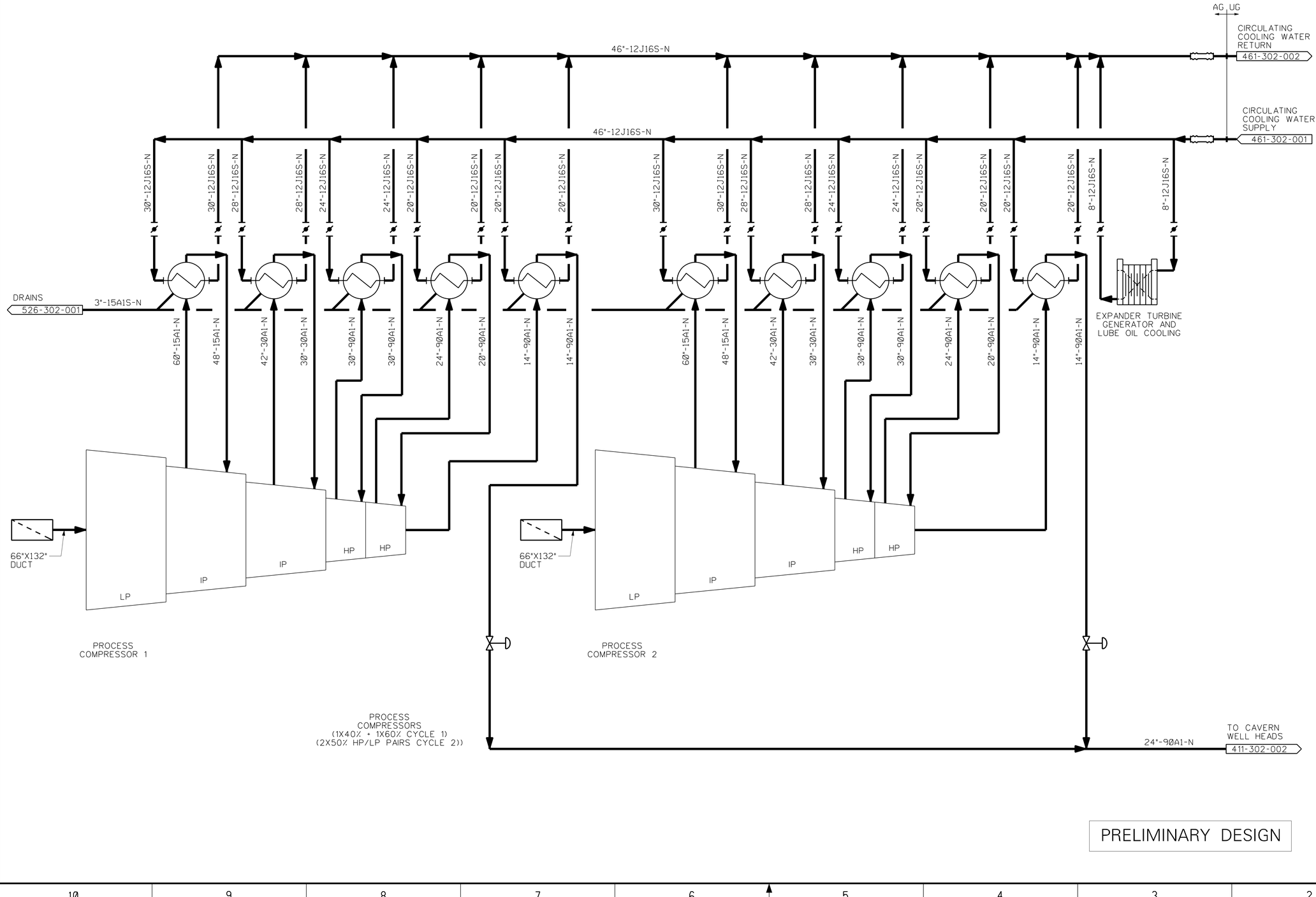
WorleyParsons
resources & energy

CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PIPING & INSTRUMENTATION DIAGRAM
EXPANDER TURBINE

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-411-302-002
REV: B

...\caes-1-dw-411-302-002.dgn 10/11/2011 11:10:10 AM



PRELIMINARY DESIGN

NOTES:

1. FOR GENERAL NOTES, ABBREVIATIONS AND SYMBOLS SEE DRAWINGS CAES-1-DW-012-302-001, 002 AND 003.
2. LINE SIZES ARE FOR INFORMATION ONLY AND MAY CHANGE DURING FINAL DESIGN.

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	LEAD ENGINEER	PROJ. ENGR MANAGER	PROJECT MANAGER
C	10/31/11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH
B	08/16/11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH

PRELIMINARY STATUS — DATE — LDE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAD	
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF
PE:_____ STATE:_____
LIC. NO.:_____ DATE:_____

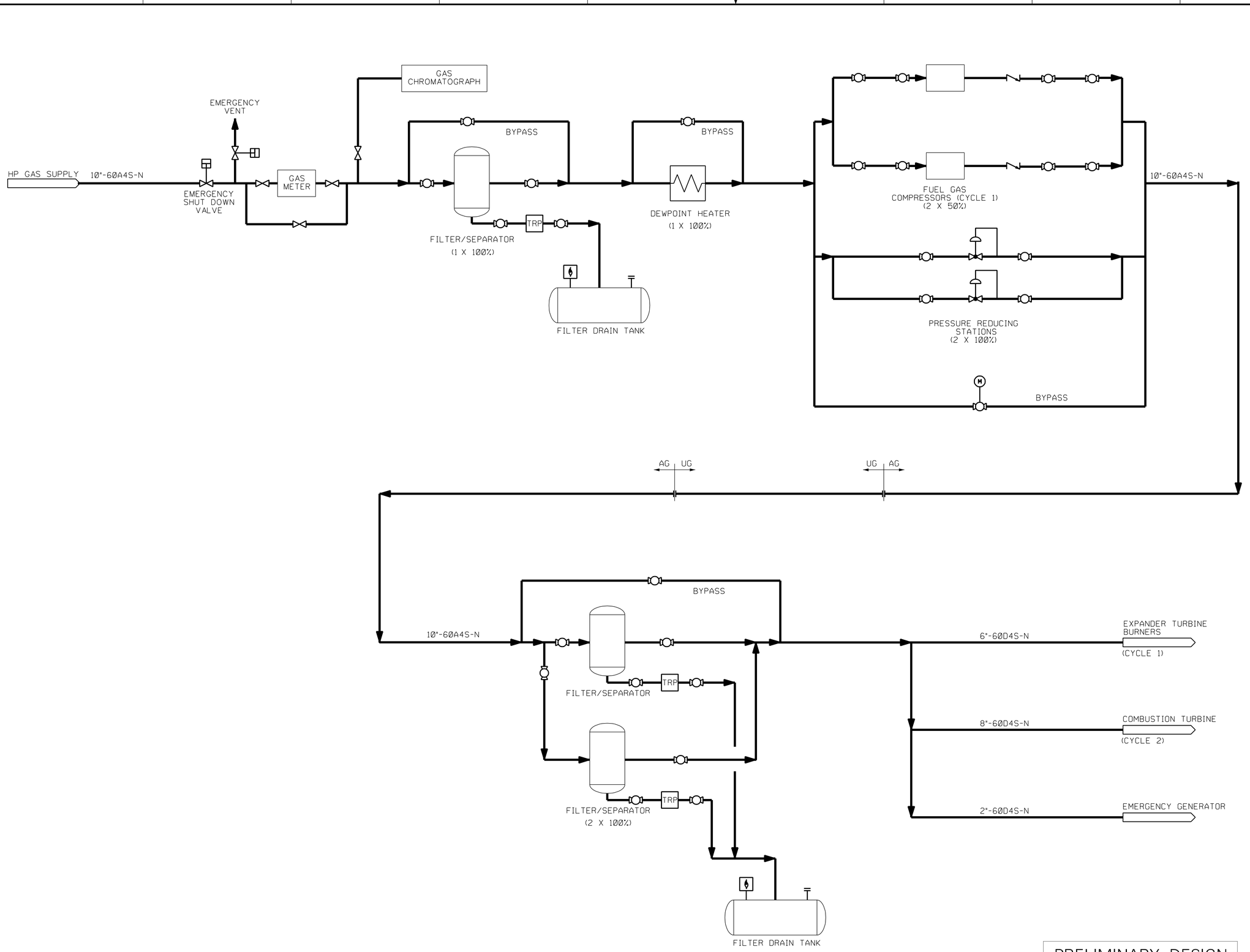
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resources & energy

CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PIPING & INSTRUMENTATION DIAGRAM
EXPANDER TURBINE

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-411-302-001
REV: C

\\caes-1-dw-411-302-001.dgn 10/17/2011 4:53:34 PM



NOTES:

1. FOR GENERAL NOTES, ABBREVIATIONS AND SYMBOLS SEE DRAWINGS CAES-1-DW-012-302-001, 002 AND 003.
2. LINE SIZES ARE FOR INFORMATION ONLY AND MAY CHANGE DURING FINAL DESIGN.

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD ENGINEER	ENGINEER/ TECH. SPEC.	LEAD DESIGNER	ENGINEER	PROJ. ENGR MANAGER	PROJECT MANAGER
C	10/11/11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE	HGE		MH
B	08/16/11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE	HGE		MH
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE	HGE		MH

PRELIMINARY STATUS — DATE — LDE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAD	ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF: PE: _____ STATE: _____ LIC. NO.: _____ DATE: _____
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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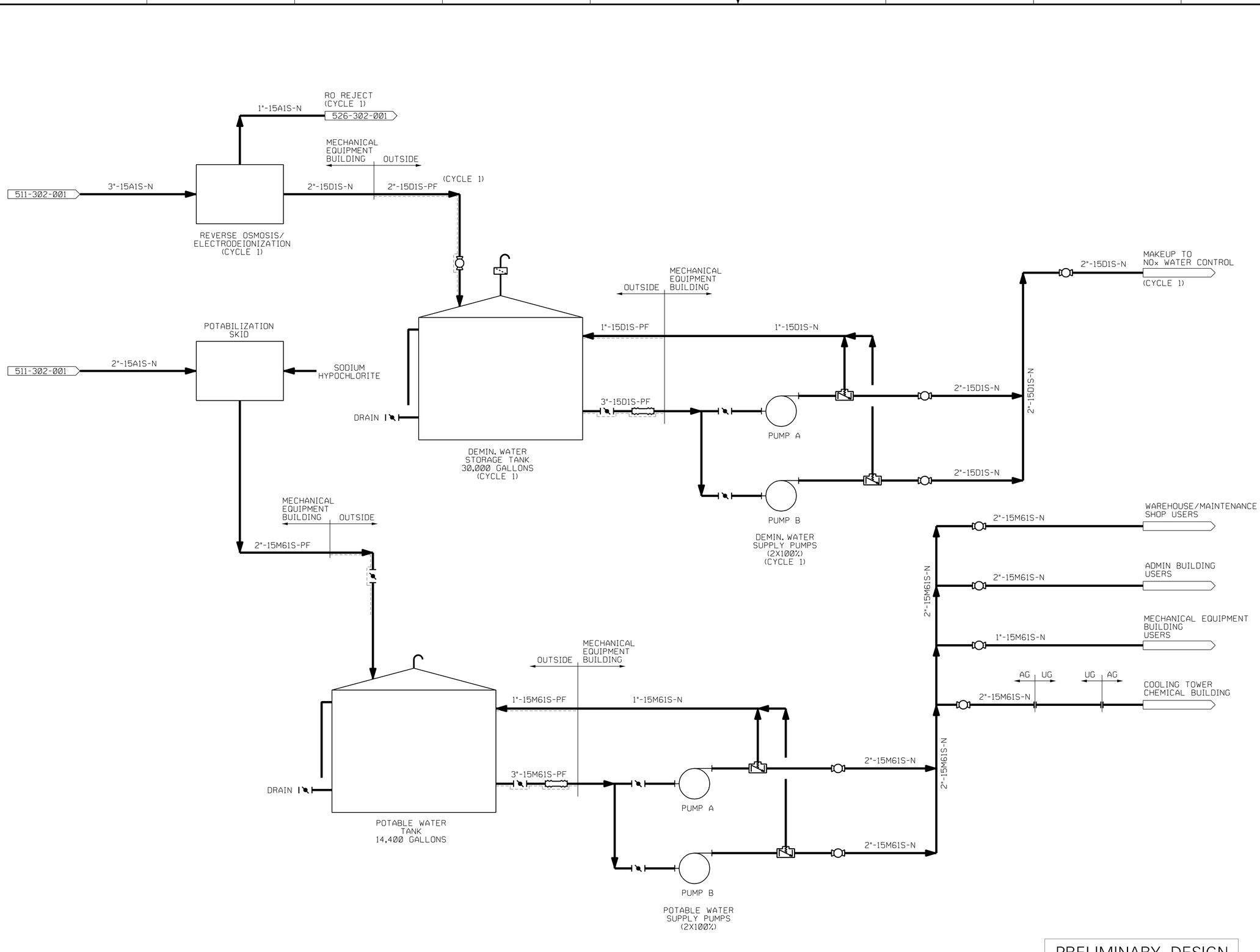
CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PIPING & INSTRUMENTATION DIAGRAM
FUEL GAS SYSTEM

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-561-302-001
REV: C

PRELIMINARY DESIGN

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10/17/2011 11:01:41 AM



PRELIMINARY DESIGN

NOTES:

1. FOR GENERAL NOTES, ABBREVIATIONS AND SYMBOLS SEE DRAWINGS CAES-1-DW-012-302-001, 002 AND 003.
2. LINE SIZES ARE FOR INFORMATION ONLY AND MAY CHANGE DURING FINAL DESIGN.

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC	LEAD DISC ENGINEER	PROJ. ENGR MANAGER	PROJECT MANAGER
B	08 16 11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		CH	HGE		MH
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		CH	HGE		MH

PRELIMINARY STATUS — DATE — LDE — REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE — REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAD	ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF PE: STATE: LIC. NO.: DATE:
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: C. HARTLINE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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CLIENT/PROJECT TITLE

NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PIPING & INSTRUMENTATION DIAGRAM
WATER TREATMENT SYSTEM

SCALE: NONE | DRAWING SIZE: ARCH D (36" x 24")

WORLEYPARSONS DWG. NO.: CAES-1-DW-511-302-002 | REV: B

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8/16/2011 9:23:18 AM

COOLING TOWER BLOWDOWN
461-302-001
6"-12J8S-N
OFF SITE

EVAPORATIVE COOLER BLOWDOWN (CYCLE 2)
2"-15A1S-N

4"-12J8S-N
NC
GENERATOR STEP UP TRANSFORMER FOUNDATION

4"-12J8S-N
NC
AUXILIARY TRANSFORMER FOUNDATION

4"-12J8S-N
NC
AUXILIARY TRANSFORMER FOUNDATION

4"-12J8S-N
NC
AUXILIARY TRANSFORMER FOUNDATION

NC
AMMONIA STORAGE TANK CONTAINMENT

4"-12J8S-N

4"-15A1S-N

AG,UG

UG,AG

4"-15A1S-N

6"-15A1S-PF

UG,AG
6"-12J8S-N
COOLING TOWER BASIN
461-302-002

AG,UG
4"-12J8S-N
COOLING TOWER BASIN
461-302-002

4"-15A1S-PF
4"-15A1S-PF

PUMP A PUMP B
SUMP PUMPS
STORM WATER
TRANSFER
(2X100%)

EMERGENCY GENERATOR
4"-12J8S-N

TURBINE/COMPRESSOR BUILDING FLOOR AND EQUIPMENT DRAINS
4"-12J8S-N

PROCESS COMPRESSOR
411-302-001
DRAINS
3"-15A1S-N

PUMP A PUMP B
SUMP PUMPS
TURBINE/COMPRESSOR BLDG
(2X100%)

PUMP A PUMP B
OIL/WATER SEPARATOR

OIL/WATER SEPARATOR DISCHARGE PUMPS
(2 X 100%)

PACKAGED SEWAGE SYSTEM
4"-12E61S-N
LEACHATE FIELD

4"-15A1S-N
4"-15A1S-N
4"-15A1S-N

AG,UG
4"-12J8S-N
COOLING TOWER BASIN
461-302-002

4"-15A1S-PF
4"-15A1S-PF

FILTER BACKWASH
511-302-001
2"-15A1S-N

RO REJECT
511-302-002
(CYCLE 1)
1"-15A1S-N

PUMP A PUMP B
SUMP PUMPS
MECHANICAL EQUIPMENT BUILDING
(2X100%)

PUMP A PUMP B
SUMP PUMPS
WAREHOUSE/MAINTENANCE SHOP
(2X100%)

PUMP A PUMP B
SUMP PUMPS
COOLING TOWER
CHEMICAL BLDG
(2X100%)

ADMIN BUILDING SANITARY
4"-12E61S-N

MECHANICAL EQUIPMENT BUILDING SANITARY
4"-12E61S-N

6"-12E61S-N

PRELIMINARY DESIGN

NOTES:

1. FOR GENERAL NOTES, ABBREVIATIONS AND SYMBOLS SEE DRAWINGS CAES-1-DW-012-302-001, 002 AND 003.
2. LINE SIZES ARE FOR INFORMATION ONLY AND MAY CHANGE DURING FINAL DESIGN.

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	LEAD DISC. ENGR.	PROJ. ENGR. MANAGER	PROJECT MANAGER
C	10/11/11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		CH	HGE		MH
B	08/16/11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		CH	HGE		MH
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		CH	HGE		MH

PRELIMINARY STATUS — DATE — LDE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAD	
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: C. HARTLINE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF
PEV _____ STATE _____
LIC.NO. _____ DATE _____

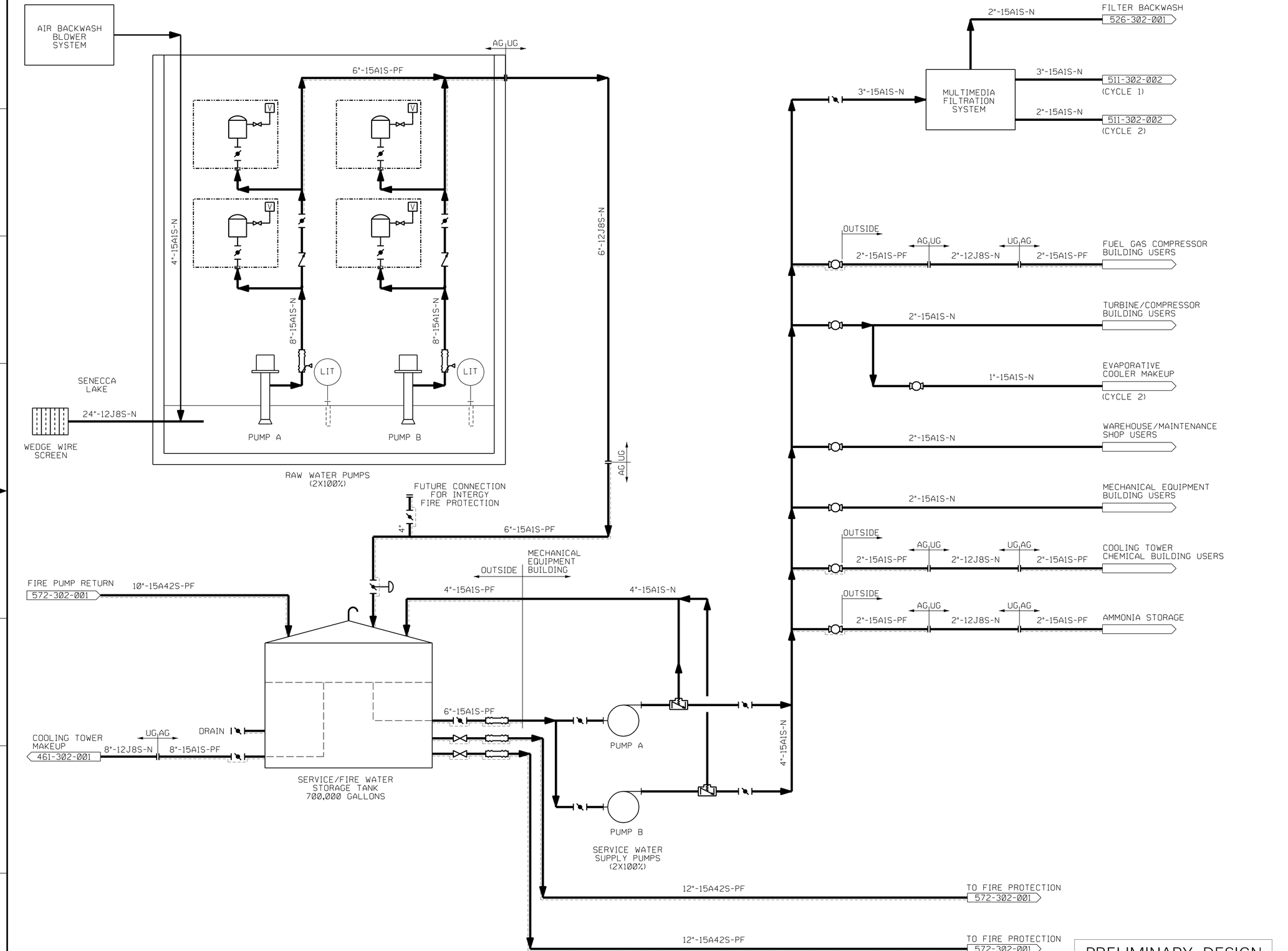
WorleyParsons
resources & energy

CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PIPING & INSTRUMENTATION DIAGRAM
WASTE WATER TREATMENT SYSTEM

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-526-302-001
REV: C

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10/11/2011 11:03:41 AM



NOTES:

1. FOR GENERAL NOTES, ABBREVIATIONS AND SYMBOLS SEE DRAWINGS CAES-1-DW-012-302-001, 002 AND 003.
2. LINE SIZES ARE FOR INFORMATION ONLY AND MAY CHANGE DURING FINAL DESIGN.

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/TECH SPECIALIST	PROJECT ENGINEER	PROJECT MANAGER
C	10, 11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		CH	HGE	MH
B	08, 16, 11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		CH	HGE	MH
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		CH	HGE	MH

PRELIMINARY STATUS — DATE — LDE: REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE: REPRESENTS REVIEWED AND APPROVED DESIGN, ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAD	
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: C. HARTLINE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF PE: STATE: LIC. NO.: DATE:

WorleyParsons resources & energy

CLIENT/PROJECT TITLE

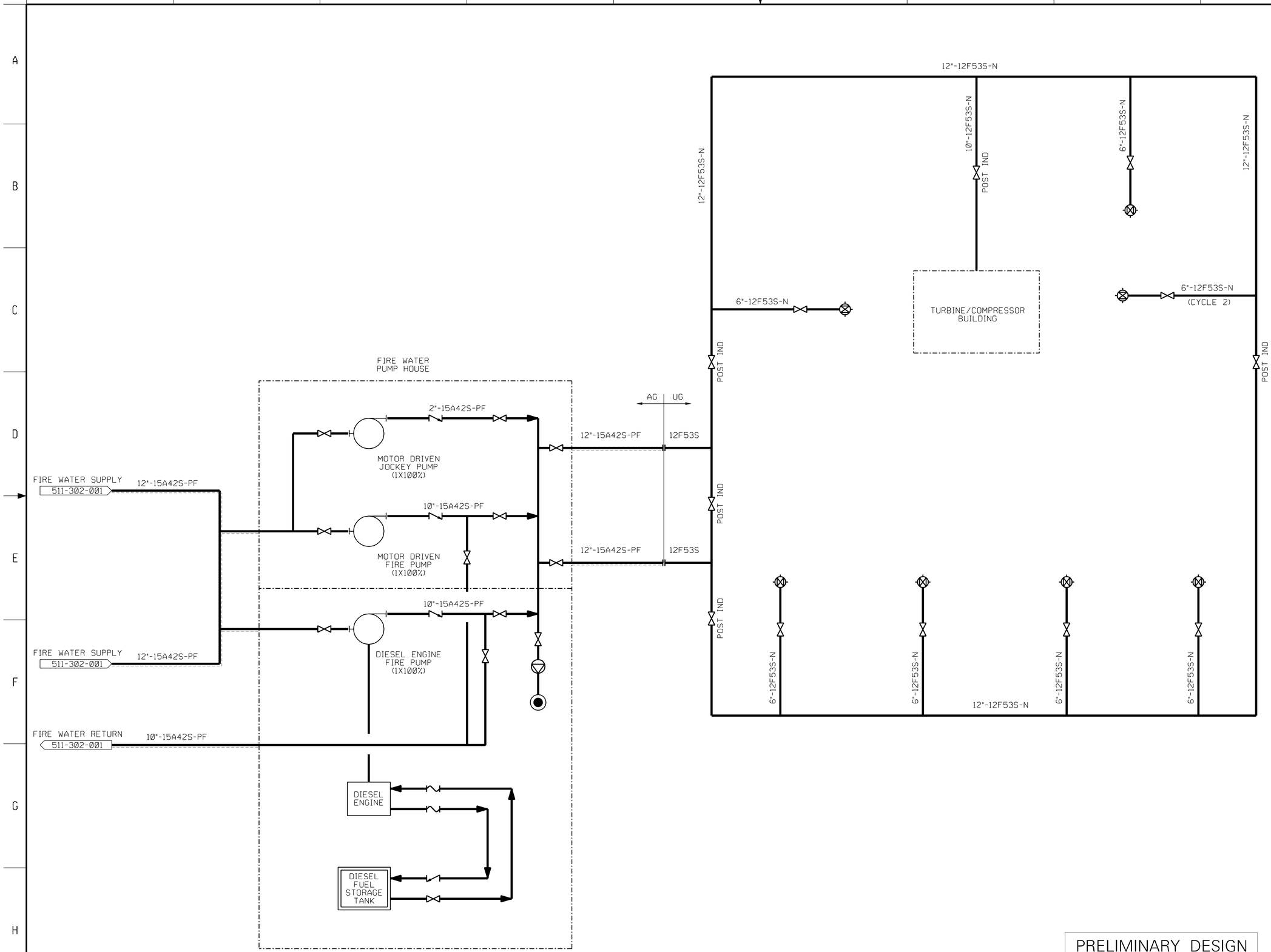
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PIPING & INSTRUMENTATION DIAGRAM
WATER TREATMENT SYSTEM

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-511-302-001
REV: C

PRELIMINARY DESIGN

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PRELIMINARY DESIGN

NOTES:

1. FOR GENERAL NOTES, ABBREVIATIONS AND SYMBOLS SEE DRAWINGS CAES-1-DW-012-302-001, 002 AND 003.
2. LINE SIZES ARE FOR INFORMATION ONLY AND MAY CHANGE DURING FINAL DESIGN.

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	LEAD DISCIPLINE ENGINEER	PROJ. ENGR. MANAGER	PROJECT MANAGER
B	08 16 11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH

PRELIMINARY STATUS — DATE — LDE: REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE: REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAD	
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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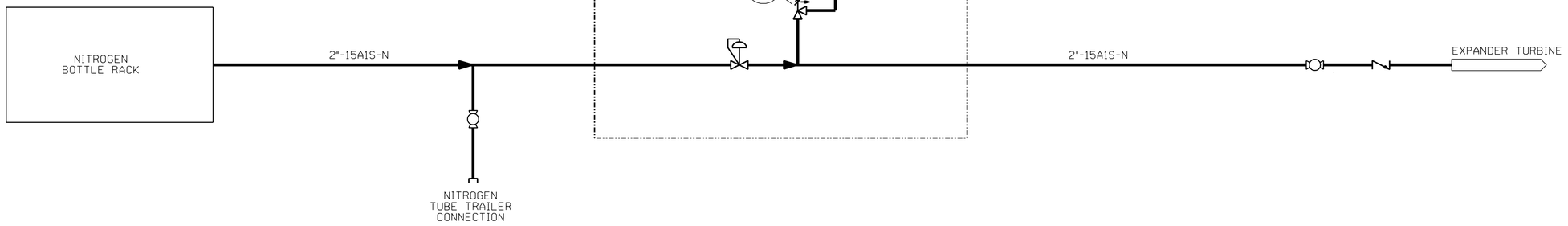
CLIENT/PROJECT TITLE

NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PIPING & INSTRUMENTATION DIAGRAM
FIRE PROTECTION SYSTEM

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-572-302-001
REV: B

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PRELIMINARY DESIGN

NOTES:

1. FOR GENERAL NOTES, ABBREVIATIONS AND SYMBOLS SEE DRAWINGS CAES-1-DW-012-302-001, 002 AND 003.
2. LINE SIZES ARE FOR INFORMATION ONLY AND MAY CHANGE DURING FINAL DESIGN.

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC.	PROJECT ENGR. MANAGER	PROJECT MANAGER
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE	MH

PRELIMINARY STATUS — DATE — LDE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN, ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAD	
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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PE: _____ STATE: _____
LIC. NO.: _____ DATE: _____

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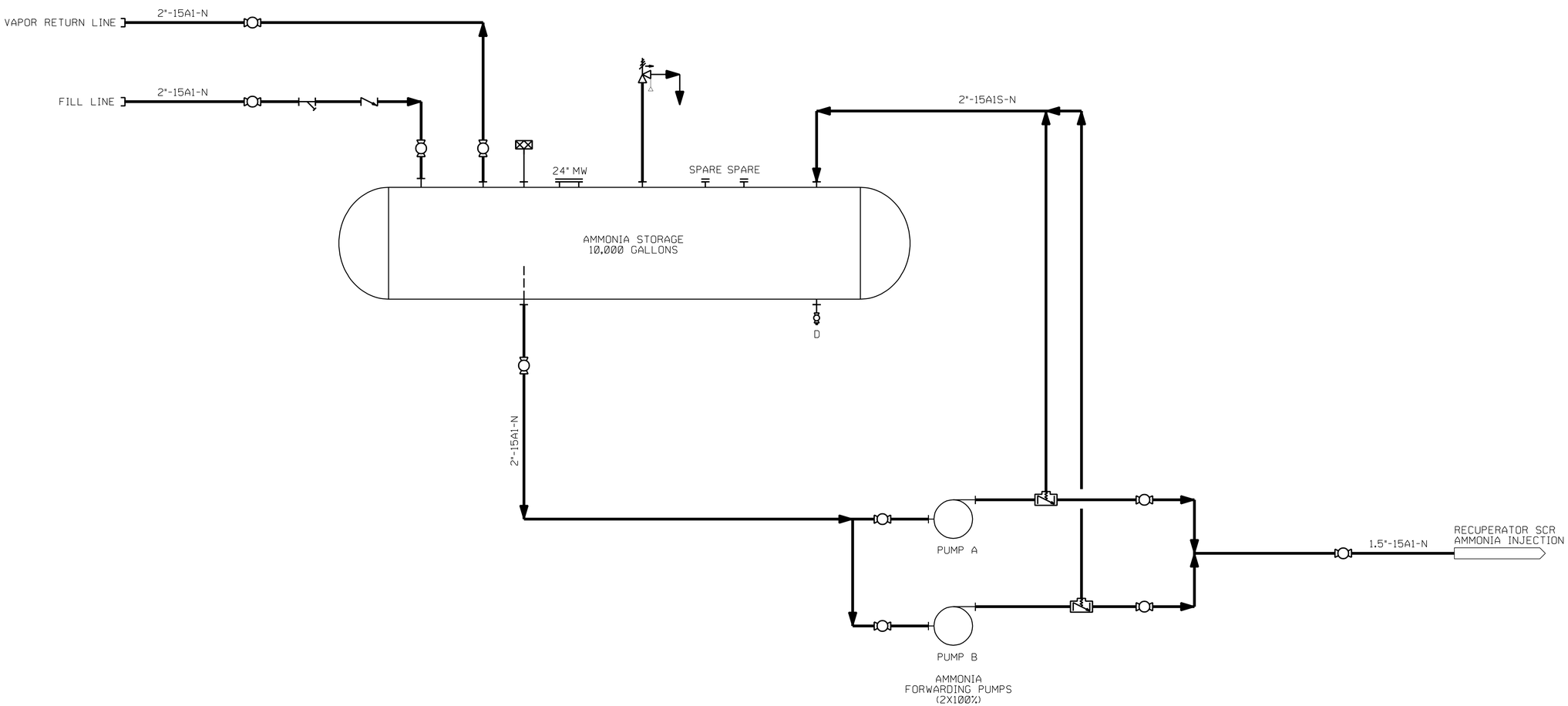
CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PIPING & INSTRUMENTATION DIAGRAM
COMPRESSED GAS

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")

WORLEYPARSONS DWG. NO.: CAES-I-DW-546-302-001
REV: A

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NOTES:

1. FOR GENERAL NOTES, ABBREVIATIONS AND SYMBOLS SEE DRAWINGS CAES-1-DW-012-302-001, 002 AND 003.
2. LINE SIZES ARE FOR INFORMATION ONLY AND MAY CHANGE DURING FINAL DESIGN.

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	LEAD DISC. ENGINEER	PROJ. ENGR. MANAGER	PROJECT MANAGER
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH

PRELIMINARY STATUS — DATE — LDE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED 'HOLD' RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAD	
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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PE: _____ STATE: _____
LIC. NO.: _____ DATE: _____

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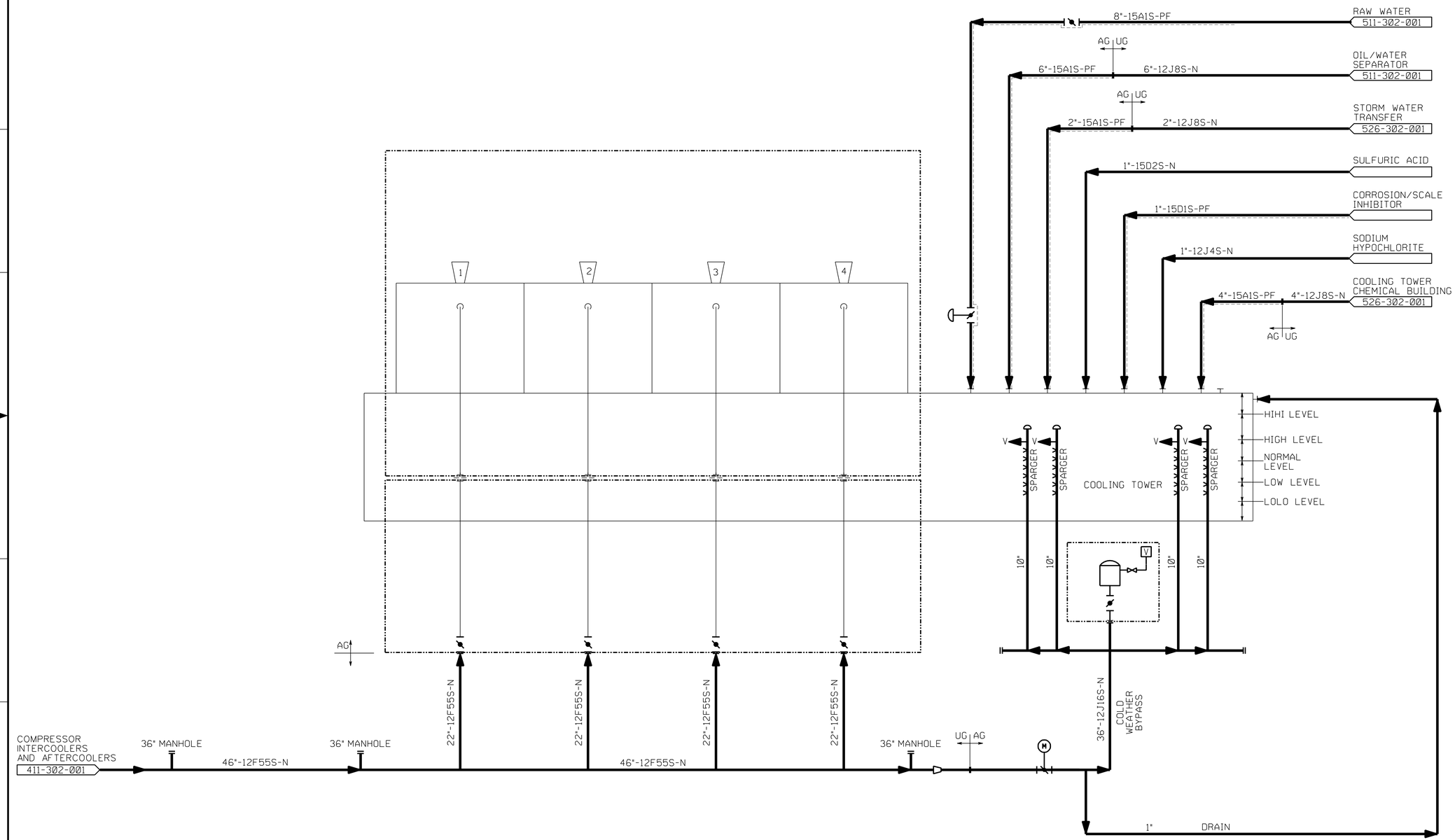
CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PIPING & INSTRUMENTATION DIAGRAM
AMMONIA STORAGE & FORWARDING

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-541-302-001
REV: A

PRELIMINARY DESIGN

7/19/2011 11:28:47 AM
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NOTES:

1. FOR GENERAL NOTES, ABBREVIATIONS AND SYMBOLS SEE DRAWINGS CAES-1-DW-012-302-001, 002 AND 003.
2. LINE SIZES ARE FOR INFORMATION ONLY AND MAY CHANGE DURING FINAL DESIGN.

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPECIL.	LEAD DISC. ENGINEER	PROJECT ENGINEER	PROJECT MANAGER
C	10/11/11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH
B	09/16/11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH

PRELIMINARY STATUS — DATE — LDE — REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE — REPRESENTS REVIEWED AND APPROVED DESIGN, ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: TAD	ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF PE, STATE, LIC. NO., DATE
CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: H.G. EISENBISE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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CLIENT/PROJECT TITLE

NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

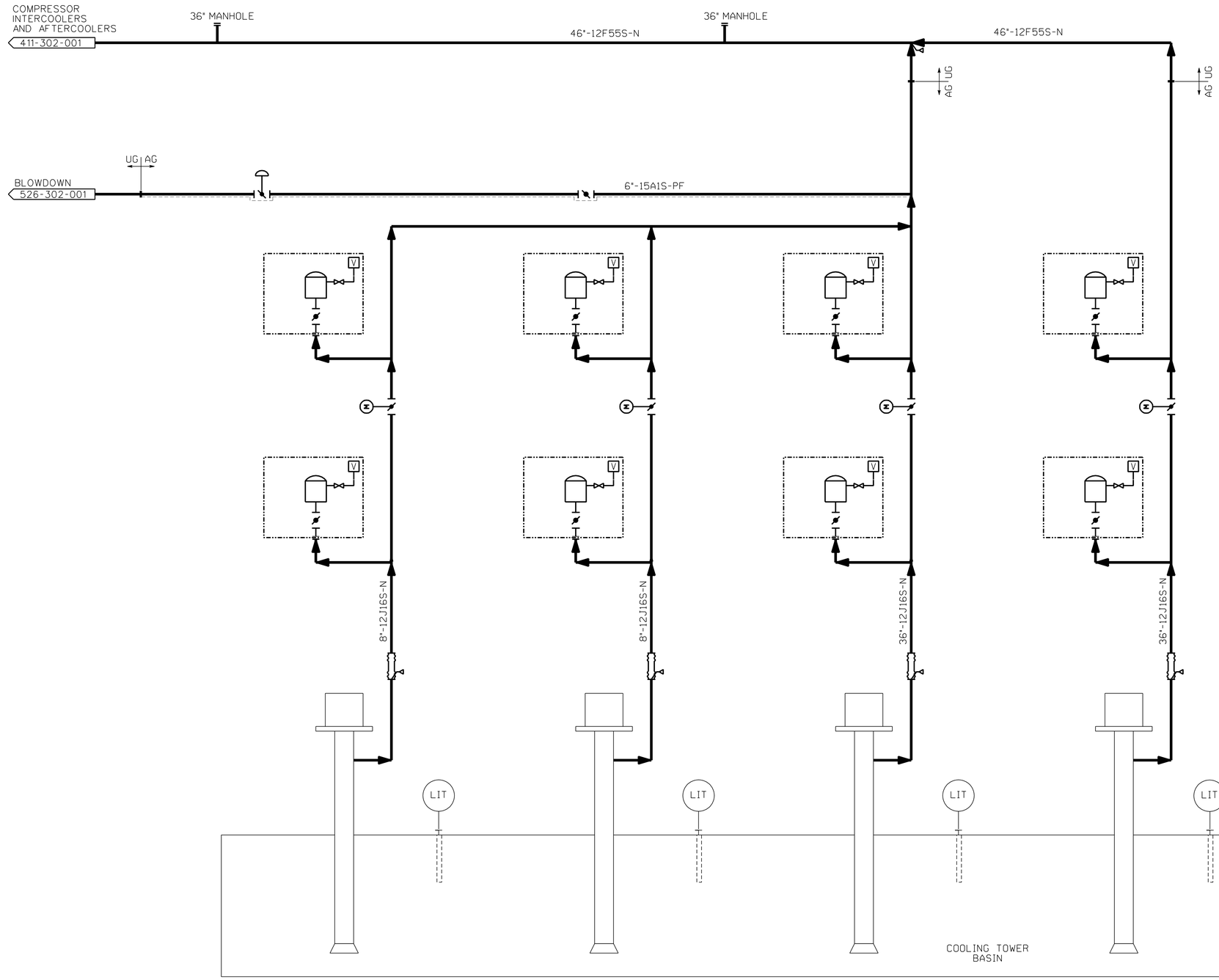
PIPING & INSTRUMENTATION DIAGRAM
CIRCULATING WATER

PRELIMINARY DESIGN

SCALE: NONE — DRAWING SIZE: ARCH D (36" x 24")

WORLEYPARSONS DWG. NO.: CAES-1-DW-461-302-002 — REV: C

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NOTES:

1. FOR GENERAL NOTES, ABBREVIATIONS AND SYMBOLS SEE DRAWINGS CAES-1-DW-012-302-001, 002 AND 003.
2. LINE SIZES ARE FOR INFORMATION ONLY AND MAY CHANGE DURING FINAL DESIGN.

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC.	LEAD DISC. ENGINEER	PROJ. ENGR. MANAGER	PROJECT MANAGER
B	08 16 11	ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		HGE	HGE		MH

PRELIMINARY STATUS — DATE — LDE
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APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED 'HOLD' RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL

DRAWN BY: TAD
CHECKED BY: H.G. EISENBISE
LEAD DESIGNER:
ENGINEER/TECH SPECIALIST: H.G. EISENBISE
PROJECT ENGINEERING MANAGER:
PROJECT MANAGER: M. HOLDRIDGE

PROFESSIONAL ENGINEER'S SEAL

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PE's _____ STATE _____
LIC. NO.s _____ DATE _____

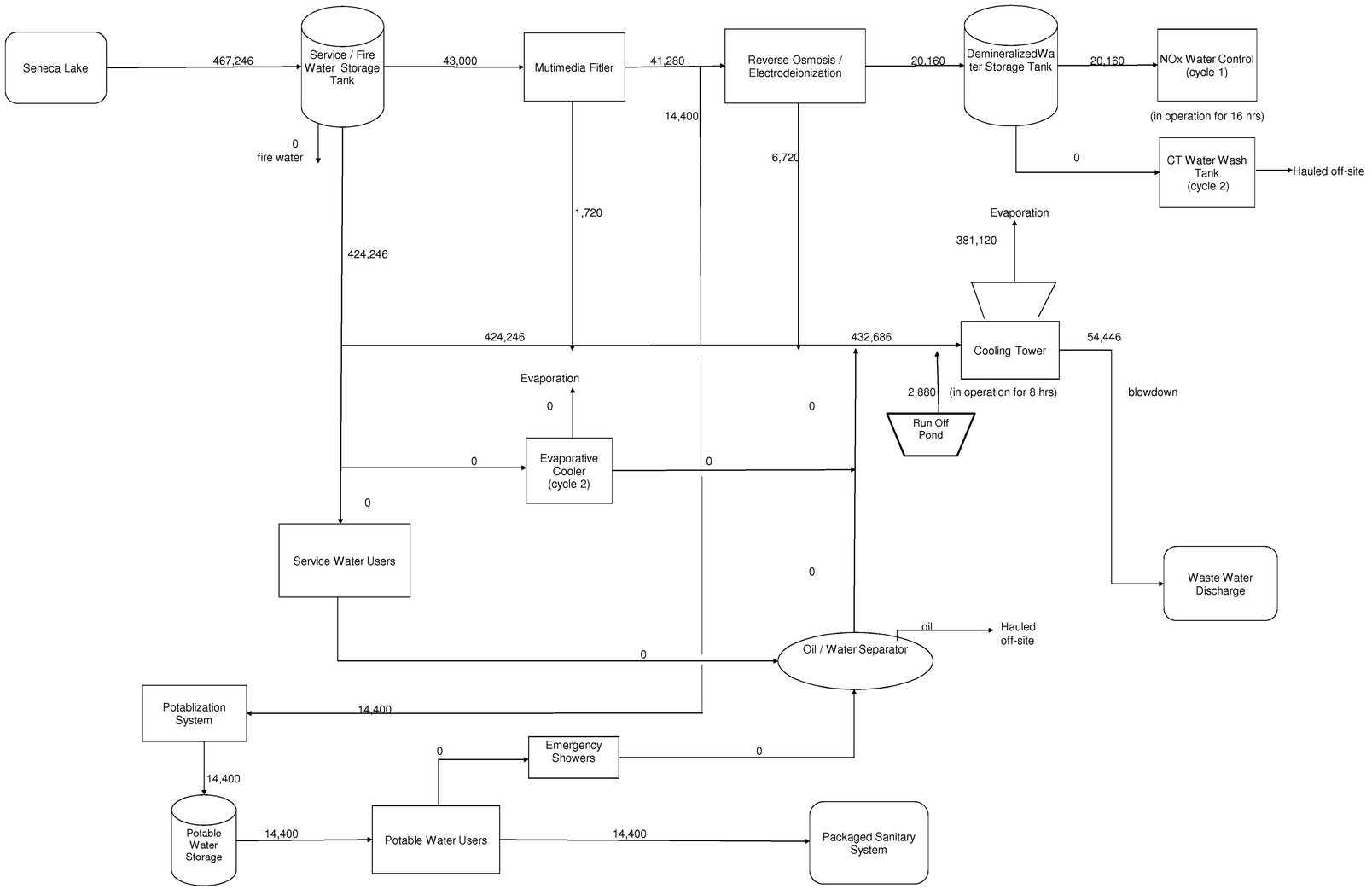
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CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PIPING & INSTRUMENTATION DIAGRAM
CIRCULATING WATER

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-461-302-001
REV: B

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Legend:
COC: Cycles of Concentration
CT: Combustion Turbine
RO: Reverse Osmosis
EDI: Electrodeionization

Notes:
1. Based on proposal data from Design Basis Document and Vendor proposals.
2. Middle ambient conditions are 45 degrees F and 60% R.H.
3. Cooling tower blowdown is based on 8 COC.
4. Evaporative cooler is wetted media type, Evap Cooler Blowdown is based on 2 COC.
5. Evaporative cooler evaporation calculated from GE turbine Data.
6. The demineralization RO / EDI system reject is assumed to be 25%.
7. Cooling tower runs at night for 8 hours and NOx water for 16 hours.

Summary Balance:

In Flow:	470,126 gpd
Out Flow:	470,126 gpd
Difference:	0

Units: All flows are in gallons per day

PRELIMINARY DESIGN

NOTES:

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC	ENGINEER	PROJ ENGR MANAGER	PROJECT MANAGER
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		CH	HGE		MH

PRELIMINARY STATUS — DATE — LDE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

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CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: C. HARTLINE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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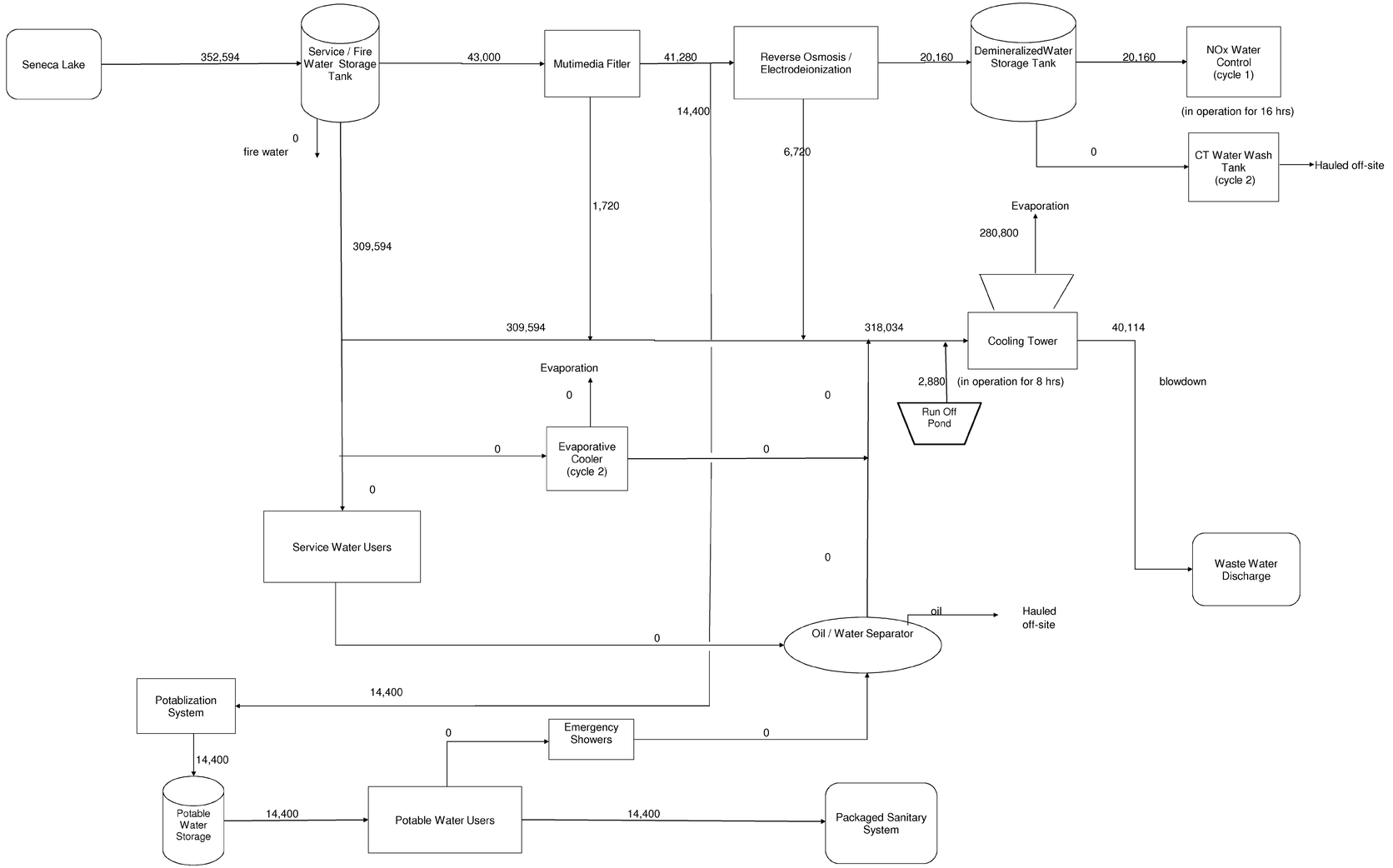
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CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PRELIMINARY WATER BALANCE
CYCLE 1
45° F, 60% RH

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-021-305-005
REV: A

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Legend:
COC: Cycles of Concentration
CT: Combustion Turbine
RO: Reverse Osmosis
EDI: Electrodeionization

Notes:
1. Based on proposal data from Design Basis Document and Vendor proposals.
2. Low ambient conditions are -2 degrees F and 50% R.H.
3. Cooling tower blowdown is based on 8 COC.
4. Evaporative cooler is wetted media type, Evap Cooler Blowdown is based on 2 COC.
5. Evaporative cooler evaporation calculated from GE turbine Data.
6. The demineralization RO / EDI system reject is assumed to be 25%.
7. Cooling tower runs at night for 8 hours and NOx water for 16 hours.

Summary Balance:

In Flow:	355,474 gpd
Out Flow:	355,474 gpd
Difference:	0

Units: All flows are in gallons per day

PRELIMINARY DESIGN

NOTES:

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER / ENGINEER / TECH SPEC / LEAD DISC ENGINEER	CH ENGR / PROJ ENGR MANAGER	PROJECT MANAGER
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		CH	HGE	MH

PRELIMINARY STATUS — DATE — LDE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED 'HOLD' RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
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CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: C. HARTLINE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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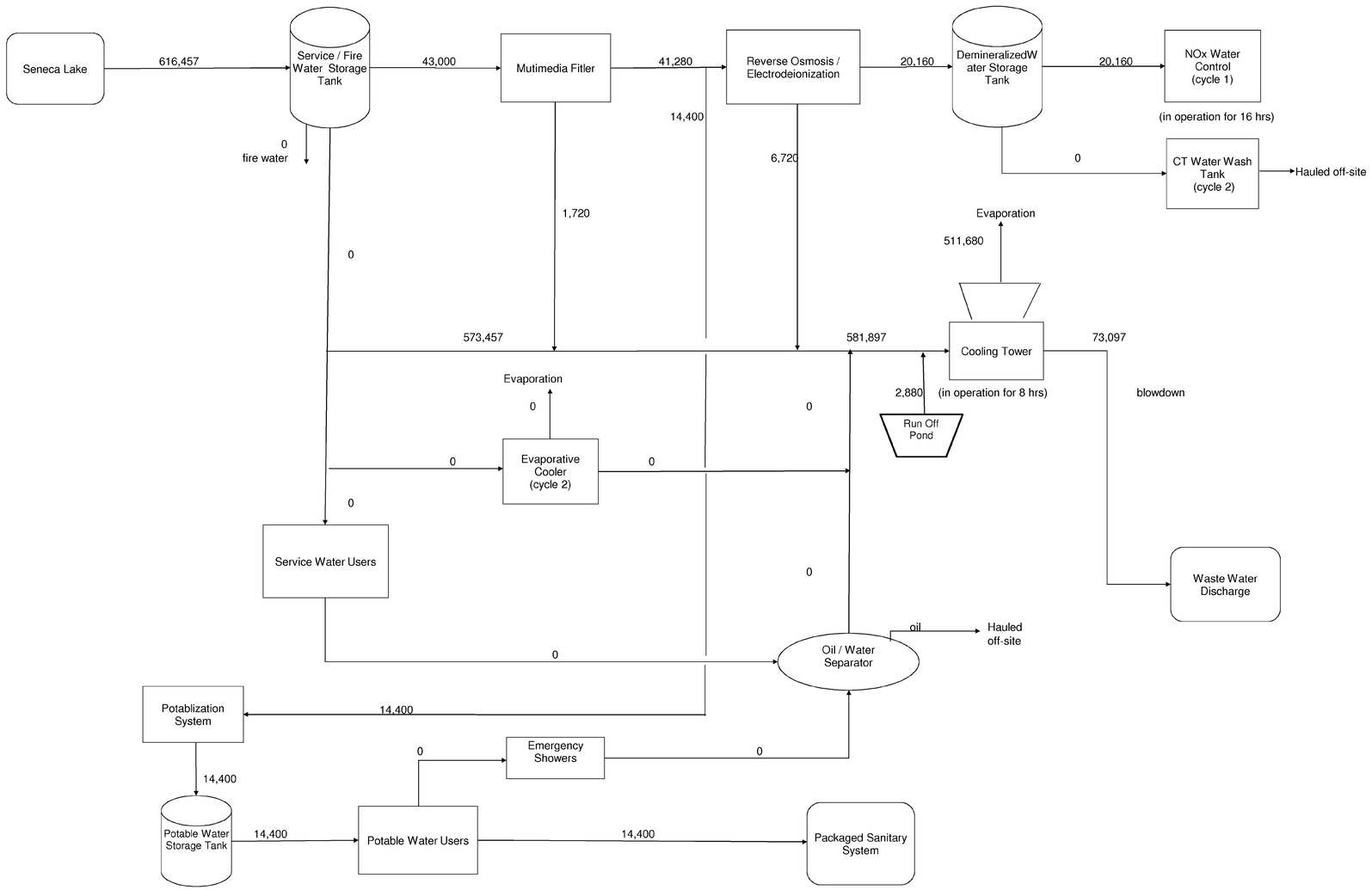
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CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PRELIMINARY WATER BALANCE
CYCLE 1
-2° F, 50% RH

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-021-305-007
REV: A

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Legend:
COC: Cycles of Concentration
CT: Combustion Turbine
RO: Reverse Osmosis
EDI: Electrodeionization

Notes:
1. Based on proposal data from Design Basis Document and Vendor proposals.
2. High ambient conditions are 87 degrees F and 46% RH (day/night wet bulb assumed constant).
3. Cooling tower blowdown is based on 8 COC.
4. Evaporative cooler is wetted media type, Evap Cooler Blowdown is based on 2 COC.
5. Evaporative cooler evaporation calculated from GE turbine Data.
6. The demineralization RO / EDI system reject is assumed to be 25%.
7. Cooling tower runs at night for 8 hours and NOx water for 16 hours.

Summary Balance:

In Flow:	619,337 gpd
Out Flow:	619,337 gpd
Difference:	0

Units: All flows are in gallons per day

PRELIMINARY DESIGN

NOTES:

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC	PROJ ENGR ENGINEER	PROJECT MANAGER
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		CH	HGE	MH

PRELIMINARY STATUS — DATE — LDE
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APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

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CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: C. HARTLINE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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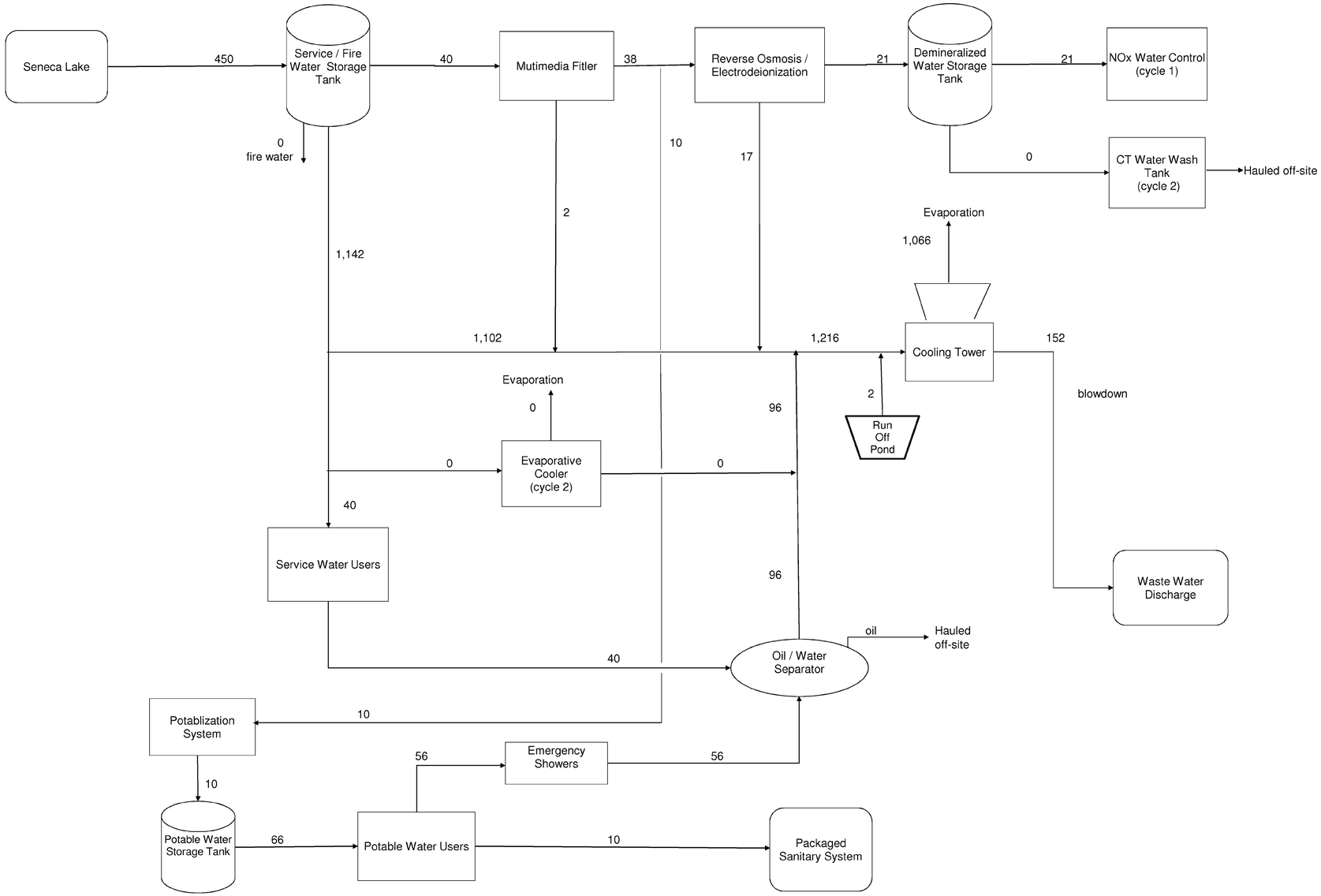
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NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PRELIMINARY WATER BALANCE
CYCLE 1
87° F, 46% RH

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-021-305-003
REV: A

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Legend:
COC: Cycles of Concentration
CT: Combustion Turbine
RO: Reverse Osmosis
EDI: Electrodeionization

Notes:
1. Based on proposal data from Design Basis Document and Vendor proposals.
2. High ambient conditions are 87 degrees F and 46% R.H.
3. Cooling tower blowdown is based on 8 COC.
4. Evaporative cooler is wetted media type, Evap Cooler Blowdown is based on 2 COC.
5. Evaporative cooler evaporation calculated from GE turbine Data.
6. The demineralization RO / EDI system reject is assumed to be 25%.
7. Maximum usage accounts for 2 additional service water hoses, employee shower use, and emergency shower use.
8. Lake Seneca supply pumps have a maximum flow rate of 450 gpm. Tank storage dampens flow to the tank.

Units: All flows are in gallons per minute

PRELIMINARY DESIGN

NOTES:

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/TECH SPEC	PROJECT ENGINEER	PROJ ENGR MANAGER	PROJECT MANAGER
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		CH	HGE		MH

PRELIMINARY STATUS — DATE — LDE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

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CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: C. HARTLINE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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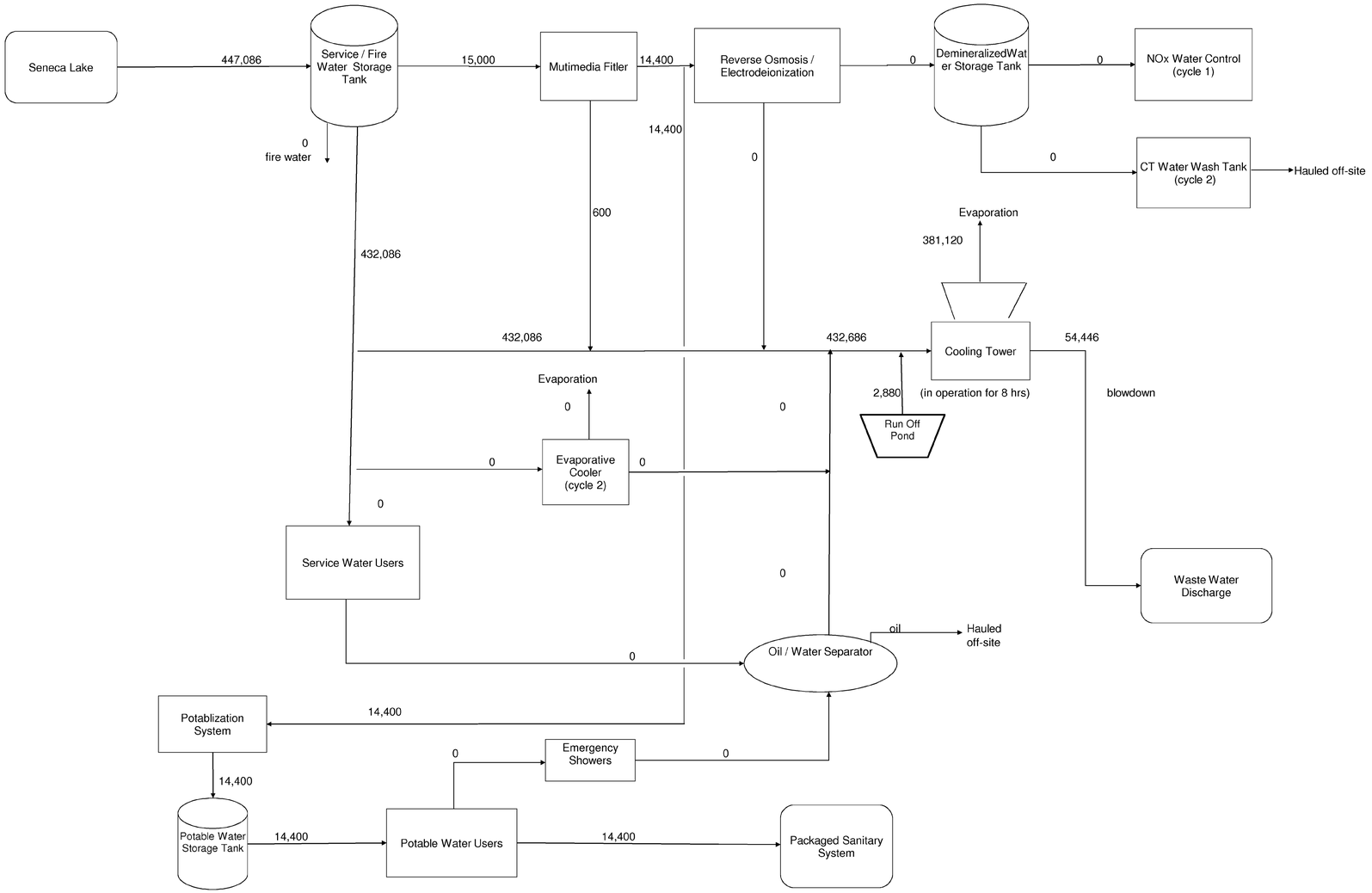
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NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PRELIMINARY WATER BALANCE
CYCLE 1
MAXIMUM USAGE

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-021-305-001
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Legend:
COC: Cycles of Concentration
CT: Combustion Turbine
RO: Reverse Osmosis
EDI: Electrodeionization

Notes:
1. Based on proposal data from Design Basis Document and Vendor proposals.
2. Middle ambient conditions are 45 degrees F and 60% R.H.
3. Cooling tower blowdown is based on 8 COC.
4. Evaporative cooler is wetted media type, Evap Cooler Blowdown is based on 2 COC.
5. Evaporative cooler evaporation calculated from GE turbine Data.
6. The demineralization RO / EDI system reject is assumed to be 25%.
7. Cooling tower runs at night for 8 hours.

Summary Balance:
In Flow: 449,966 gpd
Out Flow 449,966 gpd
Differenc 0

Units: All flows are in gallons per day

PRELIMINARY DESIGN

NOTES:

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC.	LEAD DISC. ENGINEER	PROJ. ENGR. MANAGER	PROJECT MANAGER
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		CH	HGE		MH

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CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: C. HARTLINE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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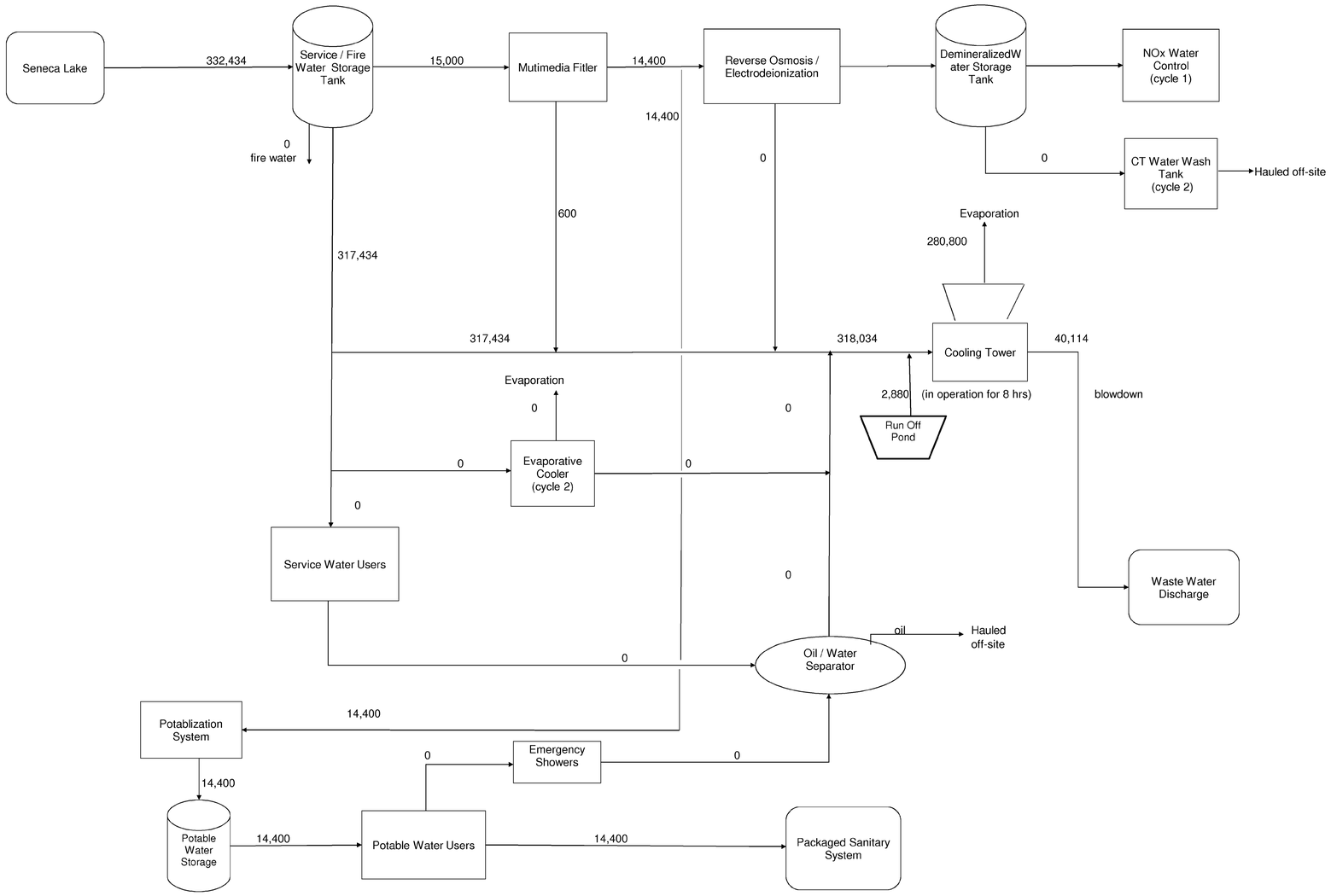
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NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PRELIMINARY WATER BALANCE
CYCLE 2
45° F, 60% RH

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-021-305-006
REV: A

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Legend:
COC: Cycles of Concentration
CT: Combustion Turbine
RO: Reverse Osmosis
EDI: Electrodeionization

Notes:
1. Based on proposal data from Design Basis Document and Vendor proposals.
2. Low ambient conditions are -2 degrees F and 50% R.H.
3. Cooling tower blowdown is based on 8 COC.
4. Evaporative cooler is wetted media type, Evap Cooler Blowdown is based on 2 COC.
5. Evaporative cooler evaporation calculated from GE turbine Data.
6. The demineralization RO / EDI system reject is assumed to be 25%.
7. Cooling tower runs at night for 8 hours.

Summary Balance:

In Flow:	335,314 gpd
Out Flow:	335,314 gpd
Difference:	0

Units: All flows are in gallons per day

PRELIMINARY DESIGN

NOTES:

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC	LEAD DESIGNER	ENGINEER	PROJ ENGR MANAGER	PROJECT MANAGER
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		CH	HGE			MH

PRELIMINARY STATUS — LDE — DATE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — LDE — DATE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
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CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: C. HARTLINE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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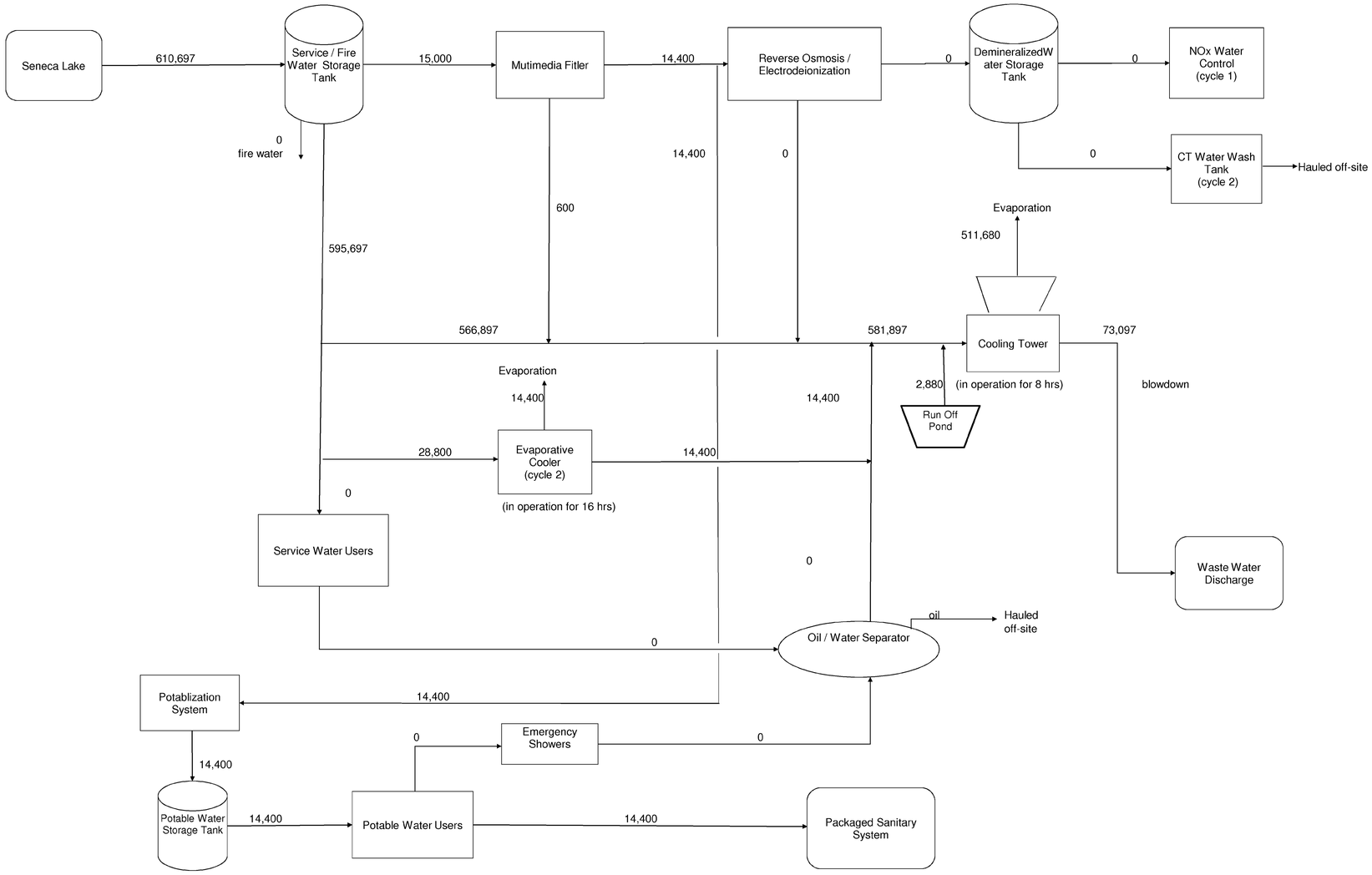
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NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PRELIMINARY WATER BALANCE
CYCLE 2
-2° F, 50% RH

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-021-305-008
REV: A

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Legend:
COC: Cycles of Concentration
CT: Combustion Turbine
RO: Reverse Osmosis
EDI: Electrodeionization

Notes:
1. Based on proposal data from Design Basis Document and Vendor proposals.
2. High ambient daytime conditions are 87 degrees F and 46% RH
3. Cooling tower blowdown is based on 8 COC.
4. Evaporative cooler is wetted media type, Evap Cooler Blowdown is based on 2 COC.
5. Evaporative cooler evaporation calculated from GE turbine Data.
6. The demineralization RO / EDI system reject is assumed to be 25%.
7. Cooling tower runs at night for 8 hours and evap. cooler for 16 hours.

Summary Balance:
In Flow: 613,577 gpd
Out Flow: 613,577 gpd
Difference: 0

Units: All flows are in gallons per day

PRELIMINARY DESIGN

NOTES:

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC.	LEAD DESIGNER	ENGINEER/ PROJ. ENGR.	PROJECT MANAGER
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		CH	HGE		MH

PRELIMINARY STATUS — DATE — LDE — REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE — REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

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CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: C. HARTLINE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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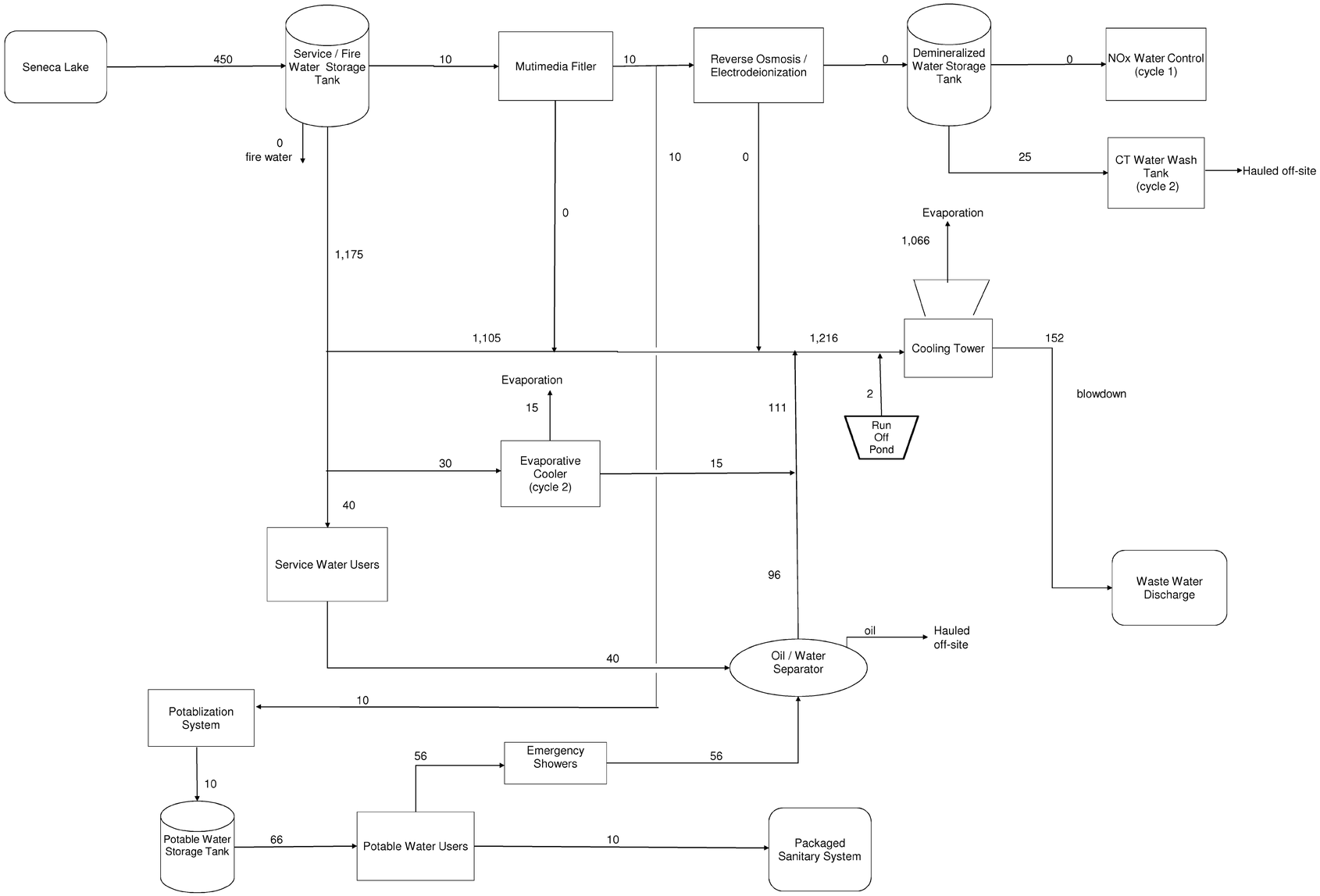
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CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PRELIMINARY WATER BALANCE
CYCLE 2
87° F, 46% RH

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-021-305-004
REV: A

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8/4/2011 11:48:17 AM



Legend:
COC: Cycles of Concentration
CT: Combustion Turbine
RO: Reverse Osmosis
EDI: Electrodeionization

Notes:
1. Based on proposal data from Design Basis Document and Vendor proposals.
2. High ambient conditions are 87 degrees F and 46% R.H.
3. Cooling tower blowdown is based on 8 COC.
4. Evaporative cooler is wetted media type, Evap Cooler Blowdown is based on 2 COC.
5. Evaporative cooler evaporation calculated from GE turbine Data.
6. The demineralization RO / EDI system reject is assumed to be 25%.
7. Maximum usage accounts for 2 additional service water hoses, employee shower use, emergency shower use, and CT wash water tanks use.
8. Lake Seneca supply pumps have a maximum flow rate of 450 gpm. Tank storage dampens flow to the tank.

Units: All flows are in gallons per minute

PRELIMINARY DESIGN

NOTES:

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH SPEC	LEAD DISCIPLINE ENGINEER	PROJ ENGR MANAGER	PROJECT MANAGER
A		ISSUED FOR REVIEW AND COMMENT	TAD	HGE		CH	HGE		MH

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APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

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CHECKED BY: H.G. EISENBISE	
LEAD DESIGNER:	
ENGINEER/TECH SPECIALIST: C. HARTLINE	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

PRELIMINARY WATER BALANCE
CYCLE 2
MAXIMUM USAGE

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-DW-021-305-002
REV: A

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NYSEG - SENECA COMPRESSED AIR ENERGY STORAGE PROJECT

Dresser Rand (Cycle 1) Generation and Compression Cycle Summary

Generation Cycle Data, 1 x 138 MW Air Expander

Item	Description	Max Generation	75% Load	50% Load	25% Load	10% Load	Remarks
1	Gross Power Output, kW	137,867	103,401	68,934	34,467	14,045	From Dresser Rand data dated 8/24/2011
2	Plant Auxiliary Power Requirements, kW	2,065	1,847	1,614	1,356	1,071	Incl. transformers, cooling tower, pumps, etc.
3	Net Power Output to Grid, kW	135,802	101,554	67,320	33,111	12,974	Power sent to grid.
4	Average Mass Flow Rate, lbs/hr	1,440,021	1,131,931	818,384	521,865	305,998	Between 1150 - 1500 psig Cavern pressure. Flowrate based on 92 deg F recuperator air inlet temperature.
5	Net Generation Specific Air Consumption, lbs/kW-hr	10.60	11.15	12.16	15.76	23.59	- Ditto -
6	Fuel Consumption HHV, MMBTU/hr	589	446	304	158	67	HHV/LHV Ratio = 1.109
7	Net Heat Rate, BTU/kW-hr - HHV	4,335	4,396	4,512	4,775	5,152	
8	Total Hours of Generation	12.36	15.73	21.75	34.11	58.17	Time until cavern is depleted for the given generation.
9	Net Energy Ratio @ 45 deg F Ambient	0.77	0.81	0.88	1.15	1.72	
10	Net Energy Ratio @ -2 deg F Ambient	0.72	0.76	0.83	1.08	1.61	
11	Net Energy Ratio @ 87 deg F Ambient	0.82	0.86	0.94	1.22	1.82	Based on 170 MW Compression
12	**Total Usable Air Storage in Cavern @ 1500 psig, lbs**	**17,800,000**					Usable air mass between 1500 and 1150 psig (125 to 85 deg F respectively).
13	Emissions (after control)						
	NOx, lbs/hr	4.66	3.69	2.69	1.73	1.14	From DR document StartupEmissions-10MinStart 5-25-11. Corrected to 2 ppmvd. 10% Load lbs/hr values estimated from 25% load values.
	NOx, lbs/MW-hr (Net)	0.034	0.036	0.040	0.052	0.088	
	CO_2, lbs/hr	73,715	55,877	37,962	19,696	9,153	From DR document, Gen Performance Tab. 5-20-2011. 10% Load lbs/hr values prorated from 25% load values.
	CO_2, lbs/MW-hr (Net)	543	550	564	595	705	
14	Additional Consumption Rates						
	19% Aqueous NH3, lbs/hr	290	228	166	106	69	2 ppmVd@15% O2 NOx at Stack, 5 ppm NH3 slip. NH3 lbs/hr values prorated from 25% load.
	19% Aqueous NH3, lbs/MW-hr	2.13	2.25	2.47	3.20	5.32	
	Demin Water, lbs/hr	10,127	7,677	5,224	2,718	0	From Dresser Rand data dated 8/24/2011
	Demin Water, lbs/MW-hr	74.57	75.60	77.59	82.09	0	

Compression Cycle Data

Item	Description	45 deg F, 60% RH		-2 deg F, 60% RH	87 deg F, 46% RH	Remarks
		110 MW Compression	170 MW Compression	170 MW Compression	170 MW Compression	
1	Compression Power, kW	110,000	168,202	168,000	168,000	From Dresser Rand Proposal, 1 x40%, 1 x 60% compressors
2	Plant Auxiliary Power Requirements, kW	2,033	2,890	2,683	3,303	Incl. transformers, cooling tower, pumps, etc.
3	Total Power Required, kW	112,033	171,092	170,683	171,303	Total power required from grid for compression cycle.
4	Average Mass Flow Rate, lbs/hr	1,549,296	2,350,656	2,499,552	2,217,600	Between 1150 - 1500 psig Cavern pressure. Flow adjusted for average and low ambient from 87 deg F ambient data.
5	Average Net Compression Specific Air Consumption, lbs/kW-hr	13.83	13.74	14.64	12.95	- Ditto -
6	Total Hours of Compression	11.49	7.57	7.12	8.03	Time required to bring cavern from 1150 to 1500 psig.

Notes:

1. Plant load percentage based on Max Generation as 100% Load Point.
2. Minimum air expander load is 10% for emission compliance based on Dresser Rand email dated 10/3/2011.
3. Compression flow rates estimated from 87 deg F ambient temperature data.
4. All generation data is valid for all ambient conditions unless specified otherwise, and a recuperator inlet air temperature of 92 deg F.

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NYSEG - SENECA COMPRESSED AIR ENERGY STORGE PROJECT

Dresser Rand (Cycle 1A-210 MW Option) Generation and Compression Cycle Summary

Generation Cycle Data, 2 x 105 MW Air Expander Trains (One HP and LP Expander per Train)

		DUAL TRAIN OPERATION					SINGLE TRAIN OPERATION			
Item	Description	Max Generation	75% Load	50% Load	25% Load	Min Load (16%)	50% Load	25% Load	Min Load (8%)	Remarks
1	Air Expander Power Output, each, kW	106,450	79,838	53,225	26,613	16,254	106,450	53,225	16,254	From Dresser Rand data dated 10/21/2011
2	Air Expanders Operating	2	2	2	2	2	1	1	1	
3	Gross Plant Power Output, kW	212,900	159,675	106,450	53,225	32,508	106,450	53,225	16,254	From Dresser Rand data dated 10/21/2011
4	Plant Auxiliary Power Requirements, kW	2,956	2,645	2,313	1,943	1,793	2,292	1,939	1,641	Incl. transformers, cooling tower, pumps, etc.
5	**Net Plant Power Output to Grid, kW**	**209,944**	**157,030**	**104,137**	**51,282**	**30,715**	104,158	51,286	14,613	Power sent to grid.
6	Total Average Mass Flow Rate, lbs/hr	2,226,295	1,757,543	1,321,896	856,923	633,613	1,113,148	660,948	316,807	Between 1150 - 1500 psig Cavern pressure. Flowrate based on 100 deg F recuperator inlet air temperature.
7	Net Generation Specific Air Consumption, lbs/kW-hr	10.60	11.19	12.69	16.71	20.63	11	13	22	- Ditto -
8	Total Fuel Consumption HHV, MMBTU/hr	919	699	475	241	153	459	238	76	HHV/LHV Ratio = 1.109
9	Net Heat Rate, BTU/kW-hr - HHV	4,376	4,450	4,565	4,692	4,968	4,410	4,635	5,221	
10	Total Hours of Generation	8.00	10.13	13.47	20.77	28.09	16	27	56	Time until cavern is depleted for the given generation.
11	Net Energy Ratio @ 45 deg F Ambient (1 x 170 MW Compressor)	0.75	0.79	0.90	1.18	1.45	1	1	2	
12	**Total Usable Air Storage in Cavern @ 1500 psig, lbs**	**17,800,000**								Usable air mass between 1500 and 1150 psig (125 to 85 deg F respectively).
13	Total Emissions (after control)									
	NOx, lbs/hr	7.30	5.76	4.32	2.79	2.16	4	2	1	From DR provided data
	NOx, lbs/MW-hr (Net)	0.035	0.037	0.042	0.054	0.070	0	0	0	Calculated
	CO_2, lbs/hr	108,860	82,799	56,335	28,514	18,082	54,430	28,167	9,041	Calculated, Assumed pure CH4, Fuel LHV: 20,949 BTU/lb
	CO_2, lbs/MW-hr (Net)	519	527	541	556	589	523	549	619	
14	Additional Consumption Rates									
	19% Aqueous NH3, lbs/hr	453	357	268	245	157	226	134	79	2 ppmVd@15% O2 NOx at Stack, 5 ppm NH3 slip. NH3 lbs/hr values provided by DR.
	19% Aqueous NH3, lbs/MW-hr	2.16	2.27	2.57	4.77	5.13	2	3	5	
	Demin Water, lbs/hr	15,444	11,750	8,179	0	0	7,534	3,900	0	From Dresser Rand data dated 10/21/2011
	Demin Water, lbs/MW-hr	73.56	74.83	78.54	0.00	0.00	72.33	76.04	0.00	

Compression Cycle Data

Item	Description	45 deg F, 60% RH, 170 MW Total Compression		Remarks
		2 x 50% Compressors	1 x 100% Compressor	
1	Number of Operating Compressors	2.00	1	
2	Compressor Size, each, kW	85000.00	170,000	Nominal Compressor(s) Size
3	Total Compression Power, kW	168000.00	168,300	From Dresser Rand Proposal
4	Plant Auxiliary Power Requirements, kW	2890.00	3,060	Incl. transformers, cooling tower, pumps, etc.
5	Total Power Required, kW	170890.00	171,360	Total power required from grid for compression cycle.
6	Total Average Mass Flow Rate, lbs/hr	2294756.00	2,430,000	Between 1150 - 1500 psig Cavern pressure.
7	Average Net Compression Specific Air Consumption, lbs/kW-hr	13.43	14.18	- Ditto -
8	Total Hours of Compression	7.76	7.33	Time required to bring cavern from 1150 to 1500 psig.

Notes:

1. Plant load percentage based on Max Generation as 100% Load Point.
2. Compression flow rates provided by Dresser Rand.
3. All generation data is valid for all ambient conditions unless specified otherwise, and a recuperator inlet air temperature of 100 deg F.
4. Min Load points are within emission compliance based on Dresser Rand email dated 10/3/2011.
5. All strikethrough data not updated from Rev A.

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Energy Storage and Power (Cycle 2) Generation and Compression Cycle Summary

Generation Cycle Data, 45 deg F, 60% RH

Item	Description	210 MW (100% Load)	75% Load	50% Load	25% Load	Remarks
1	Gross Power Output, kW	212,092	159,353	106,354	53,940	Data based on ESP Cycle parameters
2	Plant Auxiliary Power Requirements, kW	2,225	1,940	1,635	1,296	Incl. transformers, cooling tower, pumps, etc.
3	Net Power Output to Grid, kW	209,867	157,413	104,719	52,644	Power sent to grid.
4	Average Mass Flow Rate, lbs/hr	2,125,800	1,631,880	936,000	187,200	Between 1150 - 1500 psig Cavern pressure.
5	Net Generation Specific Air Consumption, lbs/kW-hr	10.13	10.37	8.94	3.56	- Ditto -
6	Fuel Consumption HHV, MMBTU/hr	895	699	647	647	HHV/LHV Ratio = 1.109
7	Net Heat Rate, BTU/kW-hr - HHV	4,267	4,439	6,181	12,294	
8	Total Hours of Generation	8.37	10.91	19.02	95.09	Time until cavern is depleted for the given generation.
9	Net Energy Ratio	0.74	0.75	0.65	0.26	Based on 170 MW Compression
10	**Total Usable Air Storage in Cavern @ 1500 psig, lbs**	**17,800,000**				Usable air mass between 1500 and 1150 psig (125 to 85 deg F respectively).
11	Emissions (after control)					
	NOx, lbs/hr	6.48	5.05	4.68	4.68	Calculated from GE provided emission rates.
	NOx, lbs/MW-hr (Net)	0.031	0.032	0.045	0.089	
	CO_2, lbs/hr	103,840	81,039	75,065	75,065	
	CO_2, lbs/MW-hr (Net)	495	515	717	1,426	
12	Additional Consumption Rates					
	19% Aqueous NH3, lbs/hr	90	70	65	65	Based on 2 ppmVd@15% O2 NOx at Stack
	19% Aqueous NH3, lbs/MW-hr	0.43	0.45	0.62	1.24	
	Demin Water, lbs/hr	0	0	0	0	N/A for CAES 2 Plant
	Demin Water, lbs/MW-hr	0.00	0.00	0.00	0.00	

Compression Cycle Data

Item	Description	145 MW Compression	170 MW Compression	Remarks
1	Compression Power, kW	145,000	168,000	From Man Turbo Proposal
2	Plant Auxiliary Power Requirements, kW	2,544	2,890	Incl. transformers, cooling tower, pumps, etc.
3	Total Power Required, kW	147,544	170,890	Total power required from grid for compression cycle.
4	Average Mass Flow Rate, lbs/hr	2,061,000	2,350,800	Between 1150 - 1500 psig Cavern pressure. Based on 45 deg F ambient air. Flow based on Man Turbo charts.
5	Average Net Compression Specific Air Consumption, lbs/kW-hr	13.97	13.76	- Ditto -
6	Total Hours of Compression	8.64	7.57	Time required to bring cavern from 1150 to 1500 psig.

Notes:

1. Plant load percentage based on 210 MW as 100% Load Point. Maximum theoretical net generation is 227 MW.
2. Minimum gas turbine load is 50% for emission compliance,
3. Operation of plant load below 40% may be undesirable due to the following reasons. Man Turbo needs to verify minimum feasible operating load.
   a. Both the gas/air temperatures across the recuperator increases significantly due to less heat extracted from gas turbine exhaust.
   b. The high gas side temperature may negatively impact the design, operation and life of the recuperator and catalysts.
4. All data is valid for 45 deg F ambient temperature and 60% RH
5. Data based on air expander inlet pressure of 1085 psia, and recuperator air inlet temperature of 100 deg F. Air expander assumed to operate on nozzle control.

NYSEG - SENECA COMPRESSED AIR ENERGY STORAGE PROJECT

Energy Storage and Power (Cycle 2) Generation and Compression Cycle Summary

Generation Cycle Data, 87 deg F, 46% RH

Item	Description	210 MW (100% Load)	75% Load	50% Load	25% Load	Remarks
1	Gross Power Output, kW	212,159	159,327	106,749	53,636	Data based on ESP Cycle parameters
2	Plant Auxiliary Power Requirements, kW	2,225	1,940	1,635	1,296	Incl. transformers, cooling tower, pumps, etc.
3	Net Power Output to Grid, kW	209,934	157,387	105,114	52,340	Power sent to grid.
4	Average Mass Flow Rate, lbs/hr	2,171,520	1,605,600	871,200	111,600	Between 1150 - 1500 psig Cavern pressure.
5	Net Generation Specific Air Consumption, lbs/kW-hr	10.34	10.20	8.29	2.13	- Ditto -
6	Fuel Consumption HHV, MMBTU/hr	872	687	672	672	HHV/LHV Ratio = 1.109
7	Net Heat Rate, BTU/kW-hr - HHV	4,152	4,368	6,390	12,832	
8	Total Hours of Generation	8.20	11.09	20.43	159.50	Time until cavern is depleted for the given generation.
9	Net Energy Ratio	0.78	0.77	0.63	0.16	Based on 170 MW Compression
10	**Total Usable Air Storage in Cavern @ 1500 psig, lbs**	**17,800,000**				Usable air mass between 1500 and 1150 psig (125 to 85 deg F respectively).
11	Emissions (after control)					
	NOx, lbs/hr	6.30	4.98	4.86	4.86	Calculated from GE provided emission rates.
	NOx, lbs/MW-hr (Net)	0.030	0.032	0.046	0.093	
	CO_2, lbs/hr	101,123	79,718	77,870	77,870	
	CO_2, lbs/MW-hr (Net)	482	507	741	1,488	
12	Additional Consumption Rates					
	19% Aqueous NH3, lbs/hr	88	69	68	68	Based on 2 ppmVd@15% O2 NOx at Stack
	19% Aqueous NH3, lbs/MW-hr	0.42	0.44	0.64	1.29	
	Demin Water, lbs/hr	0	0	0	0	N/A for CAES 2 Plant
	Demin Water, lbs/MW-hr	0.00	0.00	0.00	0.00	

Compression Cycle Data

Item	Description	145 MW Compression	170 MW Compression	Remarks
1	Compression Power, kW	145,000	168,000	From Man Turbo Proposal
2	Plant Auxiliary Power Requirements, kW	2,909	3,303	Incl. transformers, cooling tower, pumps, etc.
3	Total Power Required, kW	147,909	171,303	Total power required from grid for compression cycle.
4	Average Mass Flow Rate, lbs/hr	1,990,800	2,268,000	Between 1150 - 1500 psig Cavern pressure. Based on 87 deg F ambient air. Flow based on Man Turbo charts.
5	Average Net Compression Specific Air Consumption, lbs/kW-hr	13.46	13.24	- Ditto -
6	Total Hours of Compression	8.94	7.85	Time required to bring cavern from 1150 to 1500 psig.

Notes:

1. Plant load percentage based on 210 MW as 100% Load Point.
2. Minimum gas turbine load is 65% for emission compliance.
3. Operation of plant load below 40% may be undesirable due to the following reasons. Man Turbo needs to verify minimum feasible operating load.
   a. Both the gas/air temperatures across the recuperator increases significantly due to less heat extracted from gas turbine exhaust.
   b. The high gas side temperature may negatively impact the design, operation and life of the recuperator and catalysts.
4. All data is valid for 87 deg F ambient temperature and 46% RH
5. Data based on air expander inlet pressure of 1085 psia, and recuperator air inlet temperature of 100 deg F. Air expander assumed to operate on nozzle control.

NYSEG - SENECA COMPRESSED AIR ENERGY STORAGE PROJECT

Energy Storage and Power (Cycle 2) Generation and Compression Cycle Summary

Generation Cycle Data, -2 deg F, 50% RH

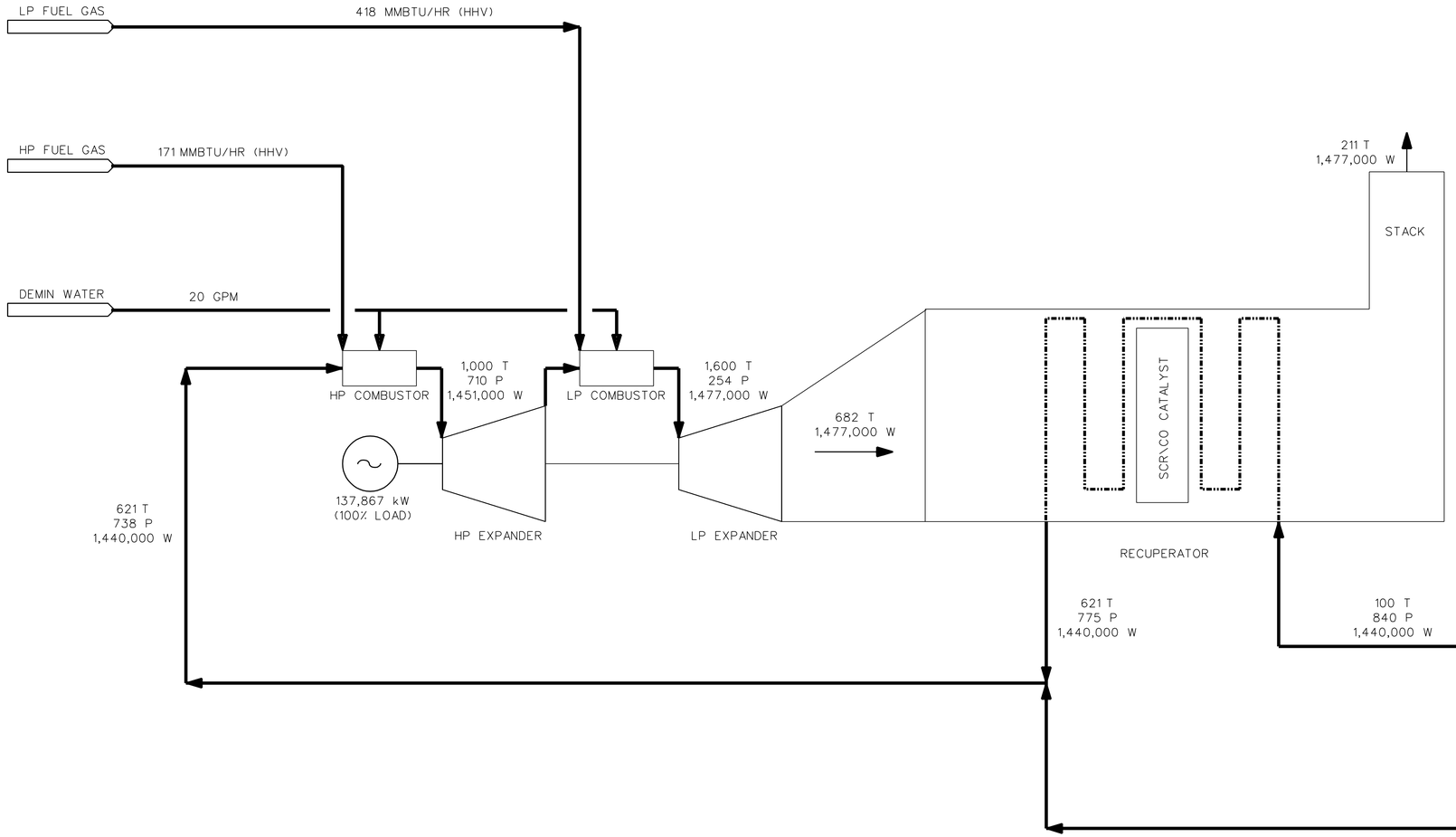
Item	Description	210 MW (100% Load)	75% Load	50% Load	25% Load	Remarks
1	Gross Power Output, kW	212,110	159,485	106,353	53,874	Data based on ESP Cycle parameters
2	Plant Auxiliary Power Requirements, kW	2,225	1,940	1,635	1,296	Incl. transformers, cooling tower, pumps, etc.
3	Net Power Output to Grid, kW	209,885	157,545	104,718	52,578	Power sent to grid.
4	Average Mass Flow Rate, lbs/hr	2,128,680	1,641,240	864,000	108,000	Between 1150 - 1500 psig Cavern pressure.
5	Net Generation Specific Air Consumption, lbs/kW-hr	10.14	10.42	8.25	2.05	- Ditto -
6	Fuel Consumption HHV, MMBTU/hr	920	719	704	704	HHV/LHV Ratio = 1.109
7	Net Heat Rate, BTU/kW-hr - HHV	4,383	4,564	6,722	13,388	
8	Total Hours of Generation	8.36	10.85	20.60	164.81	Time until cavern is depleted for the given generation.
9	Net Energy Ratio	0.70	0.72	0.57	0.14	Based on 170 MW Compression
10	**Total Usable Air Storage in Cavern @ 1500 psig, lbs**	**17,800,000**				Usable air mass between 1500 and 1150 psig (125 to 85 deg F respectively).
11	Emissions (after control)					
	NOx, lbs/hr	6.65	5.20	5.09	5.09	Calculated from GE provided emission rates.
	NOx, lbs/MW-hr (Net)	0.032	0.033	0.049	0.097	
	CO_2, lbs/hr	106,645	83,384	81,604	81,604	
	CO_2, lbs/MW-hr (Net)	508	529	779	1,552	
12	Additional Consumption Rates					
	19% Aqueous NH3, lbs/hr	93	73	71	71	Based on 2 ppmVd@15% O2 NOx at Stack
	19% Aqueous NH3, lbs/MW-hr	0.44	0.46	0.68	1.35	
	Demin Water, lbs/hr	0	0	0	0	N/A for CAES 2 Plant
	Demin Water, lbs/MW-hr	0.00	0.00	0.00	0.00	

Compression Cycle Data

Item	Description	145 MW Compression	170 MW Compression	Remarks
1	Compression Power, kW	145,000	168,000	From Man Turbo Proposal
2	Plant Auxiliary Power Requirements, kW	2,362	2,683	Incl. transformers, cooling tower, pumps, etc.
3	Total Power Required, kW	147,362	170,683	Total power required from grid for compression cycle.
4	Average Mass Flow Rate, lbs/hr	2,158,842	2,462,400	Between 1150 - 1500 psig Cavern pressure. Flow rate estimated from Man Turbo provided data.
5	Average Net Compression Specific Air Consumption, lbs/kW-hr	14.65	14.43	- Ditto -
6	Total Hours of Compression	8.25	7.23	Time required to bring cavern from 1150 to 1500 psig.

Notes:

1. Plant load percentage based on 210 MW as 100% Load Point.
2. Minimum gas turbine load is 50% for emission compliance.
3. Operation of plant load below 40% may be undesirable due to the following reasons. Man Turbo needs to verify minimum feasible operating load.
   a. Both the gas/air temperatures across the recuperator increases significantly due to less heat extracted from gas turbine exhaust.
   b. The high gas side temperature may negatively impact the design, operation and life of the recuperator and catalysts.
4. All data is valid for -2 deg F ambient temperature and 50% RH. Compression flow rates estimated from MDT data supplied for other ambient temperatures.
5. Data based on air expander inlet pressure of 1085 psia, and recuperator air inlet temperature of 100 deg F. Air expander assumed to operate on nozzle control.



NOTES:

1. FOR MORE PERFORMANCE DETAILS SEE CYCLE 1 PERFORMANCE SUMMARY (CAES-1-LI-021-0006).
2. HEAT BALANCE DIAGRAM ONLY. VALVES AND LINES SHOWN ARE NOT NECESSARILY INDICATIVE OF DESIGN.
3. AVERAGE RECUPERATOR AIR INLET TEMP ASSUMED IS 100°F.
4. NOT USED
5. PERFORMANCE IS BASED ON NEW AND CLEAN CONDITION.

LEGEND

T	TEMPERATURE, F
P	PRESSURE, PSIA
W	MASS FLOW, LBS/HR
KWe	POWER, KILOWATTS ELECTRICAL

SYSTEM PERFORMANCE SUMMARY

AMBIENT TEMPERATURE:	45° F
RELATIVE HUMIDITY:	60%
SITE ELEVATION:	1,000 FT
GROSS POWER:	137,867 KW
AUX POWER:	2,065 KW
NET POWER:	135,802 KW
NET HEAT RATE HHV:	4,335 BTU/KW-HR
NET SP. AIR CONSUMP.:	10.60 LBS/KW-HR

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER/ ENGINEER/ TECH. SPEC.	ENGINEER	PROJ. ENGR. MANAGER	PROJECT MANAGER
A	06 04 12	ISSUED FOR REVIEW AND COMMENT	JEV	KM	JEV	PMP	HGE		MH

PRELIMINARY STATUS — DATE — LDE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED 'HOLD' RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	PROFESSIONAL ENGINEER'S SEAL
DRAWN BY: JEV	
CHECKED BY: K. MUKHERJEE	
LEAD DESIGNER: J.E. VEEN	
ENGINEER/TECH SPECIALIST: P. PHIAMBOLIS	
PROJECT ENGINEERING MANAGER:	
PROJECT MANAGER: M. HOLDRIDGE	

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PE's _____ STATE: _____
LIC. NO.: _____ DATE: _____

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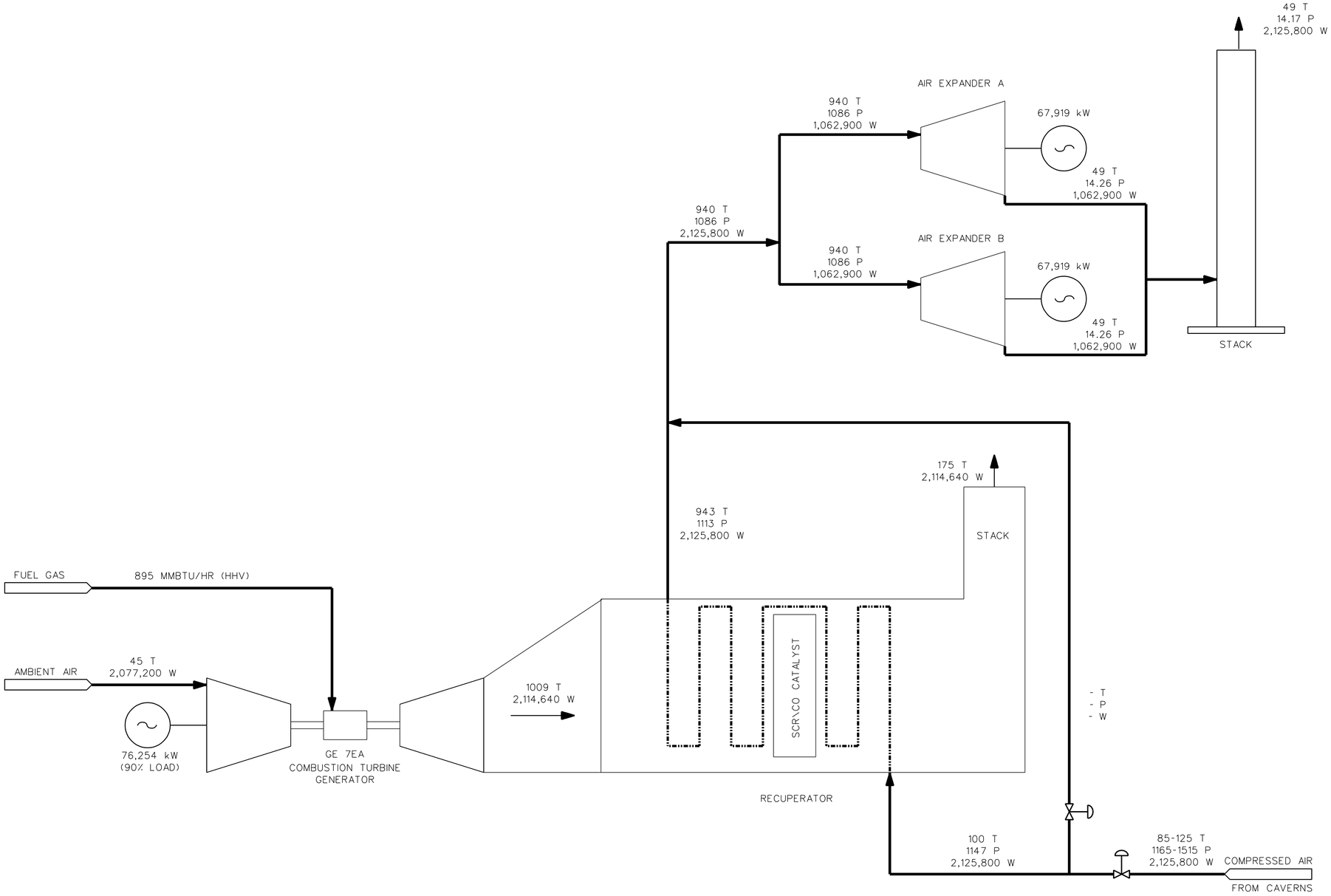
CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

HEAT AND MASS BALANCE DIAGRAM
CYCLE #1, AVERAGE AMBIENT OPERATION
45°F, 60% RH, 135 MW NET OUTPUT

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-HT-021-0159
REV: A

FOR HEAT AND MASS BALANCE PURPOSES ONLY

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NOTES:

1. FOR MORE PERFORMANCE DETAILS SEE CYCLE 2 PERFORMANCE SUMMARY (CAES-1-LI-021-0007).
2. HEAT BALANCE DIAGRAM ONLY. VALVES AND LINES SHOWN ARE NOT NECESSARILY INDICATIVE OF DESIGN.
3. AVERAGE RECUPERATOR AIR INLET TEMP ASSUMED IS 100°F.
4. CTG IS OPERATRED AT PART LOAD TO STAY WITHIN THE MAXIMUM GRID CAPACITY OF 210 MW.
5. PERFORMANCE IS BASED ON NEW AND CLEAN CONDITION.

LEGEND

T	TEMPERATURE, F
P	PRESSURE, PSIA
W	MASS FLOW, LBS/HR
KWe	POWER, KILOWATTS ELECTRICAL

SYSTEM PERFORMANCE SUMMARY

AMBIENT TEMPERATURE:	45° F
RELATIVE HUMIDITY:	60%
SITE ELEVATION:	1,000 FT
GROSS POWER:	212,092 KW
AUX POWER:	2,225 KW
NET POWER:	209,867 KW
NET HEAT RATE HHV:	4,267 BTU/KW-HR
NET SP. AIR CONSUMP.:	10.13 LBS/KW-HR

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	LEAD ENGINEER	PROJ. ENGR. MANAGER	PROJECT MANAGER
A	10.26.11	ISSUED FOR REVIEW AND COMMENT	TWB	KM		PMP	HGE		MH

PRELIMINARY STATUS — DATE — LDE — REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE — REPRESENTS REVIEWED AND APPROVED DESIGN, ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	
DRAWN BY	TWB
CHECKED BY	K. MUKHERJEE
LEAD DESIGNER	
ENGINEER/TECH SPECIALIST	P. PHIAMBOLIS
PROJECT ENGINEERING MANAGER	
PROJECT MANAGER	M. HOLDRIDGE

PROFESSIONAL ENGINEER'S SEAL

ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF
REV. ____ STATE ____
LIC. NO. ____ DATE ____

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CLIENT/PROJECT TITLE

NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

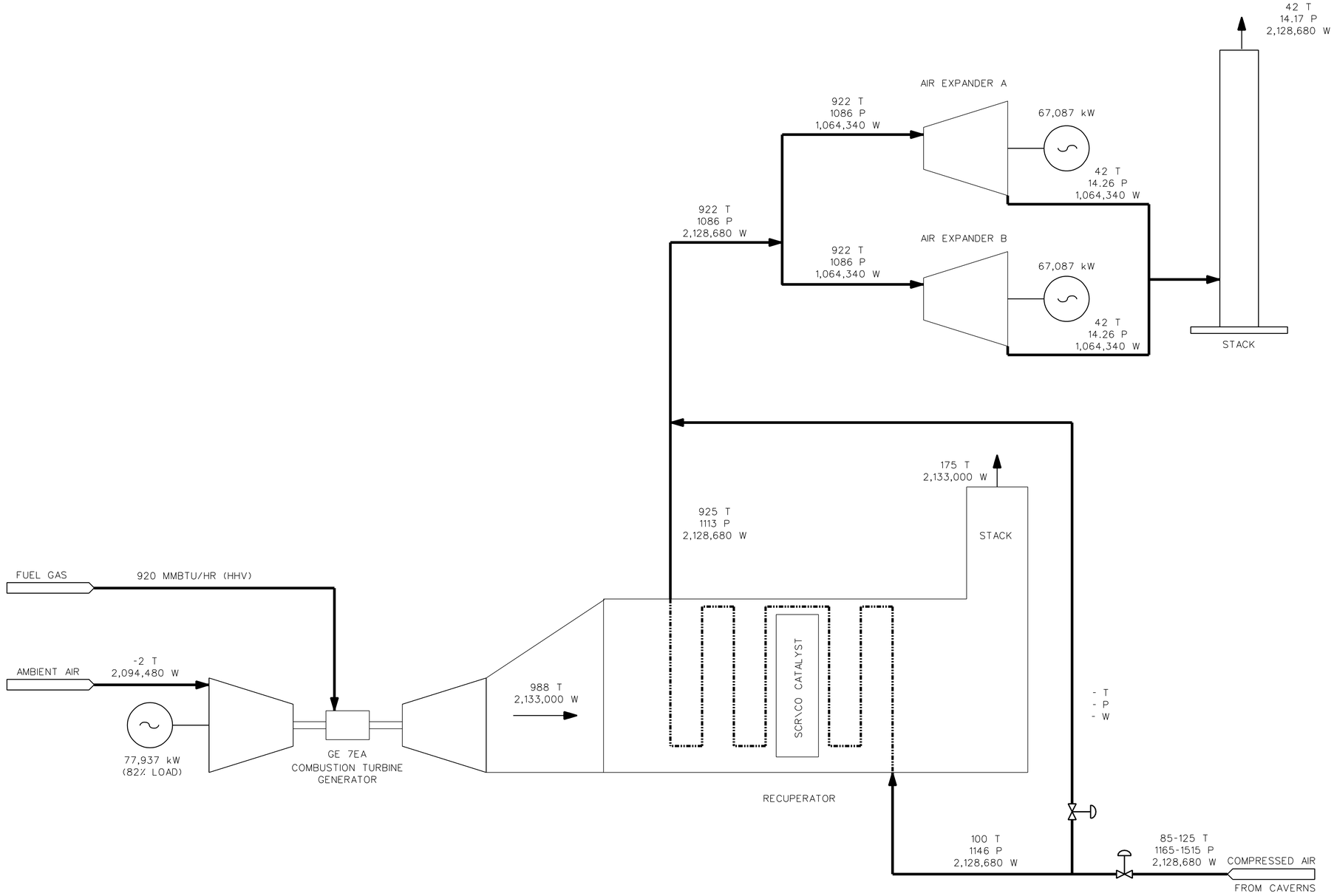
HEAT AND MASS BALANCE DIAGRAM
CYCLE #2, AVERAGE AMBIENT OPERATION
45°F, 60% RH, 210 MW NET OUTPUT

SCALE	DRAWING SIZE
NONE	ARCH D (36" x 24")

WORLEYPARSONS DWG. NO.	REV
CAES-1-HT-021-0259	A

FOR HEAT AND MASS BALANCE PURPOSES ONLY

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FOR HEAT AND MASS BALANCE PURPOSES ONLY

NOTES:

1. FOR MORE PERFORMANCE DETAILS SEE CYCLE 2 PERFORMANCE SUMMARY (CAES-1-LI-021-0007).
2. HEAT BALANCE DIAGRAM ONLY. VALVES AND LINES SHOWN ARE NOT NECESSARILY INDICATIVE OF DESIGN.
3. AVERAGE RECUPERATOR AIR INLET TEMP ASSUMED IS 100°F.
4. CTG IS OPERATRED AT PART LOAD TO STAY WITHIN THE MAXIMUM GRID CAPACITY OF 210 MW.
5. PERFORMANCE IS BASED ON NEW AND CLEAN CONDITION.

LEGEND

T	TEMPERATURE, F
P	PRESSURE, PSIA
W	MASS FLOW, LBS/HR
KWe	POWER, KILOWATTS ELECTRICAL

SYSTEM PERFORMANCE SUMMARY

AMBIENT TEMPERATURE:	-2° F
RELATIVE HUMIDITY:	50%
SITE ELEVATION:	1,000 FT
GROSS POWER:	212,110 KW
AUX POWER:	2,225 KW
NET POWER:	209,885 KW
NET HEAT RATE HHV:	4,383 BTU/KW-HR
NET SP. AIR CONSUMP.:	10.14 LBS/KW-HR

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	LEAD ENGINEER	PROJ. ENGR. MANAGER	PROJECT MANAGER
A	10.26.11	ISSUED FOR REVIEW AND COMMENT	TWB	KM		PMP	HGE		MH

PRELIMINARY STATUS — DATE — LDE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN, ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	
DRAWN BY	TWB
CHECKED BY	K. MUKHERJEE
LEAD DESIGNER	
ENGINEER/TECH SPECIALIST	P. PHIAMBOLIS
PROJECT ENGINEERING MANAGER	
PROJECT MANAGER	M. HOLDRIDGE

PROFESSIONAL ENGINEER'S SEAL

ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF
REV. ____ STATE ____
LIC. NO. ____ DATE ____

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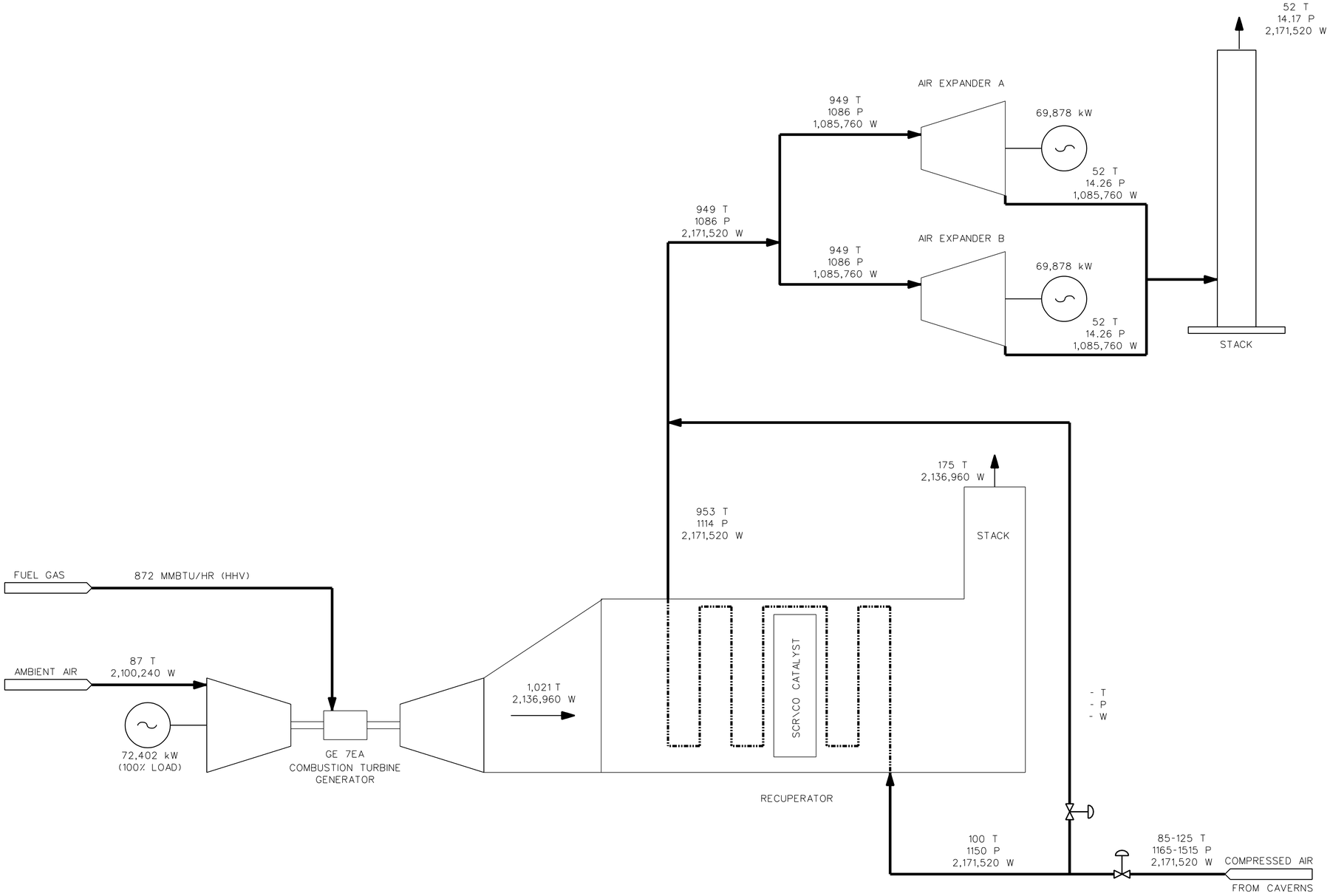
CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

HEAT AND MASS BALANCE DIAGRAM
CYCLE #2, LOW AMBIENT OPERATION
-2°F, 50% RH, 210 MW NET OUTPUT

SCALE	DRAWING SIZE
NONE	ARCH D (36" x 24")

WORLEYPARSONS DWG. NO.	REV
CAES-1-HT-021-0219	A

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FOR HEAT AND MASS BALANCE PURPOSES ONLY

NOTES:

1. FOR MORE PERFORMANCE DETAILS SEE CYCLE 2 PERFORMANCE SUMMARY (CAES-1-LI-021-0007).
2. HEAT BALANCE DIAGRAM ONLY. VALVES AND LINES SHOWN ARE NOT NECESSARILY INDICATIVE OF DESIGN.
3. AVERAGE RECUPERATOR AIR INLET TEMP ASSUMED IS 100°F.
4. CTG IS OPERATRED AT PART LOAD TO STAY WITHIN THE MAXIMUM GRID CAPACITY OF 210 MW.
5. PERFORMANCE IS BASED ON NEW AND CLEAN CONDITION.

LEGEND

T	TEMPERATURE, F
P	PRESSURE, PSIA
W	MASS FLOW, LBS/HR
KWe	POWER, KILOWATTS ELECTRICAL

SYSTEM PERFORMANCE SUMMARY

AMBIENT TEMPERATURE:	87° F
RELATIVE HUMIDITY:	46%
SITE ELEVATION:	1,000 FT
GROSS POWER:	212,159 KW
AUX POWER:	2,225 KW
NET POWER:	209,934 KW
NET HEAT RATE HHV:	4,152 BTU/KW-HR
NET SP. AIR CONSUMP.:	10.34 LBS/KW-HR

REV	DATE	DESCRIPTION	DRAWN	CHECKED	LEAD DESIGNER	ENGINEER/ TECH. SPEC.	LEAD ENGINEER	PROJ. ENGR. MANAGER	PROJECT MANAGER
A	10.26.11	ISSUED FOR REVIEW AND COMMENT	TWB	KM		PMP	HGE		MH

PRELIMINARY STATUS — DATE — LDE
REPRESENTS GENERAL DESIGN CONCEPTS BASED ON ASSUMPTIONS. REVIEWED NOT CHECKED.

APPROVED STATUS — DATE — LDE
REPRESENTS REVIEWED AND APPROVED DESIGN. ANY PORTION MARKED "HOLD" RETAINS PRELIMINARY STATUS.

ORIGINATING PERSONNEL	
DRAWN BY	TWB
CHECKED BY	K. MUKHERJEE
LEAD DESIGNER	
ENGINEER/TECH SPECIALIST	P. PHIAMBOLIS
PROJECT ENGINEERING MANAGER	
PROJECT MANAGER	M. HOLDRIDGE

PROFESSIONAL ENGINEER'S SEAL

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ORIGINALLY PREPARED UNDER THE RESPONSIBLE SUPERVISION OF
PEV _____ STATE _____
LIC. NO. _____ DATE _____

WorleyParsons
resources & energy

CLIENT/PROJECT TITLE
NYSEG
SENECA COMPRESSED AIR ENERGY STORAGE (CAES) PROJECT

HEAT AND MASS BALANCE DIAGRAM
CYCLE #2, HIGH AMBIENT OPERATION
87°F, 46% RH, 210 MW NET OUTPUT

SCALE: NONE
DRAWING SIZE: ARCH D (36" x 24")
WORLEYPARSONS DWG. NO.: CAES-1-HT-021-0299
REV: A

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Environmental Permits and Approvals Matrix - Working Draft
Seneca Compressed Air Energy Storage (CAES) Project in Reading, NY

Revision date: 12/01/2011

Lead Agency	Legislative Authority	Applicability	Type of Approval	Pre-Application Meeting Suggested by Agency	Estimated Agency Turn-Around Time	Review Fee (if applicable)	Notes
Federal							
U.S. Army Corps of Engineers (Corps)	Rivers & Harbors Act - Section 10, Navigable Waterways	Required when conducting work in, over, or under navigable waters of the United States. It is a detailed process that requires environmental surveys and may require mitigation. The construction and operation of the intake and discharge pipelines within Seneca Lake are applicable.	Standard individual permit, letter-of-permission, nationwide permit, or regional permit. The Corps will make the determination on what type of permit is needed. May qualify for Nationwide Permit # 7.	A pre-application meeting with the Corps is recommended to describe the project and present our preliminary determination of which elements may qualify for a Nationwide Permit (NWP), if any.	6-9 months	No fee	A Joint Application process with New York State Department of Environmental Conservation (NYSDEC) and the Corps is used in New York. A joint application form is to be completed and submitted to NYSDEC, who forwards a copy to the Corps. New Nationwide Permits are expected to be issued by the Corps in the next few months and may include a NWP A, which allows for up to 1/2 acre of impacts to Waters of the U.S. and may be applicable to the CAES Project.
	Clean Water Act - Section 404, Discharge of Dredge or Fill Materials	Required when discharging dredged materials or fill in wetlands and crossing navigable waters. It is a detailed process that requires environmental surveys and may require mitigation. The construction of the Plant within wetlands and installation of underground pipeline across streams are applicable.	Standard individual permit, letter-of-permission, nationwide permit, or regional permit. The Corps will make the determination on what type of permit is needed.	A pre-application meeting with the Corps is recommended to describe the project and present our preliminary determination of which elements may qualify for a Nationwide Permit, if any.	6-9 months	$100.00 upon approval	A Joint Application process with NYSDEC and the Corps is used in New York. A joint application form is to be completed and submitted to NYSDEC, who forwards a copy to the Corps. New Nationwide Permits are expected to be issued by the Corps in the next few months and may include a NWP A, which allows for up to 1/2 acre of impacts to Waters of the U.S. and may be applicable to the CAES Project.
U.S. Federal Aviation Administration	Code of Federal Regulations (CFR) Title 14, Aeronautics and Space, Part 77 Objects Affecting Navigable Airspace, §77.13 - Notice of Construction or Alteration	Required for the construction of any structure over 200 feet (can apply to shorter structures depending on the proximity to an airport). Preliminary design for CAES Plant indicates that Cycle 2 stack height to be 190 feet. (GEP stack height is 213) Likely that will need to file notice and then discuss with FAA extent of requirements.	File Form 7460-1 electronically and FAA will provide a determination and will specify lighting and marking requirements.	TBD	45 to 60 days	No Fee	The FAA Form 7460-1 should be submitted at least 30 days prior to initiation of construction. Application should be made to the FAA Eastern Regional Office Manager, Air Traffic Division, AEA-500 (Form 1 is also on-line). Following a favorable determination for stack location, FAA Form 7460-2 will need to be filed during construction once the stack reaches the maximum designed height.
U.S. Fish and Wildlife Service (USFWS)	Migratory Bird Treaty Act	Requires determination of no "taking" or harming of birds. CAES Project features are unlikely to result in taking or harming of birds; however, concurrence from USFWS is required.	Requires consultation with the agency.	Pre-application meeting is suggested.	TBD	TBD	Additional analysis will be required in Phase 2 of the Project to confirm no impacts to these resource areas, but based on the data provided by NYSDEC Natural Heritage Program and USFWS database, no adverse impacts are anticipated. USFWS must concur with this determination.
	Endangered Species Act, Section 7	Consultation on action that may jeopardize threatened & endangered (listed) species or adversely modify critical habitat. Based on preliminary review of USFWS database, no listed species would be adversely impacted; however, concurrence from USFWS is required.	Requires consultation with the agency.	Pre-application meeting is suggested.	TBD	TBD	Additional analysis will be required in Phase 2 of the Project to confirm no impacts to these resource areas, but based on the data provided by NYSDEC Natural Heritage Program and USFWS database, no adverse impacts are anticipated. USFWS must concur with this determination.
	Fish and Wildlife Coordination Act	Consultation when waters of any body of water are proposed or authorized, permitted or licensed to be impounded, diverted or otherwise controlled or modified under a Federal permit or license. If work across the tributaries to Seneca Lake are considered jurisdictional, then by-passing these streams temporarily during construction may be applicable.	Requires consultation with the agency.	Pre-application meeting is suggested.	TBD	TBD	Additional analysis will be required in Phase 2 of the Project to confirm no impacts to these resource areas, but based on the data provided by NYSDEC Natural Heritage Program and USFWS database, no adverse impacts are anticipated. USFWS must concur with this determination.
	Bald and Golden Eagle Protection Act	Requires determination of no "taking" or harming of birds. Project features are unlikely to result in taking or harming of bald and golden eagles; however, concurrence from USFWS is required.	Requires consultation with the agency.	Pre-application meeting is suggested.	TBD	TBD	Additional analysis will be required in Phase 2 of the Project to confirm no impacts to these resource areas, but based on the data provided by NYSDEC Natural Heritage Program and USFWS database, no adverse impacts are anticipated. USFWS must concur with this determination.

Lead Agency	Legislative Authority	Applicability	Type of Approval	Pre-Application Meeting Suggested by Agency	Estimated Agency Turn-Around Time	Review Fee (if applicable)	Notes
Advisory Council on Historic Preservation (ACHP)-Office of Federal Agency Programs	National Historic Preservation Act (NHPA), Section 106, 36 CFR Part 800, "Protecting Historic Properties"	The federal agency providing assistance or approvals for a proposed project is responsible for completing Section 106 reviews in consultation with appropriate State Historic Preservation Office (SHPO) and tribes.	Requires consultation between the appropriate agency and state and tribal officials	Section 106 requires each federal agency to identify and assess the effects of its actions on historic resources; the responsible federal agency must consult with appropriate state and local officials, Indian tribes, applicants for federal assistance, and members of the public.	30 days	No fee	As directed by NHPA, the ACHP serves as the primary federal policy advisor to the President and Congress; recommends administrative and legislative improvements for protecting our nation's heritage; advocates full consideration of historic values in federal decision-making; and reviews federal programs and policies to promote effectiveness, coordination, and consistency with national preservation policies. This federal agency typically delegates this consultation requirement to the appropriate state agency. May participate in controversial or precedent-setting situations.
Lead federal agency to be determined	National Environmental Policy Act (NEPA) Review Council of Environmental Quality 40 CFR Parts 1500-1508 42 USC 4321-4347	Major federal action (could include federal permitting, issuing regulations, making federal land management decisions, constructing publicly-owned facilities, or financing of an activity) that has the potential for significant impact on the human environment.	1) Categorical Exclusion, or 2) Environmental Assessment (EA), or 3) Environmental Impact Statement (EIS)	TBD	TBD based on whether an EA or an EIS is required.	No fee	NEPA requires federal agencies to integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions through the prescribed NEPA process. The need for a Corps Section 404/10 Permit and federal funding triggers the NEPA process. Further clarification is required to determine if Department of Energy NEPA process will satisfy NEPA requirements for the Corps' issuance of a Section 404/10 Permit.
U.S. Environmental Protection Agency	Clean Water Act - Section 402, National Pollutant Discharge Elimination System (NPDES) Permit	Regulates discharges of pollutants into waters of the United States. The discharge of cooling tower blowdown to Seneca Lake is applicable, as is the discharge of water from construction activities disturbing one acre or more.	New York State has delegated authority to implement the State Pollutant Discharge Elimination System (SPDES) permit for discharges to waters of the U.S. (see NYSDEC section below).	Not suggested	TBD	TBD	
	Clean Water Act Section 316(a) and 316(b), Thermal Discharges and Cooling Water Intake Structures (CWIS), respectively	Evaluation and design of cooling water discharge and intake facilities to manage, minimize and avoid adverse thermal impacts from cooling water discharges and fish impingement or entrainment from cooling water intakes. The intake structure may be applicable. Will make final applicability determination after CAES Project design has been finalized. Potential that water intake may not be regulated by US EPA but will be at discretion of NYSDEC.	TBD	TBD	TBD	TBD	Analysis will evaluate the adequacy of impingement and entrainment mitigation design. State equivalent requirements must be met.
	Title 40 CFR Parts 110 and 112 - Spill Prevention Control and Countermeasure (SPCC)	An SPCC Plan may be required for the project if certain triggers are met, including the capacity to store at least 1,320 gallons of oil-containing fluids aboveground counting only containers of oil with a capacity of 55 gallons or greater, or completely buried storage ca-pacity of the facility is greater than 42,000 gallons. The plan identifies spill prevention measures, spill response actions and procedures for timely notifications.	Approved Plan	Not suggested	TBD	No fee	The plan identifies spill prevention measures, spill response actions and procedures for timely notifications.
	40 CFR 52.21 Subpart A -Prevention of Significant Deterioration (PSD) of Air Quality	The requirements of this section apply to the construction of any new major stationary source (as defined in paragraph (b)(1) of this section) or any project at an existing major stationary source in an area designated as attainment or unclassifiable under Sections 107(d)(1)(A)(ii) or (iii) of the Act. CAES Project will trigger these requirements due to a potential to emit CO_2e in excess of the major source threshold of 100,000 TPY.	Air permit	Yes with NYSDEC	TBD	TBD	NYSDEC has been delegated authority to implement the federal PSD program.

Lead Agency	Legislative Authority	Applicability	Type of Approval	Pre-Application Meeting Suggested by Agency	Estimated Agency Turn-Around Time	Review Fee (if applicable)	Notes
	40 CFR 60 Subpart IIII, Standards Of Performance For Stationary Compression Ignition Internal Combustion Engines	Applies to manufacturers, owners, and operators of stationary compression ignition (CI) internal combustion engines (ICE). The diesel fire pump will be subject to this regulation.	Incorporated in an air permit	Yes as part of overall air permitting process	TBD	TBD	
	40 CFR 60, Subpart GG - Standards of Performance for Stationary Gas Turbines	Applies to stationary gas turbines with a heat input peak >10.7 gigajoules/hr (10 million Btu) based on the lower heating value of the fuel. Restricts emissions of NOx according to the formula provided. Restricts sulfur content of fuel to <0.8% by weight.	Incorporated in an air permit				40CFR Part 60 Subpart KKKK Stationary combustion turbines regulated under this subpart are exempt from the requirements of subpart GG of this part.
	40 CFR 60, Subpart IIII - Standards of Performance for Stationary Compression Ignition Internal Combustion Engines	Applies to manufacturers, owners, and operators of stationary compression ignition (CI) internal combustion engines (ICE)	Incorporated in an air permit	Yes as part of overall air permitting process	TBD	TBD	Facility will operate a diesel-fired fire water pump IC engine.
	40 CFR 60, Subpart JJJJ - Standards Of Performance For Stationary Spark Ignition Internal Combustion Engines	Applies to manufacturers, owners, and operators of stationary spark ignition (SI) internal combustion engines (ICE). The natural gas fired emergency generator will be subject to this regulation.	Incorporated in an air permit	Yes as part of overall air permitting process	TBD	TBD	
	40 CFR 60, Subpart KKKK - Standards Of Performance For Stationary Combustion Turbines	Applies to the owner or operator of a stationary combustion turbine with a heat input at peak load equal to or greater than 10.7 gigajoules (10 MMBtu) per hour, based on the higher heating value of the fuel, which commenced construction, modification, or reconstruction after February 18, 2005, The Cycle 2 combustion turbine will be subject to this regulation.	Incorporated in an air permit	Yes as part of overall air permitting process	TBD	TBD	
	40 CFR 63, Subpart YYYY - National Emission Standards for Hazardous Air Pollutants for Stationary Combustion Turbines	Applies to combustion turbine operations.	Incorporated in an air permit				The Facility will not be a major source of HAP
	40 CFR 63, Subpart ZZZZ - National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines (RICE)	Applies to RICE operations.	Incorporated in an air permit				Facility emergency generator/fire pump will be subject to 40 CFR 60 Subparts IIII and JJJJ.
	40 CFR 63, Subpart DDDDD - National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers and Process Heaters	Applies to industrial, commercial, and institutional boilers and process heaters located at major sources.	Incorporated in an air permit				The Facility will not be a major source of HAP
	40 CFR 63, Subpart JJJJJJ - National Emission Standards for Hazardous Air Pollutants for Industrial, Commercial, and Institutional Boilers Area Sources	Applies to industrial, commercial, and institutional boilers and process heaters located at non-major sources.	Incorporated in an air permit	Yes as part of overall air permitting process	TBD	TBD	
	40 CFR 64 - Compliance Assurance Monitoring (CAM)	Enhanced monitoring is required for emissions units subject to a National Emission Standards for Hazardous Air Pollutants (NESHAP), PSD, New Source Performance Standards (NSPS), and units with the Potential to Emit (PTE) 100% or more of the minimum potential emissions required for the source to be classified as a major source under Title V. This requirement will apply to NOx SCR system and CO oxidation catalyst.	Incorporated in an air permit	Yes as part of overall air permitting process	TBD	TBD	
New York State (NYS)							

Lead Agency	Legislative Authority	Applicability	Type of Approval	Pre-Application Meeting Suggested by Agency	Estimated Agency Turn-Around Time	Review Fee (if applicable)	Notes
New York State Department of Environmental Conservation (NYSDEC), Bureau of Water	Environmental Review process in New York State via State Environmental Quality Review Act (SEQR). [Statutory authority: Environmental Conservation Law Sections 3-0301(1)(b), 3-0301(2)(m) and 8-0113].	Most projects or activities proposed by a state agency or unit of local government, and all discretionary approvals (permits) from a NYS agency or unit of local government, require an environmental impact assessment. This process must be complete and the project deemed approvable through an Issuance of Findings Statement before State and Local permits can be issued. In general, any land use proposal requiring a permit from a local or state government, and requires discretion on the part of the permitting agency, is subject to SEQR. Based on recent legislation, the decision to undergo Environmental Review for the CAES Project may proceed under the Article X process rather than the SEQR Process for energy facility siting projects in the state (see New York State Public Service Commission section below).	Issuance of Findings Statement	NYSDEC strongly recommends a pre-application meeting for industrial projects.	The EIS could take between 2 to 9 months to review. Precedent-setting projects and permits often take longer.	TBD	The applicant must complete a "Full Environmental Assessment Form" as part of the application. More complex projects require an EIS. Any EIS could include: Project Site and Propose Activities, Environmental Baseline for various subject areas, Impact Assessment, Construction Management and Environmental Monitoring, Environmental Restoration, Operations, Maintenance, and Decommissioning descriptions, and an Alternatives Analysis. The SEQR information should be submitted to all involved agencies as it is the responsibility of the local, county and state government to ensure that its decisions are consistent with the SEQR requirements.
	Protection of Waters - Section 401 Water Quality Certification/ Stream Protection Permits	Discharge of Dredged or Fill Materials; Modification or disturbance of stream beds. Applicants for a Federal license or permit for activities (including but not limited to the construction or operation of facilities that may result in any discharge into waters of the United States) are required to apply for and obtain a Water Quality Certification from NYSDEC indicating that the proposed activity will not violate water quality standards.	Water Quality Certification	NYSDEC strongly recommends a pre-application meeting for industrial projects.	The review period is between 45 to 90 days and a public hearing may be required.	TBD	*Minor* Water Quality Certification projects include those projects which will not exceed the Minor project thresholds for Protection of Waters Permits, Freshwater Wetlands Permits or Tidal Wetlands Permits, and which do not involve the approval of construction and operation of hydroelectric generating facilities. All other projects are *Major*. The water quality certification is a prerequisite to permit review. Water Quality Certification applications are directed to NYSDEC - Division of Regulatory Affairs.
	EPA's Phase II Stormwater Rules; NYSDEC GP-02-01 requires Spill Prevention, Control and Countermeasure Plan (SPCC), State Pollutant Discharge Elimination System (SPDES) Permit including a Stormwater Pollution Prevention Plan (SWPPP)	Required for construction or use of an outlet or discharge pipe (point sources) of wastewater discharging into the surface waters) or ground water of the State.	General Permit (GP-02-01) for Stormwater Discharges from Construction Activities	NYSDEC strongly recommends a pre-application meeting for industrial projects.	TBD	TBD	
	Environmental Conservation Law (ECL) Article 11 - Endangered Species	Provide review and evaluation of these potential impacts and make recommendations to the lead agency regarding suitability of the project.	Article 11 Permit	NYSDEC strongly recommends an Article 11 pre-application meeting for industrial projects.	TBD	TBD	
	ECL Article 15 - Protection of Waters Permit - Freshwater Wetland Permit	Almost any activity which may adversely impact the natural values of wetlands or their adjacent areas (within 100 feet of the wetland boundary as designated on the official NYSDEC freshwater wetlands map or as determined through site inspection) is regulated. Typically the wetland must be 12.4 acres or greater to be regulated under this program. Smaller wetlands can be regulated if certain criteria are met. The wetlands to be disturbed within the CAES Project site have the potential to, but are not anticipated to, be regulated as state freshwater wetlands.	Article 15 Permit	NYSDEC strongly recommends an Article 15 pre-application meeting for industrial projects.	Uniform Procedures Act (UPA): A completeness determination from NYSDEC is typically made within 15 days from submittal. Minor projects have a 45-day review while major projects can take up to 90 days (without public hearing) and up to 60 days after the close of a public hearing (if necessary).*	TBD	Applications should be made to the NYSDEC - Division of Regulatory Affairs. One Article 15 Permit will be issued for all activity categories under this regulation.

Lead Agency	Legislative Authority	Applicability	Type of Approval	Pre-Application Meeting Suggested by Agency	Estimated Agency Turn-Around Time	Review Fee (if applicable)	Notes
	ECL Article 15 - Protection of Waters Permit - Excavation or Placement of Fill in Navigable Waters and their Adjacent and Contiguous Wetlands	A Protection Of Waters Permit is required for excavating or placing fill in navigable waters of the state, below the mean high water level, including adjacent and contiguous marshes and wetlands. Installation of the intake and discharge pipelines in Seneca Lake are applicable.	Article 15 Permit	NYSDEC strongly recommends an Article 15 pre-application meeting for industrial projects.	See above for UPA summary.	TBD	
	ECL Article 15 - Protection of Waters Permit - Major Construction, Reconstruction or Expansion of Docking and Mooring Facilities.	A Protection Of Waters Permit is required for constructing, reconstructing, or repairing docks or platforms and installing moorings on, in or above navigable waters to create docking facilities, mooring areas or to facilitate other activities. If any such facilities are intended for Seneca Lake, they would be applicable.	Article 15 Permit	NYSDEC strongly recommends an Article 15 pre-application meeting for industrial projects.	See above for UPA summary.	TBD	
	ECL Article 15 - Stream Bed or Bank Disturbance Permit	Required in any stream with a Class C(T) water quality classification and up for any activity that will affect drainage swales or water quality by disturbance of stream bed or bank. This permit would be required if the utility lines or underground pipelines will disturb stream beds or banks along the portion of any qualifying Seneca Lake tributaries in the Project area. [Clarification will be required from NYSDEC regarding the portion of the tributaries that will be affected and their water quality classifications.]	Article 15 Permit	NYSDEC strongly recommends an Article 15 pre-application meeting for industrial projects.	See above for UPA summary.	TBD	
	ECL Article 11 - Part 182, Fish and Wildlife	Although the Phase 1 review of the USFWS data and response from NYSDEC Natural Heritage Program indicated no listed species anticipated to be present in the Project area, additional consultation may be required regarding the waterfowl winter concentration area.	Article 11 Permit	NYSDEC strongly recommends an Article 11 pre-application meeting for industrial projects.	See above for UPA summary.	TBD	Additional analysis will be required in Phase 2 of the Project to confirm the specific species associated with the waterfowl winter concentration area and whether the Project will affect those species. Even if no Article 11 permit is required, additional consultation with NYSDEC is required for the waterfowl winter concentration area.
	ECL Article 17 - Titles 7 and 8 and Article 70	Construction projects that result in soil disturbances of at least one or more acres. Construction of the multiple CAES Project features will exceed the one-acre threshold and are applicable.	SPDES General Permit for Stormwater Discharges from Construction Activity. Permit No. GP-0-10-001.	Not suggested	Five business days from the date NYSDEC receives a complete Notice of Intent.	$100 per acre disturbed.	The General Permit will be effective five business days from the date NYSDEC receives a complete Notice of Intent for construction activities and a SWPPP has been prepared in conformance with specific technical standards identified by NYSDEC.
	EPA's Phase II Stormwater Rules; Article 17, Title 8, ECL (6 NYCRR Part 750).	Construction disturbing one acre or more requires a SPDES General Permit for Stormwater Discharges from Construction Activity.	SPDES General Permit for Stormwater Discharges from Construction Activity: GP-0-10-001	Not suggested	General permits for construction are authorized within 5 days of submission of a Notice of Intent.	TBD	NYSDEC GP-0-10-001 for construction activity requires the preparation of a Stormwater Pollution Prevention Plan (SWPPP) in accordance with NYS technical standards prior to submitting a Notice of Intent.
	ECL Article 3, Title 3; Article 15; Article 17, Titles 3, 5, 7, 8; Article 21; Article 70, Title 1; Article 71, Title 19. New York State Penal Code, Articles 175 and 210. Public Health Law, Section 502.	Discharges to waters must reasonably protect classified water use and assure compliance with applicable water quality standards. The Cooling Tower Blowdown discharge will be subject to these requirements.	Individual SPDES Permit for Discharges to Surface Waters.	NYSDEC strongly recommends a pre-application meeting for industrial projects.	TBD	TBD	
New York State Department of Environmental Conservation (NYSDEC), Division of Air Resources	6 NYCRR 201 - Air Resources - Permits and Registrations	This Part applies throughout New York State. Owners and/or operators of major stationary sources subject to Subpart 201-6 of this Part must obtain a Title V facility permit.	Incorporated in an air permit	Yes as part of overall air permitting process	TBD	TBD	
	6 NYCRR 201-8 - Air Resources - General Permits	This Subpart is intended to implement the provisions of ECL 19-0311 that provides for the issuance of general permits covering numerous similar emission sources or source categories for purposes of complying with Title V of the Act or to augment other permitting requirements under this Part.	General Permits				

Lead Agency	Legislative Authority	Applicability	Type of Approval	Pre-Application Meeting Suggested by Agency	Estimated Agency Turn-Around Time	Review Fee (if applicable)	Notes
	6 NYCRR 211 - Air Resources - General Prohibitions	General prohibition against air pollution and visible air emissions.	General Prohibitions				
	6 NYCRR 212 - Air Resources - General Process Emission Sources	Regulation establishes permissible emission rates for industrial processes based on environmental rating issued by the commissioner. The CAES Project would not be subject to this regulation because it is a combustion installation, a source category that is exempt under 6 NYCRR 212.	NA				
	6 NYCRR 225 - Air Resources - Fuel Composition And Use	Requirements related to fuel composition and use for sulfur limitations, waste fuel, gasoline, and diesel fuel. Diesel fuel for the fire pump will be subject to this regulation.	Incorporated in an air permit	Yes as part of overall air permitting process	TBD	TBD	
	6 NYCRR 226 - Air Resources - Solvent Metal Cleaning Processes	Applies to facilities engaging in the process of cleaning soils from metal surfaces by using a volatile organic compound (Solvent Metal Cleaning). The facility will be subject to this part if it operates a cold cleaning degreaser with an open surface area of greater than 11 square feet and an internal volume of greater than 93 gallons or, has an organic solvent loss of greater than 3 gallons per days.	Incorporated in an air permit	Yes as part of overall air permitting process	TBD	TBD	
	6 NYCRR 231 - Air Resources - New Source Review For New And Modified Facilities	Applies to projects in which there is a threshold increase in annual actual emissions from an air contamination source project above the de minimis emission limits found in section 231-1.9 of this Subpart. The purpose of this Part is to establish the new source review (NSR) preconstruction, construction and operation requirements for new and modified facilities in a manner which furthers the policy and objectives of Article 19 of the Environmental Conservation Law, and meets the plan requirements for nonattainment areas (Part D) and PSD of air quality (Part C) of subchapter I of the act.	Incorporated in an air permit	Yes as part of overall air permitting process	TBD	TBD	The Facility will be major for CO2e and PM, PM10, and PM2.5.
	6 NYCRR 257 - Air Resources - Air Quality Standards	Compliance with Air Quality Standards must be demonstrated. Air quality modeling will be required to demonstrate compliance	Incorporated in an air permit	Yes as part of overall air permitting process	TBD	TBD	
	6 NYCRR 257-7 - Air Resources - Air Quality Standards - Nitrogen Dioxide (NO_2)	The objective of this Subpart is the attainment of the annual average which, with an adequate safety margin, will provide for protection of public health and will protect against known and anticipated adverse effects on public welfare. During any 12 consecutive months, the annual average of the 24-hour concentrations, shall not exceed 0.05 ppm (100 $\mu g/m^3$) in all levels. This project may need to demonstrate compliance with this standard through dispersion modeling.	Incorporated in an air permit	Yes as part of overall air permitting process	TBD	TBD	
	NYSDEC Policy DAR-1 - Guidelines for the Control of Toxic Ambient Air Contaminants Air Guide 1	This policy provides guidance for the control of toxic ambient air contaminants in New York State and outlines the procedures for evaluating sources of air pollution for those chemical contaminants directly addressed by New York State or federal regulations and those for which no State or federal ambient air quality standards exist.	Incorporated in an air permit	Yes as part of overall air permitting process	TBD	TBD	
New York State Office of Parks, Recreation, and Historic Preservation (OPRHP)	Section 106 of the National Historic Preservation Act of 1966 (NHPA), 36 CFR Part 800, Protection of Historic Properties AND Section 14.09 of the New York State Historic Preservation Act	Federal undertaking and/or requiring federal funding, licensing, and/or permitting. Should be applicable only if federal involvement is required. Environmental reviews undertaken by the Field Services Bureau relate only to Historic/Cultural resources and do not include potential environmental impacts to New York State Parkland near the project. Such impacts must be considered as part of the environmental review of the project pursuant to the State Environmental Quality Review Act (New York Environmental Conservation Law Article 8) and its implementing regulations (6 NYCRR Part 617).	Section 106 Consultation, NEPA compliance, and/or consultation through SEQR.	Need for consultation will be determined following submittal of ERM's Phase 1A report to the SHPO.	30 days for the initial review and finding for the Project. Resolving adverse effect findings and signing a Memorandum of Agreement can be a lengthy process.	No fee--if tribal consultation is required (Section 106), tribal review fees may apply	Section 106 requires every agency (federal, state, local) to "take into account" how its undertakings (construction, rehabilitation/repair projects, demolition, licenses, permits, loans, grants, etc.) could affect historic properties. The SHPO advises local communities on local preservation environmental reviews, upon request, under the provisions of the State Environmental Quality Review Act.

Lead Agency	Legislative Authority	Applicability	Type of Approval	Pre-Application Meeting Suggested by Agency	Estimated Agency Turn-Around Time	Review Fee (if applicable)	Notes
New York State Public Service Commission (NYSPSC)	Article X - Board on Electric Generation Siting and the Environment	If regulations are promulgated in time to allow the CAES Project to utilize this program, the program will replace the NYSDEC SEQR process described above. Article X requires an environmental and public health impact analysis, studies regarding environmental justice and public safety, and consideration of local laws. Applicants will also provide funding for both the pre-application and application phases. Funding to be used to help intervenors (affected municipalities and other parties) hire experts to participate in the review of the application and for legal fees (but not for judicial challenges). Requires a utility security plan reviewed by Homeland Security and, for New York City (NYC) plants, NYC's emergency management office. Provides for appointment of ad hoc public members of the Siting Board from the municipality where the facility is proposed to be sited. Requires a public information coordinator within the Department of Public Service to "assist and advise interested parties and members of the public" in participating in the siting process. Required for the construction and operation a major electric generating facility 25 megawatts or more.	Certificate of Public Convenience and Necessity	Yes	TBD	TBD	If the Article X process is completed, no other state environmental review is required. However compliance with each of the applicable rules is still required. The Article X environmental review process is as comprehensive as the SEQR process. There is a coordinated effort between NYSDEC and the PSC to ensure that the EIS covers the needs of both regulatory agencies (try to minimize duplication).
New York State Office of General Services (NYSOGS)	License/Lease of NY State Owned Submerged Lands - NY State Assembly Law Public Lands Law, Article 6, Section 75 (NYCRR, Title 9, Subtitle G, Chapter 2 Part 270)	For use of Lands Underwater: Grants, Easements, Leases, Permits. If Seneca Lake is owned by New York State, then the installation, operation, and maintenance of the intake structure and associated pipelines would be applicable. Applicability to be determined.	Lease or license for "Lesser Interest in Lands Underwater"	A pre-application meeting is strongly recommended.	No license or lease can be issued until all other permits are issued. The process can take 2 to 3 months to complete.	The cost of the lease will need to be negotiated with the NYSOGS.	Issued for a period of up to 40 years. If no pre-application meeting is held, NYSOGS requests that a copy of the Joint Permit Application be submitted to them. Applicability yet to be determined.
	Easement for use of NY State Owned Submerged Lands - NY State Assembly Law Public Lands Law, Article 2, Sub 3, Sub 2 (NYCRR, Title 9, Subtitle G, Chapter 2, Part 271)	An easement must be obtained for Lands Underwater for Cables, Conduits, Pipelines, Hydroelectric Power - A 30-foot width easement is the minimum width approved. If Seneca Lake is owned by New York State, then the installation, operation, and maintenance of the intake structure and associated pipelines would be applicable. Applicability to be determined.	Easement for underwater intake structure and associated pipelines	TBD	The process can take 2 to 3 months to complete.	TBD	Issued for a period of 25 years. Applicability yet to be determined.
New York State Department of Transportation (NYSDOT)	Highway Work Permit for Utility Work	Allow construction within the right-of-way of a state highway including the installation and maintenance of utilities.	Permit	TBD	Review is completed within 10 days of the receipt of a complete application.	Calculated based on project specific information (e.g., activity type and distance (feet) of disturbance).	Application made to the NYS Department of Transportation.
Local							
Typical County/Local Permits/Approvals	Land Use Law for the Town of Reading	Projects to include greater than 15,000 square feet of area, and Project elements near Seneca Lake exceed the 'Site Plan Only' review option and trigger the need for a Special Permit.	Special Permit	A pre-application meeting is suggested to determine if the project elements proposed along the shore of and within Seneca Lake will be permitable, or will require a variance process (which is not provided for in the Land Use Law).	TBD	TBD	

Lead Agency	Legislative Authority	Applicability	Type of Approval	Pre-Application Meeting Suggested by Agency	Estimated Agency Turn-Around Time	Review Fee (if applicable)	Notes
	Building Permit	Required to begin the removal, erection, construction, placement, enlargement, improvement, alteration or demolition of any building or structure; or installation of heating, ventilating and air conditioning, plumbing or electrical equipment.	Permit	TBD	TBD	TBD	The time between application and issuance of a building permit varies by municipality. Applications are to be made to the code enforcement officer or municipal building inspector.
	Flood Hazard Area Permit	Required for the construction of any structure within areas classified by the Federal Emergency Management Agency (FEMA) as being in a flood hazard area (within the 100-year floodplain). As of the time of this review, no 100-year flood plains are mapped by FEMA in the Town of Reading.	Permit	TBD	TBD	TBD	
	Site Plan Review	Site plan reviews are required to review the layout and design of a development site. It is completed to insure that the development is in harmony with the character of the area in which it is located and that important resources will be protected and to ensure compliance with local zoning and subdivision ordinances.	Review and recommendation	TBD	TBD	TBD	
	General Municipal Law 239 Review	If a special use permit, approval of site plans, granting of use or area variances or other authorizations which a referring body may issue under the provisions of any zoning ordinance or local law, and such a permit is within 500 feet of the boundary of any city, village or town, or the boundary of any existing or proposed county or state park or any other recreation area, or the right-of-way of any existing or proposed county or state parkway, thruway, expressway, road or highway; or the existing or proposed right-of-way of any stream or drainage channel owned by the county or for which the county has established channel lines; or the existing or proposed boundary of any county or state owned land on which a public building or institution is situated; or the boundary of a farm operation located in an agricultural district, defined by Article 25-AA of the Agriculture and Markets Law, (except for area variances), then the approvable action must be submitted for review.	Review and recommendation	TBD	30 days from receipt of full statement of proposed action.	TBD	This review brings intermunicipal or county-wide concerns to the municipality before it takes action on an application. Application should be made to the county planning commission 30 days prior to the action by the local board so that Schuyler County Planning Commission can make a recommendation for consideration by the local board. Any new projects of significant size require approval from the Community Development and Natural Resources Committee of the Schuyler County Legislature.
	Driveway Access Permit	Required to join a driveway to a county road. The installation of the substation driveway off County Route 28 is applicable. This requirement may also apply to driveway to the CAES Plant.	Permit	TBD	TBD	No fee	The applicant must stake out the driveway. It will be inspected by the county within 10 days of application to determine if it is in a safe location and if a culvert is required. If a culvert is required it must be purchased from the county. A crew will deliver and install the culvert with no charge. Application should be made to the Schuyler County Department of Public Works.
	Permit for Construction in a County Highway Right-of-Way	Allows construction in a county highway ROW /easement. Installation of the overhead power lines across County Route 28 is applicable.	Permit	TBD	TBD	No fee	Application must be made at least 30 days prior to the start of construction at the Schuyler County Department of Public Works.
Preservation League of New York State	NHPA/SEQR consulting party potential	If an easement exists on a historic property, applicant should go through correct process to abide by easement owner's wishes/objections on a property or land.	Non-profit preservation organization that may hold easements	Need for consultation will be determined following submittal of ERM's Phase 1A report to the SHPO.	TBD	TBD	Refer to ERM's Phase 1A Cultural Resources report prepared in anticipation of submittal to the New York State Historic Preservation Office (NYSHPO). This report recommended additional investigations to be conducted under Phase 1B. The response from SHPO on this report will direct the need for further consultation and investigation of architectural and archaeological resources.

Lead Agency	Legislative Authority	Applicability	Type of Approval	Pre-Application Meeting Suggested by Agency	Estimated Agency Turn-Around Time	Review Fee (if applicable)	Notes
The Landmark Society of Western New York	NHPA/SEQR consulting party potential	If an easement exists on a historic property, applicant should go through correct process to abide by easement owner's wishes/objections on a property or land.	Non-profit preservation organization that may hold easements	Need for consultation will be determined following submittal of ERM's Phase 1A report to the SHPO.	TBD	TBD	Refer to ERM's Phase 1A Cultural Resources report prepared in anticipation of submittal to the NYSHPO. This report recommended additional investigations to be conducted under Phase 1B. The response from SHPO on this report will direct the need for further consultation and investigation of architectural and archaeological resources.
Schuyler County, NY	NHPA/SEQR consulting party potential	If NHPA or SEQR apply	Input on historic properties	Need for consultation will be determined following submittal of ERM's Phase 1A report to the SHPO.	TBD	TBD	Refer to ERM's Phase 1A Cultural Resources report prepared in anticipation of submittal to the NYSHPO. This report recommended additional investigations to be conducted under Phase 1B. The response from SHPO on this report will direct the need for further consultation and investigation of architectural and archaeological resources.
Town of Reading, NY	NHPA/SEQR consulting party potential	If NHPA or SEQR apply	Input on historic properties	Need for consultation will be determined following submittal of ERM's Phase 1A report to the SHPO.	TBD	TBD	Refer to ERM's Phase 1A Cultural Resources report prepared in anticipation of submittal to the NYSHPO. This report recommended additional investigations to be conducted under Phase 1B. The response from SHPO on this report will direct the need for further consultation and investigation of architectural and archaeological resources.
Tribal Governments							
Tribal Consultation	NHPA tribal consultation requirement, SEQR consulting party	Tribal Consultation for Federally recognized and State recognized tribes	Consultation required under Section 106 and NEPA process	Need for consultation will be determined following submittal of ERM's Phase 1A report to the SHPO.	TBD	Review Fee (if applicable)	Refer to ERM's Phase 1A Cultural Resources report prepared in anticipation of submittal to the NYSHPO. This report recommended additional investigations to be conducted under Phase 1B. The response from SHPO on this report will direct the need for further consultation and investigation of architectural and archaeological resources. Note that at least two Indian Nations (Seneca and Cayuga) have interest in the CAES Project vicinity.

* Minor Projects - NYSDEC must make a permit decision on minor projects within 45 days of determining the application complete. Major Projects - 1. If no hearing is held, NYSDEC makes its final decision on the application within 90 days of its determination that the application is complete. 2. If a hearing is held, NYSDEC notifies the applicant and the public of a hearing within 60 days of the completeness determination. The hearing must commence within 90 days of the completeness determination. Once the hearing ends, NYSDEC must issue a final decision on the application within 60 days after receiving the final hearing record. A completeness determination must be made within 15 days.

Notes:

1. The permitting approval times are subject to change based on the nature of the project. Approval for state-issued permits and federal-issued permits can vary and could take nine months or greater.
2. TBD = To be determined as the project scope is further defined.

Phase 1 Preliminary Assessment

Air Quality

Seneca Compressed Air Energy Storage Project

New York State Electric and Gas

Town of Reading

Schuyler County, New York

Environmental Resources Management
399 Boylston Street
Boston, MA 02116

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A preliminary assessment of potential air quality requirements and impacts reveals that the Seneca compressed air energy storage (CAES) Project will be a major emission source under New York State Department of Environmental Conservation (NYSDEC) air pollution control regulations and thereby be subject to Prevention of Significant Deterioration (PSD) pre-construction permitting. The CAES Project will be a major PSD source because potential emissions of greenhouse gases (GHG) will exceed the applicable PSD thresholds. In addition, once a source triggers major source status for one PSD air pollutant, any other PSD contaminant that exceeds its corresponding significant emissions increase threshold would also be subject to PSD review. Based on current emissions information available for the CAES Project, particulate matter (PM) including PM 10 microns or smaller (PM_{10}) and PM 2.5 microns or smaller ($PM_{2.5}$) will also be subject to PSD review because projected emissions of these pollutants exceed their corresponding PSD significant emission increase thresholds.

It should be recognized that the CAES Project will be required to install and operate a selective catalytic reduction (SCR) unit and an oxidation catalyst to avoid triggering more stringent air permitting requirements for nitrogen oxides and carbon monoxide.

Additionally, the CAES Project also will be subject to Title V permitting. However, when compared to PSD pre-construction permitting requirements, the requirements for obtaining a Title V operating permit are less burdensome and the process can be deferred for one year.

Finally, there will be other less burdensome air pollution control regulations that will apply to the CAES Project, but none have nearly the impact on project costs and schedule that the PSD permitting effort will have.

This report presents a preliminary assessment of potential air quality impacts and regulatory requirements associated with the Seneca compressed air energy storage (CAES) Project. Two CAES plant Cycles are currently under review that will comprise a 130 to 180 MW compressed air energy storage facility that consists of an electrically driven compression cycle and a turbine expansion cycle to produce electricity. The CAES plant is intended to provide sufficient storage to allow full operation during peak demand time periods in support of transmission system and market needs (approximately 10 hours per day). The CAES Project will be located west of Seneca Lake in Reading, Schuyler County, New York off of State Route 14A (see Figure 1). The property occupies approximately 18 acres, of which, approximately 13 acres of the property will be developed with CAES process equipment, support buildings, storm water retention pond, and parking areas. Various linear corridors that contain underground water pipelines, a natural gas pipeline and overhead power lines will also be associated with CAES project.

As mentioned above, two different Cycles are currently being evaluated for the CAES Project. The first cycle (Cycle 1) will use natural gas-fired external combustion units to heat the storage air prior to admitting it to expansion turbine generators. The second cycle (Cycle 2) will use a natural gas-fired utility scale combustion turbine with a heat exchanger downstream of the combustion turbine (CT) exhaust to heat the storage air prior to admitting it to the expansion turbine generators.

Support plant equipment that will be additional sources of air emissions include a small duct burner downstream of the CT in Cycle 2 to support fast startup, a natural gas-fired emergency generator, a diesel-fired fire water pump engine, and an induced draft cooling tower to cool noncontact water used to cool the electric driven compressors.

The CAES Project will be located in an area of New York State that is attaining US Environmental Protection Agency's (USEPA) primary and secondary National Ambient Air Quality Standards (NAAQS) for all criteria air pollutants with the exception of ozone.[1] The State of New York is in the ozone transport region (OTR) and is classified by the New York State Department of Environmental Conservation (NYSDEC) as a moderate nonattainment area for ozone. Precursors to the formation of ozone are nitrogen oxides and volatile organic compounds. The "primary" standard has been established to protect the public, including children, people with asthma, and the elderly from health risk. The "secondary" standard was established to prevent unacceptable effects on public welfare, e.g., unacceptable damage to crops and vegetation, buildings and property, and ecosystems.

The attainment status of existing air quality in a geographic region is important because it establishes the requirements for performing technical analyses such as air dispersion modeling, applying air pollution control equipment, and conducting other impact analyses to support pre-construction air permitting. Similarly, with respect to identifying pre-construction permitting requirements, a key regulatory applicability factor will be whether the CAES Project will be deemed a "major" source of emissions under any of a number of state and federal regulatory programs and thereby potentially trigger more rigorous permitting under NYSDEC and/or USEPA air pollution control regulations. Furthermore, with recent changes in air pollution control regulations, certain aspects of the air permitting process may be precedent setting and require innovative solutions in order to gain requisite approvals from state and federal agencies. Some of the critical air permitting requirements that will likely need to be addressed to successfully permit the CAES Project are summarized below.

[1] USEPA's Office of Air Quality Planning and Standards (OAQPS) has set primary and secondary National Ambient Air Quality Standards for six principal pollutants, which are called "criteria" pollutants and include carbon monoxide, nitrogen dioxide, lead, particulate matter (both PM 10 and PM 2.5), ozone, and sulfur dioxide. See http://www.epa.gov/air/criteria.html

GHG Tailoring Rule

USEPA recently has begun regulating greenhouse gas (GHG) emissions as a pollutant under the Clean Air Act and issued the "GHG Tailoring Rule" to implement Prevention of Significant Deterioration (PSD) pre-construction permitting and Title V Operating Permit requirements. PSD permitting for GHG emissions is a new concept in the US, and federal and state agencies are currently determining how to implement these permitting requirements for affected sources. The PSD permitting process is rigorous and involves public review. In addition, projects requiring a PSD permit are more likely to undergo extensive environmental review under programs like New York State Public Service Commission's Article X or NYSDEC State Environmental Quality Review (SEQR). The federal PSD pre-construction permitting program, which is implemented by NYSDEC, has established applicability thresholds that define a "major" source. The PSD "major" source threshold that applies to the CAES Project is 250 tons per year (tpy) of any PSD-regulated pollutant. For GHGs, the major source threshold is 250 tpy on a mass basis for the aggregate of GHGs[2] and 100,000 tons per year of carbon dioxide equivalents (CO2e).

Under USEPA's new GHG Tailoring Rule, the CAES Project will trigger PSD permitting because emissions of carbon dioxide equivalents (CO2e) will exceed 100,000 tons per year and carbon dioxide emissions will exceed 250 tons per year on a mass basis, the applicability thresholds for new projects. Additionally, by triggering PSD permitting for CO2e emissions, other PSD-regulated air pollutants emitted may be caught in the PSD permitting web. Under the PSD requirements, which are implemented in New York by NYSDEC, once a source triggers "major" source status for one regulated PSD air pollutant, then each regulated PSD contaminant emitted from the source that exceeds the significant emission increase thresholds found in NYCRR Subpart 231-7 is also subject to the PSD permitting requirements (see additional discussion below).

[2] Under USEPA's GHG Tailoring Rule, GHG PSD applicability is based on both a GHG mass and carbon dioxide equivalents (CO2e) emissions basis. The mass basis threshold is required to conform to the historical PSD regulation that requires PSD applicability to be based on mass emissions of the affected PSD pollutant, i.e., the 100 or 250 tpy thresholds.

Sources subject to PSD permitting must:

- Apply best available control technology (BACT) to the PSD-affected pollutant(s);

- Conduct an air quality impact analysis to demonstrate compliance with the NAAQS for the PSD-affected pollutant(s);

- Analyze impacts to soil, vegetation, and visibility; and

- Demonstrate no adverse impacts on Federal Class 1 areas

Additionally, because potential CO2e emissions will exceed 100,000 tons per year, the CAES facility also will be subject to Title V permitting; an air-quality operating permit program. However, when compared to PSD pre-construction permitting requirements, the requirements for obtaining a Title V operating permit are less burdensome and the process can be deferred for one year.

Compliance with National Ambient Air Quality Standards (NAAQS) and State of New York Air Quality Standards

Depending on the Cycle selected and finalized emissions profile, there may be the need to demonstrate compliance with the NAAQS if PSD permitting is triggered. Based on current available information, this may apply to particulate matter (PM), including PM 10 microns or smaller (PM_{10}) and PM 2.5 microns or smaller ($PM_{2.5}$). However, even if no other PSD-pollutant, other than CO2e (for which there are no NAAQS and thus no modeling requirements), triggers PSD permitting, based on ERM's recent permitting work nationally, we expect that NYSDEC's may require some level of dispersion modeling to demonstrate compliance with the recently adopted short term one-hour NAAQS for nitrogen dioxide (NO_2) as part of permitting the CAES Project[3]. For NO_2, this entails running air dispersion models to predict ambient concentrations of NO_2 at ground

[3] Note: a short term one-hour NAAQS has recently been established for sulfur dioxide (SO_2) as well but it is not expected that NYSDEC would require a demonstration of compliance with this standard given that natural gas is the principal fuel that will be used at the CAES plant and SO_2 emissions will be insignificant.

level in the surrounding area and then comparing the modeled results with corresponding NAAQS. It is noted that the new one-hour NO_2 standard is quite stringently low, which can pose problems in demonstrating compliance with the NO_2 NAAQS. The extent of modeling required for PM_{10}, $PM_{2.5}$, and/or NO_2 will not be known until Phase 2 of the CAES Project is initiated and after a pre-application meeting with NYSDEC staff of the Office of Air Resources, Climate Change & Energy, Division of Air Resources.

In addition to demonstrating compliance with NAAQS for the affected pollutants, permitting will also require demonstrating compliance with State of New York Air Quality Standards under Chapter III- Air Resources, Subchapter B: Air Quality Classifications and Standards Part 257: Air Quality Standards.

While the ultimate air permitting requirements that will need to be satisfied will not be determined until the design basis for the CAES Project has been finalized, based on what we currently know about expected emission levels for the CAES Project (as summarized below), the following more substantial air permitting requirements will likely be triggered or at least need to be discussed with NYSDEC and subsequently ruled out:

1. Pre-construction air permitting and Title V permitting under 6 New York Code of Rules and Regulations (NYCRR) 201;

2. New Source Review (meaning PSD) permitting under 6 NYCRR 231; and

3. Demonstration of compliance with National Ambient Air Quality Standards (requires air dispersion modeling).

Non-attainment Area New Source Review

As mentioned above, the State of New York is in the ozone transport region (OTR) and is classified by NYSDEC as a moderate nonattainment area for ozone. Precursors to the formation of ozone are nitrogen oxides and volatile organic compounds. Emissions of these two pollutants will be well-controlled through the installation and operation of a selective catalytic reduction (SCR) system and an oxidation catalyst, respectively. The resulting controlled emissions will be below 6 NYCRR Part 231-13.1 nonattainment area new source review (NNSR) major source thresholds

and thus the CAES Project will not be subject to NNSR pre-construction permitting.

Air Toxics Review under 6 NYCRR 212 and DAR-1 Air Guide 1

NYSDEC has an Air Toxics Program that it implements under 6 NYCRR 212 to address the control of toxic air pollutants emitted from industrial processes. The CAES Project would not be subject to this regulation because it is a combustion installation, a source category that is exempt under 6 NYCRR 212.

It is noted, however, that NYSDEC could require an assessment of off-site impacts of air contaminants emitted from the CAES Projects under its Policy DAR-1: Guidelines for the Control of Toxic Ambient Air Contaminants Air Guide 1. The need to undertake such an assessment will be discussed during Phase 2 of the Project at a pre-application meeting with NYSDEC's Division of Air Resources staff.

Finally, there will be other less burdensome air pollution control regulations that will apply to the CAES Project but none have nearly the impact on project costs and schedule that the PSD permitting effort will have.

The majority of emissions from the CAES Project will result from the combustion of natural gas to heat the storage air prior to admitting it to the expansion turbine generators. The proposed method for heating the storage air under Cycle 1 is through the use of a 589 MMBtu/hour process heater. Cycle 2 will utilize a conventional 979 MMBtu/hour utility scale stationary combustion turbine.

Potential emissions from these large combustion sources have been estimated based on a worst-case operating scenario of 8,760 hours per year. Vendor-provided emission rates along with USEPA AP-42 emission factors have been applied to each Cycle scenario to estimate annual emissions of carbon dioxide equivalents (CO2e), carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), volatile organic compounds (VOC), particulate matter (PM) including PM 10 microns or smaller (PM_{10}) and PM 2.5 microns or smaller ($PM_{2.5}$) and ammonia (resulting from the use of SCR). The emission factors used to estimate emissions for the two cycles are presented in Attachment A. The emission factors for PM_{10} and $PM_{2.5}$ include both the filterable and condensable fractions of PM, as required.

Selective catalytic reduction (SCR) will be used with both Cycle 1 and Cycle 2 to provide post-combustion NO_x control. Combustor water injection also will be used on the Cycle 1 process heater to reduce NO_x emissions. An oxidation catalyst will be used to control CO and VOC emissions from the large combustion units for both Cycles. Both uncontrolled and controlled emissions are provided for NO_x, CO, and VOC.

In addition, emissions from facility support equipment, including a small duct burner downstream of the CT in Cycle 2, a natural gas-fired emergency generator, a diesel-fired fire water pump engine, and an induced draft cooling tower, are presented below as well.

Emissions from the proposed natural gas fired emergency generator were calculated assuming compliance with the 40 CFR 60, Subpart JJJJ, New Source Performance Standards (NSPS) for Stationary Emergency Engines. Emissions from the diesel fire pump engine were calculated in a similar manner referencing the Subpart IIII NSPS standards for Diesel Fire

Pumps. In both cases, 500 hours per year of operation were assumed. Note that NYSDEC allows up 500 hours of operation for engines to still be deemed "emergency" status.

Particulate emissions from the induced draft cooling tower were calculated using AP-42 Chapter 13.4 Emission Factors for Wet Cooling Towers.

Estimated annual potential emissions of key regulatory air pollutants for Cycle 1 and Cycle 2 are presented in the following tables (Tables 3A through 3E); where potential emissions are based on running the major combustion emission sources 8,760 hours per year. For comparison, as a possible alternative permitting strategy, ERM also calculated annual emissions based on running the major combustion emissions sources 3,120 hours per year, i.e., operating 12 hours per day and 260 cycles per year. This latter scenario would result in slightly less rigorous permitting requirements but would place restrictions on plant operations. More in-depth analyses of various permitting strategies and options will be conducted under Phase 2 of the Project.

Table 3A. CAES Cycle 1 Estimated Annual Potential Emissions at Full Operation – 8760 Hours per Year for Major Emission Sources (TPY)

	CO2e	*CO*		*NOx*		*SO2*	*VOC*		*PM*	*PM-10*	*PM-2.5*	*NH3*
		Inlet	*Outlet[a]*	*Inlet*	*Outlet[a]*		*Inlet*	*Outlet[a]*				
Cycle 1	**322,989**	**381.0**	**12.5**	**469.6**	**20.8**	**4.9**	**not provided**	**6.2**	**46.4**	**46.4**	**46.4**	18.1
Support Equipment	**198**	**4.7**	**4.7**	**2.5**	**2.5**	**0.1**	**-**	**1.4**	**2.4**	**2.4**	**2.4**	-
Total	**323,187**	**385.7**	**17.2**	**472.1**	**23.4**	**5.0**	**-**	**7.6**	**48.8**	**48.8**	**48.8**	18.1
Attainment Major Facility Threshold (TPY)[b]	**250/100,000**		**250**	_	**250**	**250**	_	_	**250**	**250**	**250**	_
Non-Attainment Major Facility Threshold (TPY) [c]	_	_	_	**-**	**100**	_	**-**	**50**	_	_	_	_
Significant Increase Threshold For Attainment Areas (TPY)[d]	**75,000**	**-**	**100**	**--**	**40**	**40**	_	_	**25**	**15**	**10**	-
Significant Increase Threshold For Non-Attainment Areas (TPY) [e]	_	_	_	**-**	**40**	_	**-**	**40**	_	_	_	_
PSD Permitting Triggered	**Yes**	**-**	**No [f]**	**-**	**No [f]**	**No**	**No**	**No**	**Yes**	**Yes**	**Yes**	No

[a] Outlet from oxidation catalyst and SCR unit
[b] 6 NYCRR Part 231-13.5 Major Facility Thresholds For Attainment and Unclassified Areas
[c] 6 NYCRR Part 231-13.1 Major Facility Thresholds And Offset Ratios For Ozone Nonattainment Areas And The Ozone Transport Region
[d] 6 NYCRR Part 231-13.6 Significant Project Thresholds and Significant Net Emission Increase Thresholds for Attainment and Unclassified Areas. Note: According to NYSDEC NH3 is not a regulated NSR pollutant.
[e] 6 NYCRR Part 231-13.3 Significant Project Thresholds, Significant Net Emissions Increase Thresholds, And Offset Ratios For Ozone Nonattainment Areas And The Ozone Transport Region
[f] Will require federally enforceable permit condition mandating the operation of oxidation catalyst and SCR unit whenever attendant emission source is running.

Table 3B. CAES Cycle 2 Estimated Annual Potential Emissions at Full Operation – 8760 Hours per Year for Major Emission Sources (TPY)

	CO2e	*CO*		*NOx*		*SO2*	*VOC*		*PM*	*PM-10*	*PM-2.5*	*NH3*
		Inlet	*Outlet[a]*	*Inlet*	*Outlet[a]*		*Inlet*	*Outlet[a]*				
Cycle 2	**527,034**	**236.9**	**20.1**	**148.1**	**32.9**	**4.5**	**8.8**	**5.3**	**49.5**	**49.5**	**49.5**	30.2
Support Equipment	**198**	**4.7**	**4.7**	**2.5**	**2.5**	**0.1**	**1.4**	**1.4**	**2.4**	**2.4**	**2.4**	-
Total	**527,232**	**241.6**	**24.8**	**150.6**	**35.4**	**4.6**	**10.2**	**6.7**	**51.9**	**51.9**	**51.9**	30.2
Attainment Major Facility Threshold (TPY)[b]	**250/100,000**		**250**	_	**250**	**250**	_	_	**250**	**250**	**250**	_
Non-Attainment Major Facility Threshold (TPY) [c]	_	_	_	**-**	**100**	_	**-**	**50**	_	_	_	_
Significant Increase Threshold For Attainment Areas (TPY)[d]	**75,000**	**-**	**100**	_	**40**	**40**	_	_	**25**	**15**	**10**	-
Significant Increase Threshold For Non-Attainment Areas (TPY) [e]	_	_	_	**-**	**40**	_	**-**	**40**	_	_	_	_
PSD Permitting Triggered	**Yes**	**-**	**No [f]**	**-**	**No [f]**	**No**	**No**	**No**	**Yes**	**Yes**	**Yes**	No

[a] Outlet from oxidation catalyst and SCR unit
[b] 6 NYCRR Part 231-13.5 Major Facility Thresholds For Attainment and Unclassified Areas
[c] 6 NYCRR Part 231-13.1 Major Facility Thresholds And Offset Ratios For Ozone Nonattainment Areas And The Ozone Transport Region
[d] 6 NYCRR Part 231-13.6 Significant Project Thresholds and Significant Net Emission Increase Thresholds for Attainment and Unclassified Areas. Note: According to NYSDEC NH3 is not a regulated NSR pollutant.
[e] 6 NYCRR Part 231-13.3 Significant Project Thresholds, Significant Net Emissions Increase Thresholds, And Offset Ratios For Ozone Nonattainment Areas And The Ozone Transport Region
[f] Will require federally enforceable permit condition mandating the operation of oxidation catalyst and SCR unit whenever attendant emission source is running.

Table 3C. CAES Cycle 1 Estimated Annual Potential Emissions at Reduced Operation – 3120 Hours per Year for Major Emission Sources (TPY)

	CO2e	*CO*		*NOx*		*SO2*	*VOC*		*PM*	*PM-10*	*PM-2.5*	*NH3*
		Inlet	*Outlet[a]*	*Inlet*	*Outlet[a]*		*Inlet*	*Outlet[a]*				
Cycle 1	**116,512**	**137.4**	**4.5**	**169.4**	**7.5**	**1.8**	**not provided**	**2.3**	**16.8**	**16.8**	**16.8**	6.5
Support Equipment	**198**	**4.7**	**4.7**	**2.5**	**2.5**	**0.1**	**-**	**1.4**	**1.7**	**1.7**	**1.7**	-
Total	**116,710**	**142.2**	**9.2**	**171.9**	**10.1**	**1.9**	**-**	**3.7**	**18.5**	**18.5**	**18.5**	6.5
Attainment Major Facility Threshold (TPY)[b]	**250/100,000**		**250**	_	**250**	**250**	_	_	**250**	**250**	**250**	_
Non-Attainment Major Facility Threshold (TPY) [c]	_	_	_	**-**	**100**	_	**-**	**50**	_	_	_	_
Significant Increase Threshold For Attainment Areas (TPY)[d]	**75,000**	**-**	**100**	_	**40**	**40**	_	_	**25**	**15**	**10**	-
Significant Increase Threshold For Non-Attainment Areas (TPY) [e]	_	_	_	**-**	**40**	_	**-**	**40**	_	_	_	_
PSD Permitting Triggered	**Yes**	**-**	**No [f]**	**-**	**No [f]**	**No**	**No**	**No**	**No**	**Yes**	**Yes**	No

[a] Outlet from oxidation catalyst and SCR unit
[b] 6 NYCRR Part 231-13.5 Major Facility Thresholds For Attainment and Unclassified Areas
[c] 6 NYCRR Part 231-13.1 Major Facility Thresholds And Offset Ratios For Ozone Nonattainment Areas And The Ozone Transport Region
[d] 6 NYCRR Part 231-13.6 Significant Project Thresholds and Significant Net Emission Increase Thresholds for Attainment and Unclassified Areas. Note: According to NYSDEC NH3 is not a regulated NSR pollutant.
[e] 6 NYCRR Part 231-13.3 Significant Project Thresholds, Significant Net Emissions Increase Thresholds, And Offset Ratios For Ozone Nonattainment Areas And The Ozone Transport Region
[f] Will require federally enforceable permit condition mandating the operation of oxidation catalyst and SCR unit whenever attendant emission source is running.

Table 3D.CAES Cycle 2 Estimated Annual Potential Emissions at Reduced Operation – 3120 Hours per Year for Major Emission Sources (TPY)

	CO2e	*CO*		*NOx*		*SO2*	*VOC*		*PM*	*PM-10*	*PM-2.5*	*NH3*
		Inlet	*Outlet[a]*	*Inlet*	*Outlet[a]*		*Inlet*	*Outlet[a]*				
Cycle 2	**190,155**	**85.5**	**7.3**	**53.5**	**11.9**	**1.6**	**3.2**	**1.9**	**17.9**	**17.9**	**17.9**	10.9
Support Equipment	**198**	**4.7**	**4.7**	**2.5**	**2.5**	**0.1**	**1.4**	**1.4**	**1.7**	**1.7**	**1.7**	-
Total	**190,353**	**90.2**	**12.0**	**56.0**	**14.4**	**1.7**	**4.6**	**3.3**	**19.6**	**19.6**	**19.6**	10.9
Attainment Major Facility Threshold (TPY)[b]	**250/100,000**	**-**	**250**	_	**250**	**250**	_	_	**250**	**250**	**250**	_
Non-Attainment Major Facility Threshold (TPY) [c]	_	_	_	**-**	**100**	_	**-**	**50**	_	_	_	_
Significant Increase Threshold For Attainment Areas (TPY)[d]	**75,000**	**-**	**100**	_	_	**40**	_	_	**25**	**15**	**10**	**-**
Significant Increase Threshold For Non-Attainment Areas (TPY) [e]	_	_	_	**-**	**40**	_	**-**	**40**	_	_	_	_
PSD Permitting Triggered	**Yes**	**-**	**No [f]**	**-**	**No [f]**	**No**	**No**	**No**	**No**	**Yes**	**Yes**	No

[a] Outlet from oxidation catalyst and SCR unit
[b] 6 NYCRR Part 231-13.5 Major Facility Thresholds For Attainment and Unclassified Areas
[c] 6 NYCRR Part 231-13.1 Major Facility Thresholds And Offset Ratios For Ozone Nonattainment Areas And The Ozone Transport Region
[d] 6 NYCRR Part 231-13.6 Significant Project Thresholds and Significant Net Emission Increase Thresholds for Attainment and Unclassified Areas. Note: According to NYSDEC NH3 is not a regulated NSR pollutant.
[e] 6 NYCRR Part 231-13.3 Significant Project Thresholds, Significant Net Emissions Increase Thresholds, And Offset Ratios For Ozone Nonattainment Areas And The Ozone Transport Region
[f] Will require federally enforceable permit condition mandating the operation of oxidation catalyst and SCR unit whenever attendant emission source is running.

Table 3E. Estimated Emissions for CAES Facility Support Equipment (TPY)

	CO2e	*CO*	*NOx*	*SO2*	*VOC*	*PM*	*PM-10*	*PM-2.5*
Emergency Generator	140.0	4.4	2.2	0.0	1.1	0.0	0.0	0.0
Fire Pump	57.8	0.3	0.3	0.1	0.3	0.0	0.0	0.0
Cooling Tower[a]	-	-	-	-	-	2.4/1.7	2.4/1.7	2.4/1.7
Total (tpy)	**197.8**	**4.7**	**2.5**	**0.1**	**1.4**	**2.4/1.7**	**2.4/1.7**	**2.4/1.7**

a (8760/3120 hours per year)

Cycle 1 and Cycle 2 operating scenarios would be deemed a Subpart 231 PSD major source because CO2e (100,000 tpy) and CO_2 (250 tpy) emissions exceed the permitting threshold.

Furthermore, under the full operating mode (8760), emissions of PM, PM_{10} and $PM_{2.5}$ will also be subject to PSD review because projected emissions of these pollutants exceed their corresponding PSD significant emission increase thresholds. Only PM emissions would be excluded from PSD review if the operating scenario was reduce to 3120 hours per year.

Finally, it should be recognized that the CAES Project will be required to install and operate a selective catalytic reduction (SCR) unit and an oxidation catalyst to avoid triggering PSD review for nitrogen oxides and carbon monoxide and avoid nonattainment area new source review (NNSR) for nitrogen oxides.

While the technical analyses to be carried under Phase 2 will be required to substantiate these preliminary findings and also will be needed to complete permit applications, air emissions released during operation of the CAES Project are not anticipated to adversely impact that regional air quality attainment status and also not contribute to further degradation of the moderate nonattainment status for ozone for the area. Similarly, air emissions during CAES plant construction are anticipated to be minor and will cease upon completion of the construction phase with no long-term effects. Therefore, no adverse long term impacts to local air quality are anticipated to result from the Project.

Based on results of this preliminary assessment, the CAES Project will need to satisfy the PSD permitting requirements for CO2e, PM, PM_{10} and $PM_{2.5}$. As outlined above, sources subject to PSD permitting must:

- Apply best available control technology (BACT) to the PSD-affected pollutant(s);

- Conduct an air quality impact analysis to demonstrate compliance with the NAAQS for the PSD-affected pollutant(s);

- Analyze impacts to soil, vegetation, and visibility; and

- Demonstrate no adverse impacts on Federal Class 1 areas

BACT Review. BACT requirements are intended to ensure that a proposed project will incorporate control systems that reflect the latest demonstrated practical techniques for that particular facility. The BACT evaluation requires the documentation of performance levels achievable for control technology on a pollutant-by-pollutant basis.

One the challenging permitting requirements going forward will be completing the BACT analysis for CO2e emissions. USEPA has published a GHG BACT Guidance document that presents information on BACT applicability to new and modified sources, and outlines a five step process for determining BACT. USEPA recommends that a "top-down" approach be taken when evaluating available air pollution control technologies. This approach to the BACT process involves determining the most stringent control technique available for a similar or identical emission

source. If it can be shown that the most stringent level of control currently in use on a similar emission unit is technically, environmentally, or economically impractical on a case-by-case basis for the particular source, then the next most stringent level of control is determined and similarly evaluated. The process continues until a control technology and associated emission level is determined which cannot be eliminated by any technical, environmental or economic objections.

Working with NYSDEC staff to determine BACT for CO2e will require additional time because this topic is covering new territory for them. Note that BACT reviews will need to be performed for PM, PM_{10} and $PM_{2.5}$ emissions as well.

Ambient Air Quality Impacts Analysis. Another key requirement of PSD permitting that will need to be addressed under Phase 2 of the Project is the need to demonstrate compliance with both National Ambient Air Quality Standards (NAAQS) and State of New York Air Quality Standards under Chapter III- Air Resources, Subchapter B: Air Quality Classifications and Standards Part 257: Air Quality Standards. This effort will require submitting a modeling protocol to NYSDEC for review and approval. Often preliminary modeling is conducted in advance of submitting a protocol to gain advance knowledge of expected impacts before committing to a modeling approach with the State.

As mentioned above, even if no other PSD-pollutants, other than CO2e (for which there are no NAAQS and thus no air dispersion modeling requirements), trigger PSD permitting, based on ERM's recent permitting work nationally, NYSDEC may require some level of dispersion modeling to demonstrate compliance with the recently adopted short term one-hour NAAQS for nitrogen dioxide (NO_2) as part of permitting the CAES Project.

As part of the PSD permitting process, an analysis of impacts to soil, vegetation, and visibility, and demonstration of no adverse impacts on Federal Class 1 areas also will need to be completed.

Also, NYSDEC could require an assessment of off-site impacts of air contaminants emitted from the CAES Projects under its Policy DAR-1: Guidelines for the Control of Toxic Ambient Air Contaminants Air Guide 1.

Other Related Issues. The schedule for PSD permitting can range from 12 to 18 months covering the time to complete all the technical analyses and

prepare the application, to time for NYSDEC to review the application submittal and deemed it complete and then subsequently perform their technical reviews through to allowing time for the public (including US EPA) to comment on the draft permit.

Additionally, because potential CO2e emissions will exceed 100,000 tons per year, the CAES facility also will be subject to Title V permitting. However, when compared to PSD pre-construction permitting requirements, the requirements for obtaining a Title V operating permit are less burdensome and the process can be deferred for one year.

It is also noted that the preceding discussion covers the major emission sources during the operational phase of the CAES Project. Air emissions also will result during construction of the CAES plant. The construction phase is anticipated to result in short-term impacts to local air quality from the combustion exhaust of construction vehicles and equipment as well as the generation of dust during site preparation involving earth moving and other associated activities. These impacts are anticipated to be minor and will cease upon completion of the construction phase with no long-term effects.

Finally, there will be other less burdensome air pollution control regulations that will apply to the CAES Project but none have nearly the impact on project costs and schedule that the PSD permitting effort will have.

A preliminary review of potential air pollution control regulations applicable to the CAES Project has been completed and the results are presented in Attachment B. This initial assessment will be refined under Phase 2 after the CAES Cycle has been selected and final plant design information is available.

Attachment A – Source of Emission Factors

Table A-1. Cycle 1 - 589 MMBtu/Hr Process Heater Emission Factors

Contaminant	Emission Factor (HHV)	Source of Emission Factor
CO2e	73,742 lbs/hour	Worley Parsons, Air Environmental Overview
CO - Uncontrolled	87.0 lbs/hour	Worley Parsons, Air Environmental Overview
CO - Controlled	2.9 lbs/hour	Worley Parsons, Air Environmental Overview
NOx - Uncontrolled	107.2 lbs/hour	Worley Parsons, Air Environmental Overview
NOx - Controlled	4.8 lbs/hour	Worley Parsons, Air Environmental Overview
VOC - Uncontrolled	Not provided	
VOC - Controlled	0.0024 lbs/MMBtu	Worley Parsons, 11/02/11 Takats Email
SO2	0.0019 lb/MMBtu	Worley Parsons, 11/02/11 Takats Email
PM/PM-10/ PM-2.5*	0.018 lb/MMBtu	Worley Parsons, 11/02/11 Takats Email
NH3	0.0070 lbs/MMBtu	Worley Parsons, 11/02/11 Takats Email

** Provided as emission factor for PM-10*

Table A-2. Cycle 2 – Combustion Turbine (979 MMBtu/hr) 100% Load – Average Ambient

Contaminant	Emission Factor	Source of Emission Factor
CO2e	120,314 lbs/hour	Worley Parsons, CAES-1-LI-022-0009
CO - Uncontrolled	54.08 lbs/hour	Worley Parsons, CAES-1-LI-022-0009
CO - Controlled	4.57 lbs/hour	Worley Parsons, CAES-1-LI-022-0009
NOx - Uncontrolled	33.8 lbs/hour	Worley Parsons, CAES-1-LI-022-0009
NOx - Controlled	7.50 lbs/hour	Worley Parsons, CAES-1-LI-022-0009
VOC - Uncontrolled	2.0 lbs/hour	Worley Parsons, CAES-1-LI-022-0009
VOC - Controlled	1.2 lbs/hour	Worley Parsons, CAES-1-LI-022-0009
SO2	1.03 lbs/hour	Worley Parsons, CAES-1-LI-022-0009
PM/PM-10/ PM-2.5*	11.3 lbs/hour	Worley Parsons, CAES-1-LI-022-0009
NH3	6.9 lbs/hour	Worley Parsons, CAES-1-LI-022-0009

** Stack PM emissions are assumed to be PM-2.5*

Table A-3. Cycle 2 – Duct Burner (100 MMBtu/hr))

Contaminant	AP-42 1.4 Natural Gas Combustion	Emission Factor for 100 MMBtu/Hr Duct Burner
CO2e	120,000 lbs/10^6 SCF	11,765 lbs/hour
CO	84 lbs/10^6 SCF	8.24 lbs/hour
NOx	100 lbs/10^6 SCF	9.80 lbs/hour
VOC	5.5 lbs/10^6 SCF	0.54 lbs/hour
SO2	0.6 lbs/10^6 SCF	0.059 lbs/hour
PM/PM-10/ PM-2.5	7.6 lbs/10^6 SCF	0.75 lbs/hour

Table A-4. Emergency Generator – 2000 HP Natural Gas Fired

Contaminant	40CFR 60, Subpart JJJJ Emission Standard	AP-42 3.2 Natural Gas Fired Reciprocating Engines	Emission Factor for 2000 HP Generator
CO2e	-	110 lbs/MMBtu	559.9 lbs/hour
NOx	2.0 g/HP-hr	-	8.87 lbs/hour
CO	4.0 g/HP-hr	-	17.74 lbs/hour
VOC	1.0 g/HP-hr	-	4.43 lbs/hour
PM	-	0.00950 lbs/MMBtu	0.0484 lbs/hour
SO2	-	0.000588 lbs/MMBtu	0.00299 lbs/hour

Table A-5. Fire pump – 200 HP Diesel Fired

Contaminant	40CFR 60, Subpart IIII Emission Standard	AP-42 3.3 Gasoline and Diesel Industrial Engines	Emission Factor for 1500 GPM Fire pump
CO2e	-	1.15 lbs/HP-hr	231.3 lbs/hour
NMHC + NOx	3.0 g/HP-hr	-	1.33 lbs/hour
CO	2.6 g/HP-hr	-	1.15 lbs/hour
PM	0.15 g/HP-hr	-	0.07 lbs/hour
SO2	-	0.00205 lbs/HP-hr	0.41 lbs/hour

Table A-6. Cooling Tower – 60,000 GPM Induced Draft

Contaminant	AP-42 13.4 Wet Cooling Towers	Calculated Emission Factor
PM-10	Drift Loss * TDS Fraction	0.54 lbs/hour

Attachment B – ***POTENTIAL APPLICABLE AIR POLLUTION CONTROL PERMITTING REQUIREMENTS***

ATTACHMENT B: POTENTIAL APPLICABLE AIR POLLUTION CONTROL PERMIITING REQUIREMENTS

Regulation	Description	Requirement / Standard	Effective Date	Applicability
New York State Regulations				
6 NYCRR 201-8	General Permits	This Subpart is intended to implement the provisions of ECL 19-0311 that provides for the issuance of general permits covering numerous similar emission sources or source categories for purposes of complying with Title V of the Act or to augment other permitting requirements under this Part.	06/26/1996	Yes
6 NYCRR 211	General Prohibitions	General prohibition against air pollution and visible air emissions.	08/06/2010	Yes
6 NYCRR 225	Fuel Composition And Use	Requirements related to fuel composition and use for sulfur limitations, waste fuel, gasoline, and diesel fuel	04/28/1972	Yes
6 NYCRR 231	New Source Review For New And Modified Facilities	Applies to projects in which there is a threshold increase in annual actual emissions from an air contamination source project above the de minimis emission limits found in section 231-1.9 of this Subpart.	09/1971	Yes Facility will be major for CO2e and PM, PM10, and PM2.5.
6 NYCRR 257	Air Quality Standards	Compliance with Air Quality Standards must be demonstrated.		Yes Air quality modeling will be required to demonstrate compliance
40 CFR 60 Federal Regulations				
40 CFR 60 Subpart GG	Stationary gas turbines	Applies to stationary gas turbines with a heat input peak >10.7 gigajoules/hr (10 million Btu) based on the lower heating value of the fuel. Restricts emissions of NO_x according to the formula provided. Restricts sulfur content of fuel to <0.8% by weight.	10/3/77	No *§60.4305(b) (40CFR Part 60 Subpart KKKK) Stationary combustion turbines regulated under this subpart are exempt from the requirements of subpart GG of this part.*
40 CFR 60 Subpart IIII	Standards Of Performance For Stationary Compression Ignition Internal Combustion Engines	Applies to manufacturers, owners, and operators of stationary compression ignition (CI) internal combustion engines (ICE).		Yes Facility will operate a diesel-fired fire water pump IC engine.
40 CFR 60 Subpart JJJJ	Standards Of Performance For Stationary Spark Ignition Internal Combustion Engines	Applies to manufacturers, owners, and operators of stationary spark ignition (SI) internal combustion engines (ICE)		Yes Facility will operate a natural gas-fired emergency generator.
40 CFR 60 Subpart KKKK	Standards Of Performance For Stationary Combustion Turbines	Applies to the owner or operator of a stationary combustion turbine with a heat input at peak load equal to or greater than 10.7 gigajoules (10 MMBtu) per hour, based on the higher heating value of the fuel, which commenced construction, modification, or reconstruction after February 18, 2005,		Yes Proposed turbine is in the range of 589 MMBtu/hr to 979 MMBtu/hr
40 CFR 63 Subpart YYYY	NESHAP: Combustion Turbines	Applies to combustion turbine operations.	3/5/2004	No Facility will not be a major source of HAP
40 CFR 63 Subpart ZZZZ	NESHAP: Recip. Internal Combustion Engines (RICE MACT)	Applies to RICE operations.	See Regulation	No Facility emergency generator/fire pump engine will be subject to 40 CFR 60 Subparts IIII and JJJJ.
40 CFR 64	Compliance Assurance Monitoring (CAM)	Enhanced monitoring is required for emissions units subject to a NESHAP, PSD, NSPS, and units with the PTE 100% or more of the minimum potential emissions required for the source to be classified as a major source under Title V.	See Regulation	Yes

Attachment C – Emission Calculations

NYSEG Compressed Air Energy Storage Emission Calculations

Hourly Emission Rates

					NOx		CO		VOC						
			Annual Operation (hours)	CO2e (lbs/hour)	SCR Inlet (lbs/hour)	SCR Outlet (lbs/hour)	CatOx Inlet (lbs/hour)	CatOx Outlet (lbs/hour)	CatOx Inlet (lbs/hour)	CatOx Outlet (lbs/hour)	SO2 (lbs/hour)	PM (lbs/hour)	PM-10 (lbs/hour)	PM-2.5 (lbs/hour)	NH3 (lbs/hour)
Cycle 1	589	MMBtu/Hr	8760	73,741.7	107.2	4.8	87.0	2.9		1.4	1.1	10.6	10.6	10.6	4.1
Cycle 2 CTG	979	MMBtu/Hr	8760	120,314.0	33.8	7.5	54.1	4.6	2.0	1.2	1.0	11.3	11.3	11.3	6.9
Cycle 2 Duct Burner	10	MMBtu/Hr	100	1,176.5	1.0	1.0	0.8	0.8	0.1	0.1	0.0	0.1	0.1	0.1	0.0
Emergency Generator	2000	HP NG	500	559.9	8.9	8.9	17.7	17.7	4.4	4.4	0.0	0.0	0.0	0.0	0.0
Fire Pump Engine	200	HP Diesel	500	231.3	1.3	1.3	1.2	1.2	1.3	1.3	0.4	0.1	0.1	0.1	0.0
Cooling Tower	60,000	GPM	8760	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.0

Annual Emissions at Full Operation (8760 hours per year)

					NOx		CO		VOC						
			Annual Operation (hours)	CO2e (tons)	SCR Inlet (tons)	SCR Outlet (tons)	CatOx Inlet (tons)	CatOx Outlet (tons)	CatOx Inlet (tons)	CatOx Outlet (tons)	SO2 (tons)	PM (tons)	PM-10 (tons)	PM-2.5 (tons)	NH3 (tons)
Cycle 1	589	MMBtu/Hr	8760	322,988.8	469.6	20.8	381.0	12.5	0.0	6.2	4.9	46.4	46.4	46.4	18.1
Cycle 2 CTG	979	MMBtu/Hr	8760	526,975.3	148.0	32.9	236.9	20.0	8.8	5.3	4.5	49.5	49.5	49.5	30.2
Cycle 2 Duct Burner	10	MMBtu/Hr	100	58.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Emergency Generator	2000	HP NG	500	140.0	2.2	2.2	4.4	4.4	1.1	1.1	0.0	0.0	0.0	0.0	0.0
Fire Pump Engine	200	HP Diesel	500	57.8	0.3	0.3	0.3	0.3	0.3	0.3	0.1	0.0	0.0	0.0	0.0
Cooling Tower	60,000	GPM	8760	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	2.4	2.4	0.0
Facility Support Equipment				197.8	2.5	2.5	4.7	4.7	1.4	1.4	0.1	2.4	2.4	2.4	0.0
Cycle 1 and Facility Support Equipment				323,186.6	472.1	23.4	385.7	17.2	1.4	7.6	5.0	48.8	48.8	48.8	18.1
Cycle 2 CTG and Duct Burner				527,034.1	148.1	32.9	236.9	20.1	8.8	5.3	4.5	49.5	49.5	49.5	30.2
Cycle 2 and Facility Support Equipment				527,231.9	150.6	35.4	241.6	24.8	10.2	6.7	4.6	51.9	51.9	51.9	30.2

Annual Emissions at Reduced Operation (3120 hours per year - 12 hours/day for 260 days/year)

					NOx		CO		VOC						
			Annual Operation (hours)	CO2e (tons)	SCR Inlet (tons)	SCR Outlet (tons)	CatOx Inlet (tons)	CatOx Outlet (tons)	CatOx Inlet (tons)	CatOx Outlet (tons)	SO2 (tons)	PM (tons)	PM-10 (tons)	PM-2.5 (tons)	NH3 (tons)
Cycle 1	589	MMBtu/Hr	3160	116,511.9	169.4	7.5	137.4	4.5	0.0	2.2	1.8	16.8	16.8	16.8	6.5
Cycle 2 CTG	979	MMBtu/Hr	3160	190,096.1	53.4	11.9	85.4	7.2	3.2	1.9	1.6	17.9	17.9	17.9	10.9
Cycle 2 Duct Burner	10	MMBtu/Hr	100	58.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Emergency Generator	2000	HP NG	500	140.0	2.2	2.2	4.4	4.4	1.1	1.1	0.0	0.0	0.0	0.0	0.0
Fire Pump Engine	200	HP Diesel	500	57.8	0.3	0.3	0.3	0.3	0.3	0.3	0.1	0.0	0.0	0.0	0.0
Cooling Tower	60,000	GPM	6240	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.7	1.7	0.0
Facility Support Equipment				197.8	2.5	2.5	4.7	4.7	1.4	1.4	0.1	1.7	1.7	1.7	0.0
Cycle 2 CTG and Duct Burner				190,154.9	53.5	11.9	85.5	7.3	3.2	1.9	1.6	17.9	17.9	17.9	10.9
Cycle 1 and Facility Support Equipment				116,709.7	171.9	10.1	142.2	9.2	1.4	3.7	1.9	18.5	18.5	18.5	6.5
Cycle 2 and Facility Support Equipment				190,352.7	56.0	14.4	90.2	12.0	4.6	3.3	1.7	19.6	19.6	19.6	10.9

New York Archaeological Council
Phase I Cultural Resource Investigations: Reconnaissance
Phase IA Literature Search and Sensitivity Assessment for Proposed
NYSEG CAES Project

Reading Center Vicinity, Schuyler County, New York

Submitted by:
Jacquie Payette, RPA, PI Archaeology
Danna Gosney, PI Architectural History

Environmental Resources Management
399 Boylston Street
Boston, MA 02116

Lead Agency:
TBD

December 16, 2011

ERM

Management Summary

New York State Office of Parks, Recreation and Historic Preservation Project Review Number (if available):

Involved State and Federal Agencies (DEC, CORPS, FHWA, etc): USDOE & NYSERDA

Phase of Survey: IA

Location Information
Location: State Route 14A
Minor Civil Division: Reading
County: Schuyler

Survey Area (Metric & English)
No formal survey conducted—Phase IA informal reconnaissance only

USGS 7.5 Minute Quadrangle Map
Reading Center, New York (1979)

Archaeological Survey Overview
Number & Interval of Shovel Tests: 0
Number & Size of Units: N/A
Width of Plowed Strips: N/A
Surface Survey Transect Interval: no formal survey conducted

Results of Archaeological Survey
Number & name of prehistoric sites identified: 0
Number & name of historic sites identified: 0
Number & name of sites recommended for Phase II/Avoidance: 0

Results of Architectural Survey
Number of buildings/structures/cemeteries within project area: 0
Number of buildings/structures/cemeteries adjacent to project area: 14
Number of previously determined NR listed or eligible buildings/structures/cemeteries/districts: 0
Number of identified eligible buildings/structures/cemeteries/districts: 0

Report Authors
Jacquie Payette, RPA, Archaeology PI
Danna Allen, Architectural History PI

Report Date
December 16, 2011

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1.0 Introduction

1.1 Project Description

The purpose of this Phase IA Cultural Resources Survey is to provide information about historic architectural and archaeological properties within the direct and indirect Areas of Potential Effects (APEs) of the New York State Electric & Gas (NYSEG) Seneca Compressed Air Energy Storage (CAES) Project located west of Seneca Lake off State Route 14A, in Reading, Schuyler County, New York (Appendix A, Figure 1). The CAES Project is a 130 to 180 MW compressed air energy storage plant that consists of an electrically driven compression cycle and a turbine expansion cycle that will produce electricity. The CAES plant will provide sufficient storage to allow full operation during peak demand time periods in support of transmission system and market needs (approximately 10 hours per day).

This Phase IA Cultural Resources Survey will be reviewed by the New York State Historic Preservation Office (NYSHPO). This study was performed to establish whether any previously-identified historic properties exist within the project's APE and to investigate the potential existence of previously unidentified historic properties.

1.2 Subject Property

The subject property is located off State Route 14A, Reading, Schuyler County, New York (Appendix A, Figure 1). The property occupies approximately 18 acres, of which, approximately 13 acres of the property developed with CAES process equipment, support buildings and parking areas. The surrounding land use is predominantly agricultural.

1.3 Area of Potential Effects (APE)

The National Historic Preservation Act of 1966 defines Area of Potential Effect (APE) as:

> "The geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historic properties, if any such properties exist. The area of potential effects is influenced by the scale and nature of an undertaking and may be different for different kinds of effects caused by the undertaking (36 CFR 800.16(d), amended 2004)."

To determine the APE, the full scope of the intended project must be understood. The direct APE includes all areas directly affected by the development and implementation of the project, including the project footprint as well as any areas used for borrow, fill, staging, or any other purposes during construction and maintenance. Determining the indirect APE should take into consideration visual effects; auditory effects; and other indirect effects; beneficial, as well as adverse effects; physical effects; and changes in the way the land or historic properties are used. A project may have a single APE that includes all of these effects or may generate multiple APEs, one each for visual effects, direct effects, and indirect effects, which may or may not overlap.

The APE for archaeological resources includes where the proposed project would have a physical effect on buried historic properties, if any exist. The physical or direct APE includes those portions of the subject property that will be disturbed by the proposed undertaking or the project footprint.

The APE for historic architectural resources is the area within which the proposed undertaking could reasonably be expected to have a physical or visual effect on above-ground historic properties if any exist. The physical or direct APE includes those portions of the subject property that will be disturbed by the proposed undertaking. The indirect APE includes a 2-mile buffer around the subject property (Appendix A, Figure 1).

1.4 Dates the Study Was Conducted

The project area was visited by Jacquie Payette, RPA on September 6, 2011. Kim Croshier, of Croshier Archaeological Research, completed the site files search at the New York SHPO (NYSHPO) and New York State Museum (NYSM) on September 1, 2011.

1.5 Methodology

The purpose of a cultural resources investigation is to identify buildings, structures, sites and objects listed on or eligible for listing on the National Register of Historic Places (NRHP). Jacquie Payette, RPA of ERM conducted a reconnaissance survey of the project site and areas within the 2-mile study area, centered around the anticipated approximate center of the project footprint, that had the potential to be affected visually by the project.

2.0 Background Research

2.1 Methods

Researchers systematically reviewed background materials and conducted site inspections to search for previously identified historic properties within the study area and to evaluate the potential of the study area to contain previously unidentified historic properties. Archives that were visited or consulted include the following:

- NYSHPO online resources at http://nysparks.stat.ny.us;
- NYSHPO office files; and
- New York State Museum (NYSM) office files.

The potential for prehistoric use of the study area, which includes a two-mile radius around the anticipated approximate center of the project footprint, was assessed through a review of site records, maps and cultural resource management reports on projects in the project vicinity housed at NYSHPO and NYSM. In addition, review of soils in the study area was performed to aid in assessing

archaeological potential.

Prior historic-period land use was researched primarily through a review of historic maps, historic aerials, and the previously noted secondary sources. Also consulted were NYSHPO's files on properties determined eligible for listing on the National Register of Historic Places (NRHP).

2.2 Historic Context

A review of historic aerial photographs was conducted to assess the sensitivity of the property for previously unrecorded archaeological and historic structural resources. ERM reviewed aerial photographs (1942, 1957, 1960, 1985, 1994, 2006, 2008; Appendix C). Table 1 presents comments on these aerial photographs.

Table 1. Comments on Historic Aerial Photographs

Year	Comments
1942	A smaller building on a parcel northwest of the project site, closest to the road, is shown. The area where the new facility will be built is shown as undeveloped and in agricultural use. The surrounding land use appears to be agricultural with some wooded land to the south.
1957	The smaller building, closest to the road, is shown. The area where the new facility will be built appears to be undeveloped, possibly agricultural in use. There is a roadway or some other kind of transportation route(s) that appears to come into the facility from the west - southwest. The route has a spur approximately 375-feet from the facility that leads to the south. The surrounding land use appears to be agricultural with some wooded land to the south.
1960	This aerial is difficult to discern; it appears that the second building may be extant. The area where the new facility will be built appears to be undeveloped. The transportation route(s) are not identifiable. The surrounding land use appears to be agricultural with some wooded land to the south.
1985	Both buildings and parking areas are present on the parent parcel. The area where the new facility will be built appears to be undeveloped. The surrounding land use appears to be wooded.
1994	Both buildings and parking areas are present on the parent parcel. The area where the new facility will be built appears to be undeveloped. The alignment for the transportation routes does not appear to be present. The immediately surrounding properties appear to be wooded land to the east and south.
2006	Both buildings and parking areas are present on the parent parcel. The area where the new facility will be built appears to be undeveloped. The alignment for the transportation routes does not appear to be present. The immediately surrounding property appears to be wooded land to the east and south.
2008	Both buildings and parking areas are present on the parent parcel. The area where the new facility will be built is shown as undeveloped land. The alignment for the transportation routes is not shown. The immediately surrounding property is wooded land to the south and west.

2.3 Soils and Land Slopes

Soils within the project area consist mainly of Burdett silt loams (BuB), with slopes of 3 to 8 percent (Appendix A, Figures2 and 3. A typical profile for this soil type consists of silt loam at 0 to 8 inches,

overlying another layer of silt loam from 8 to 19 inches, overlying silty clay loam from 19 to 32 inches, with channery silt loam below that to 64 inches. The parent material for Burdett silt loam is a thin silt mantle overlying till that includes shale. This soil is somewhat poorly drained, and the setting is drumliniod ridges, hills, and till plains (USDA NRCS Web Soil Survey 2011). Burdett silt loam is present at the proposed main facility location and some of the linear corridor routes.

Along the linear corridor running to the west, Conesus silt loam (CsB) is present, with slopes of 3 to 8 percent. The parent material for this soil type is loamy till derived from shales including siltstone, sandstone, and limestone. The typical soil profile includes layered silt loams to a depth of 56 inches, with gravelly silt loam to 77 inches. This soil is moderately well drained, and occurs along similar landforms as Burdett silt loams.

Along the linear corridor running to the east, Schoharie silty clay loam (ScC3 and ScB3) predominates. Slopes vary from 8 to 15 percent, and the soils are severely eroded. A typical soil profile includes layered silty clay loam or silty clay 60 inches. This moderately well drained soil is derived from parent material of reddish clayey and silty glaciolacustrine deposits (USDA NRCS Web Soil Survey 2011).

Previous investigations in the general area have encountered artifacts within the first 20 cm below ground surface, and have described soils as often being shallow, with bedrock often exposed. Deeply buried cultural deposits do not appear likely in this area. The proposed CAES plant site is located on fairly level ground with slopes of 8% or less. Portions of the linear corridors running east and west include more steeply sloped areas (Appendix A, Figure 2).

3.0 Archaeology

3.1 Previously Identified Archaeological Sites

A review of existing documents and records for information about known archaeological sites within, or immediately adjacent to, the boundaries of the subject property included an examination of the records housed at both the NYSHPO and the NYSM, and secondary sources that included cultural resource management reports. The research did not identify any recorded archaeological sites within the study area.

3.2 Potential for Previously Unidentified Archaeological Sites

A 1979 study just north of Watkins Glen along Salt Point Road, including a small portion of the current study area along the railroad tracks running up to Salt Point along the western shore of Seneca Lake, found that two previously recorded archaeological sites were located within their study area, which does not overlap with the current project area (Mair 1979). This study estimated that the archaeological sensitivity for relatively level and undisturbed portions of their study area was moderate to high. Due to slope and prior disturbance, much of the study area proved unavailable for archaeological testing.

A 1995 survey followed a corridor in Schuyler County that included the US Salt property, with negative results (Murphy 1995).

In 1997, a 43-mile corridor through Steuben and Schuyler counties that includes a portion that runs roughly north-south just west of Irelandville, turning east just north of that town, terminating near Seneca Lake, just north of Salt Point (see Figure 2), was studied (Dean et al 1997). The study identified a total of 11 prehistoric archaeological sites, eight of which consisted of isolated finds. Three of the identified sites were lithic scatters recommended to have the potential to yield valuable information

relevant to prehistory, all located on the south side of the Cohocton River. No sites were identified in the vicinity of the current project area.

Hartgen Archeological Associates conducted a survey of a 3.5 mile by 20 foot corridor from Route 14 to Salt Point (Stull 2004). The area was tested with 357 shovel test probes at 15 m intervals, six of which yielded historic cultural materials. No sites with research potential were identified. A sensitivity assessment provided in this study found that, based on the lack of known sites within one-half mile of the study area, the fact that sites within one mile could not be relocated during professional survey, and the historic Seneca focus south of Seneca Lake along the shoreline, the area has low sensitivity for historic cultural materials. The combination of previously disturbed areas and areas with bedrock at the surface further decreases the likelihood of identifying significant archaeological sites.

Hartgen Archeological Associates, in 2005, conducted archaeological reconnaissance survey along Nye Road, northeast of Reading Center, between Schuyler Airfield Road and the Conrail Tracks, a corridor of 2,800 by 20 feet (Stull 2005). This study considered the study area to have low sensitivity for prehistoric cultural material, based on the literature review results, and the limited access to the uplands from the lakeshore because of steep topography. The sensitivity for historic cultural materials is considered low, based on settlement patterns, consisting of agricultural use and scattered farmsteads. Of 58 shovel test probes, five were positive for historic materials. No sites with research value were identified, based on lack of integrity and limited assemblages.

Several cultural resources studies have been conducted in the vicinity of the CAES project area. No archaeological sites are recorded within two miles of the project area. Because the entire project area has not been subjected to systematic archaeological survey, the potential exists for previously unidentified sites to be present. However, based on the historic use of the general area for agricultural and industrial purposes, the presence of bedrock at the surface in some areas, the apparent lack of both prehistoric and historic activity in the area, and the numerous negative surveys in the area, this potential is considered to be very low.

3.3 Sensitivity Assessment

Prehistoric

No prehistoric sites are recorded within two miles of the project area, even though there have been several cultural resources surveys conducted. The soils in the CAES project area are somewhat poorly drained. The project area has poor access to water, based on steep topography. Therefore, prehistoric sites would likely be limited to expedient use locations for sharpening of tools or hunting, or very short-term camps. Based on previous survey reports, negative previous survey results, consideration of soils and topography, and historic Seneca land-use patterns, the sensitivity of the project area for prehistoric sites is considered low. In areas of steep slope along the linear corridors, the sensitivity would be extremely low.

Historic

No historic sites are recorded within two miles of the project area. Historic cultural materials identified by previous surveys in the area have not been recommended as having potential to provide significant information based on lack of integrity and limited material recovered. Based on agricultural use, commercial/industrial development including but not limited to salt procurement, and the presence of roads and railroads through the general area, diffusely scattered modern and recent historic rubbish is expected in the area. Review of aerial photographs did not indicate specific historic use of the project area, other than for agriculture. Therefore, the sensitivity of the project area for historic sites is considered low. In areas of steep slope along the linear corridors, the sensitivity would be extremely low.

3.4 Disturbance

Based on the proximity of the CAES project area to developed roads, railroads, commercial/industrial facilities, and agricultural areas, some prior disturbance of the project area is anticipated. However, review of historic aerials did not show specific evidence of disturbances. Previous surveys in the general area encountered disturbed soils. During the field visit, heavy plant cover completely obscured the ground surface and condition (Appendix B). Therefore, although specific prior disturbance could not be documented at the time of this report, some prior disturbance within the project area is likely to have occurred.

3.5 Testing Recommendations

The sensitivity of the project area for significant prehistoric and historic archaeological sites is considered to be low, as discussed above. However, previously unidentified archaeological sites could exist in undisturbed portions of the project area. Limited sub-surface archaeological testing is recommended to determine what portions of the project area are undisturbed, and to confirm the low sensitivity assessment of the project area.

4.0 Historic Architectural Resources

4.1 Previously Identified Architectural Resources

A review of existing documents and records for information about known archaeological sites within, or immediately adjacent to, the boundaries of the property included an examination of the records housed at both the NYSHPO and the NYSM, and secondary sources that included cultural resource management reports. Research results included:

- No **recorded** architectural site(s) exist within the direct APE.
- No **recorded** NRL or NRE properties exist within the direct APE or indirect APE.
- Eleven previously recorded sites within the indirect APE which have no determination of eligibility. These previously recorded sites are listed in TABLE 2 below.

Table 2 Previously Recorded Sites

Building Inventory Number	Property Description	Form Available	Photo Location
9707.007	2675 Cemetery Road	Yes	2
9707.0010	4011 Rt. 14 A	Yes	1
9707.0012	4489 State Rt. 14	Yes	5
9707.0009	3461 County Rt. 30/Salt Pt. Rd.	Yes; location unknown	4
9707.0003	Drovers Tavern	Yes; exact location unknown	N/A
9707.0001	John Ireland Manor House	Yes; exact location unknown	N/A
9707.0002	White Pump Tavern	Yes; exact location unknown, form illegible	N/A
9707.0008	2571 Church Rd; Morgan Farm	No form	3
9707.0016	4555 NY 14; Russell Residence	No form	6
9707.0015	2625 Spencer Rd.	No form	7
9707.0014	3451 Vanvleet Rd.	No form; however street maps over 6 miles sw of project site not within 2 mile indirect APE	N/A

4.2 Potential for Previously Unidentified Architectural Resources

No systematic architectural survey of the indirect APE has been conducted. The exact radius of the indirect APE has not been determined. The field visit conducted by Ms. Payette on September 6, 2011 considered previously recorded structures within two miles of the project area. At the same time, Ms. Payette observed and photographed typical structures throughout the area. Unidentified architectural resources are very likely to exist within two miles of the project area. Whether any significant historic structures exist within the actual indirect APE remains to be determined. Based on the field visit and archival research, seven previously unidentified architectural resources that may be 50 years or more of age were noted within two miles of the project area. These seven resources are described in Table 3 below.

Table 3 Architectural Resources

Property Location & Description	Photo Location
Route 14; Cemetery	17
3851 Rt. 28; Two story, rectangular plan, side-gabled house with five ranked windows with center door, asbestos shingle siding, exterior gable wall concrete block chimney, standing seam metal roof and full width front porch supported by a spindlework frieze and bracketed columns..	20
3921 Rt. 14A; One and a half story house with an asymmetrical plan vinyl siding and an asphalt shingle roof.	22
Route 14A; One and a half story house with rectangular plan, 1/1 light windows, and front porch supported by square columns on square piers.	23
3811 Rt. 14; One and a half story house with a dual pitched hipped roof with asphalt shingles, vinyl siding and enclosed front porch.	25
3815 Rt. 14- Chieftain Motel; One story mid twentieth-century roadside motel with exterior entrances to the rooms	26
Rt 14; house next to Chieftain Motel. The house appears to be comprised of at least two different blocks or volumes; a square 4 ranked block and an L-shape block with a porch.	26

4.3 Survey Recommendations

Discussions with NYSHPO should take place to determine the appropriate indirect APE based on the proposed CAES project undertaking. Once the indirect APE is decided, a limited Phase IB field investigation survey, to include limited archaeological testing as well as architectural survey, is warranted based on ERM's research and this Phase IA report.

5.0 Conclusions and Recommendations

No archaeological sites are known to exist within the direct APE, nor within two miles of the project area. Although prior surveys exist for the area, a lack of identified sites, and environmental factors such as topography and poor access to water, the historic use of the area for industrial and commercial purposes and the possible previous disturbance within areas that constitute the direct APE, the CAES project area has low potential to contain intact buried cultural remains. Therefore, ERM recommends a limited subsurface archaeological testing under Phase IB to evaluate the level of prior disturbance throughout the project area and to confirm the low sensitivity finding.

A review of previously recorded architectural resources indicated that there are no such resources within the direct APE. Eleven documented architectural resources were found within a two-mile radius of the proposed project area. The significance of the seven previously unidentified properties included in this report as representative examples would be addressed in a Phase IB report, if they were determined to fall within the indirect APE for this project. ERM recommends that discussions with NYSHPO take place to determine the appropriate indirect APE based on the proposed undertaking and given the fact that unidentified architectural resources are likely to exist within the viewshed. Once the indirect APE is indicated, whether any significant historic structures exist within the indirect APE will need to be determined through a Phase IB survey.

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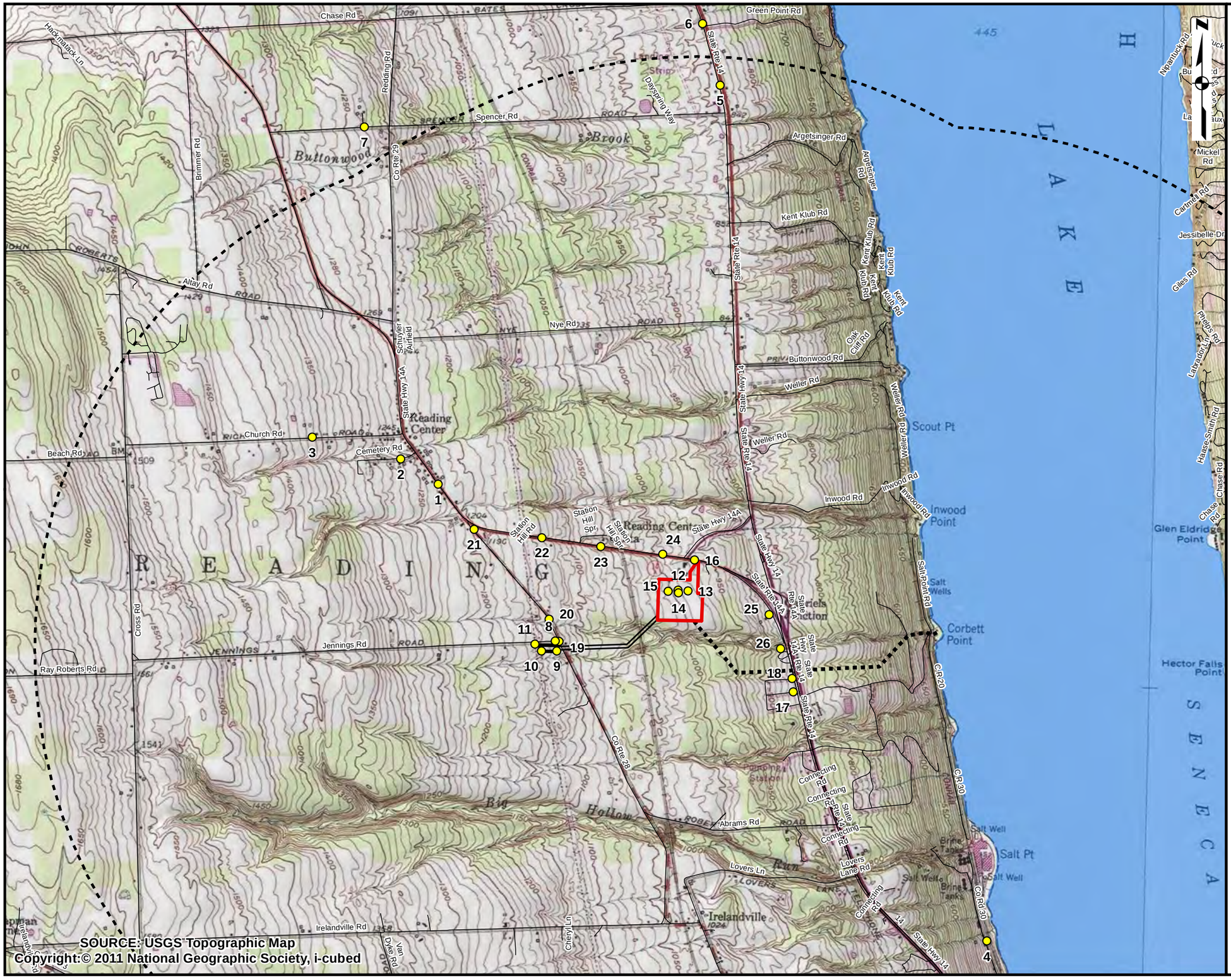
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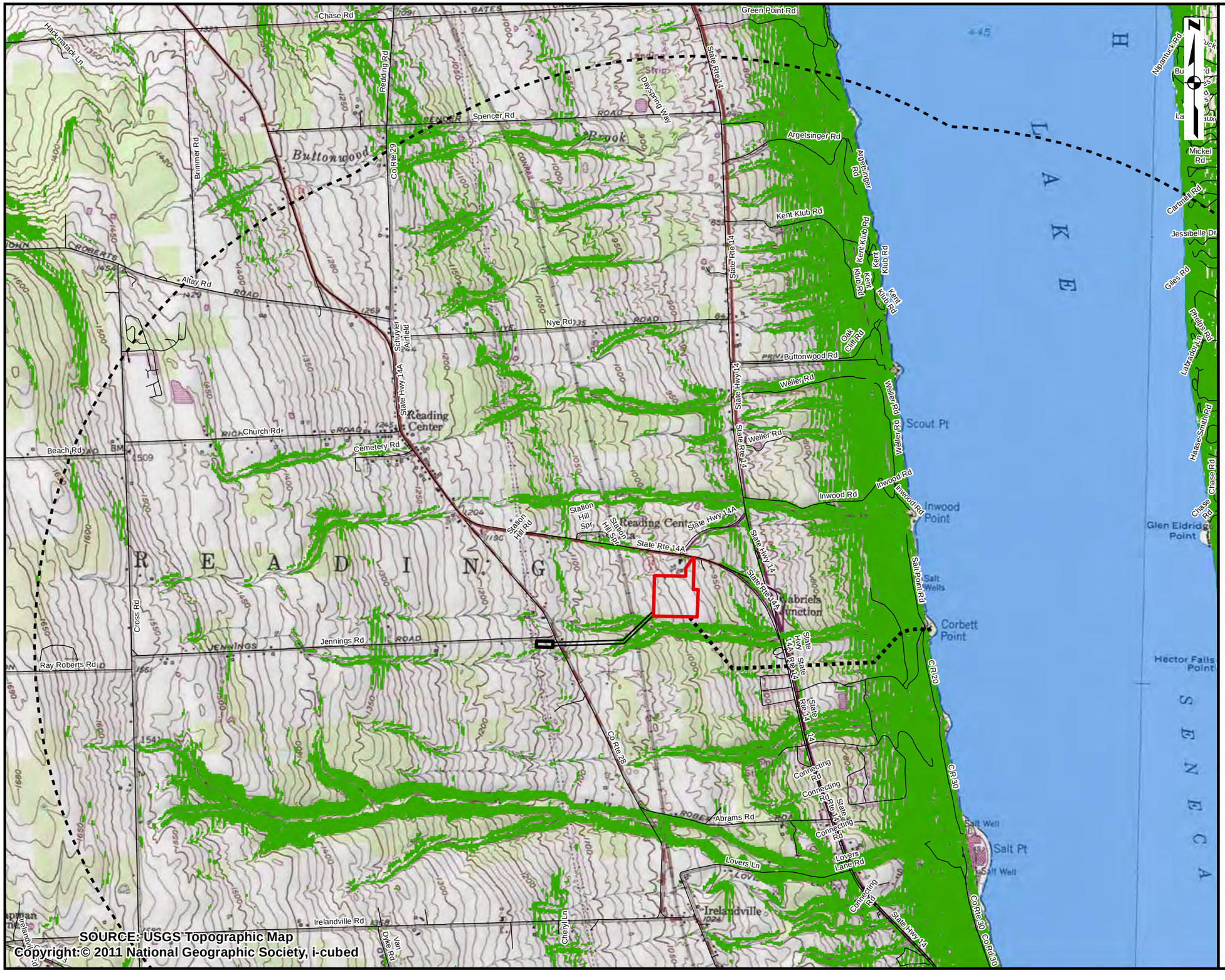
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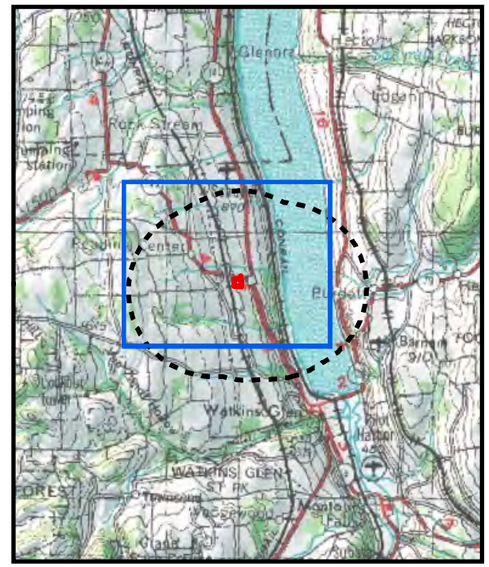
Web Soil Survey
2011 *USDA NRCS Web Soil Survey.* Accessed on September 15, 2011. Accessed at websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx. Spatial and tabular data dated February 18, 2010.

Aerial Photographs
2011 *Provided by Environmental Data Resources (EDR)*


Chase Rd
Green Point Rd
Spencer Rd
Argetsinger Rd
Kent Klub Rd
Nye Rd
Buttonwood Rd
Weller Rd
Inwood Rd
Alfay Rd
Church Rd
Cemetery Rd
Beach Rd
Jennings Rd
Ray Roberts Rd
Irelandville Rd
Abrams Rd
Lovers Ln
Redding Rd
Brimmer Rd
Co Rte 29
State Rte 14
State Hwy 14A
Schuyler Airfield
Oak Cliff Rd
Mickel Rd
Cartmel Rd
Jessibelle Dr
Giles Rd
Phelps Rd
Labrador Ln
Haase-Smith Rd
Chase Rd
Nipantuck Rd
Salt Point Rd
Corbett Point
Hector Falls Point
Glen Eldridge Point
Scout Pt
Inwood Point
Salt Pt
Salt Well
Salt Wells
Brine Tanks
Co Rte 30
Co Rte 28
Cross Rd
Chery Ln
Van Dyke Rd
Dalyspring Way
Station Hill Rd
Station Hill Spr
Connecting Rd
Lovers Lane Rd
Reading Center
Irelandville
Buttonwood
Big Hollow
Lovers Run
Brook
Strip
Airfield
Rock Stream
Glenora
Watkins Glen
Watkins Glen ST PK
Montour Falls
Barrett Hill
Pine Harbor
Woodland Park
Grand View
Hector
Seneca Lake
445
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
N
Legend
Approximate Site Infrastructure -
Approximate Facility Boundary
Approximate Substation Boundary
Approximate Intake Pipeline
Approximate Power Lines
Other Features -
Photo Point Locations
2 Mile Project Area Buffer
Permanent Standing Water
2010 TIGER/Line - Roads
0 0.25 0.5 1
Miles
1:24,000
Figure 1: Project Map
NYSEG
Schuyler County, NY
ERM
SOURCE: USGS Topographic Map
Copyright:© 2011 National Geographic Society, i-cubed
G:\Graphics\Clients_V_Z\Worley\Parsons\Watkins Glen, NY\MXD\WorkingFigures\ProjectMap_20110913.mxd Date: 12/16/2011



SOURCE: USGS Topographic Map
Copyright:© 2011 National Geographic Society, i-cubed



Legend

Approximate Site Infrastructure -

- Approximate Facility Boundary
- Approximate Substation Boundary
- Approximate Intake Pipeline
- Approximate Power Lines

Other Features -

- >12% Slope
- 2 Mile Project Area Buffer
- Permanent Standing Water
- 2010 TIGER/Line - Roads

NOTE: % Slope calculated from the USGS National Elevation Dataset (NED) 1/3rd Arc Second

0 0.25 0.5 1 Miles

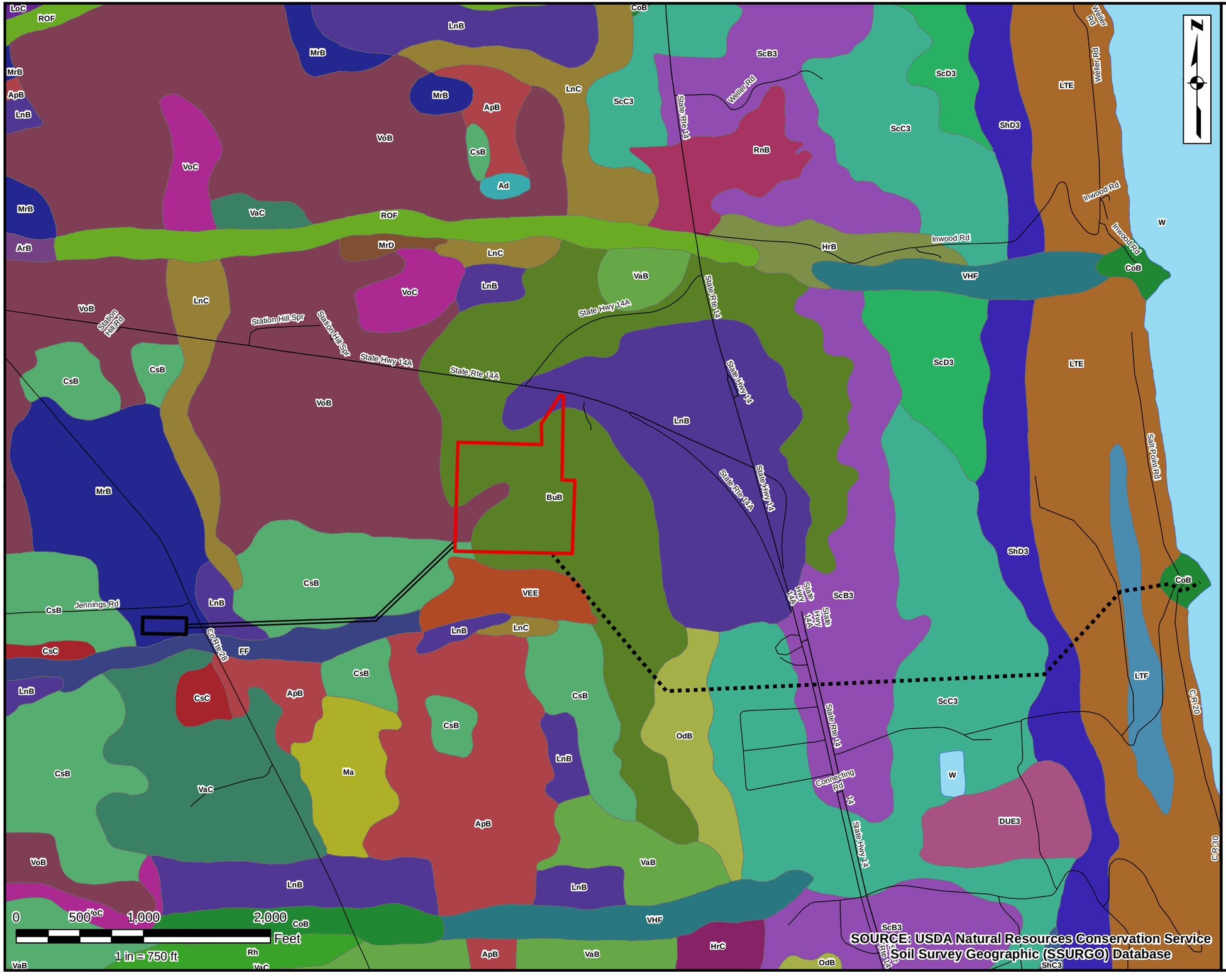
1:24,000

Figure 2: Project Map - Slope

NYSEG
Schuyler County, NY

ERM

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Legend

Approximate Site Infrastructure -

- Approximate Facility Boundary
- Approximate Substation Boundary
- Approximate Intake Pipeline
- Approximate Power Lines
- 2010 TIGER/Line - Roads

USDA - NRCS Soils -

- Ad - Alden silt loam
- ApB - Appleton silt loam, 3 to 8 percent slopes
- ArB - Arnot channery silt loam, 3 to 8 percent slopes
- BuB - Burdett silt loam, 3 to 8 percent slopes
- CoB - Chenango channery silt loam, fan, 0 to 8 percent slopes
- CsB - Conesus silt loam, 3 to 8 percent slopes
- CsC - Conesus silt loam, 8 to 15 percent slopes
- DUE3 - Dunkirk and Hudson soils, steep, severely eroded
- FF - Fluvaquents-Udifluvents complex, frequently flooded
- HrB - Howard gravelly loam, 3 to 8 percent slopes
- HrC - Howard gravelly loam, 8 to 15 percent slopes
- LTE - Lordstown-Arnot complex, steep
- LTF - Lordstown-Arnot complex, very steep
- LnB - Lansing gravelly silt loam, 3 to 8 percent slopes
- LnC - Lansing gravelly silt loam, 8 to 15 percent slopes
- LoC - Lordstown channery silt loam, 8 to 15 percent slopes
- Ma - Madalin silt loam
- MrB - Mardin channery silt loam, 3 to 8 percent slopes
- MrC - Mardin channery silt loam, 8 to 15 percent slopes
- MrD - Mardin channery silt loam, 15 to 25 percent slopes
- OdB - Odessa silt loam, 3 to 8 percent slopes
- ROF - Rock outcrop-Arnot complex, very steep
- Rh - Red Hook gravelly silt loam
- RnB - Rhinebeck gravelly silt loam, 3 to 8 percent slopes
- ScB3 - Schoharie silty clay loam, 3 to 8 percent slopes, severely eroded
- ScC3 - Schoharie silty clay loam, 8 to 15 percent slopes, severely eroded
- ScD3 - Schoharie silty clay loam, 15 to 25 percent slopes, severely eroded
- ShC3 - Schoharie variant silty clay loam, 8 to 15 percent slopes, severely eroded
- ShD3 - Schoharie variant silty clay loam, 15 to 25 percent slopes, severely eroded
- VEE - Valois soils, steep
- VHF - Valois and Howard soils, very steep
- VaB - Valois gravelly silt loam, 3 to 8 percent slopes
- VaC - Valois gravelly silt loam, 8 to 15 percent slopes
- VoB - Volusia channery silt loam, 3 to 8 percent slopes
- VoC - Volusia channery silt loam, 8 to 15 percent slopes
- W - Water

Figure 3: Project Map - Soils

NYSEG

Schuyler County, NY

ERM

G:\Graphics\Clients_V_Z\Worley\Parsons\Watkins Glen, NY\MXD\WorkingFigures\ProjectMap_Soils_20110915.mxd Date: 12/16/2011



Photo Location: *1*	*4011 Rt. 14A; 9707.00010*

Compressed Air Energy Storage (CAES) Report	***ERM***	*State Route 14A Reading, Schuyler County, NY*

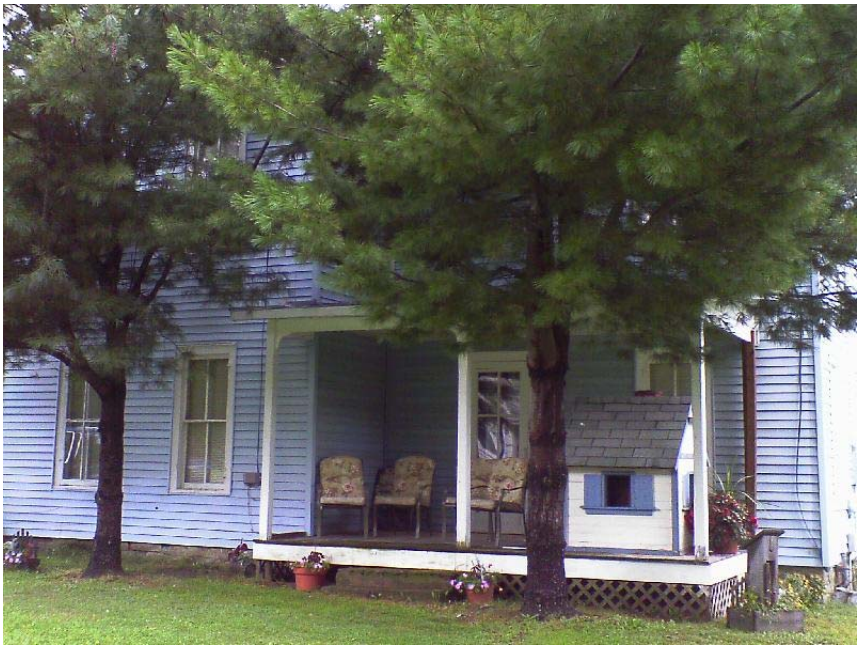


Photo Location: *2*	*2675 Cemetery Road; 970.00007*

Compressed Air Energy Storage (CAES) Report	***ERM***	*State Route 14A Reading, Schuyler County, NY*



Photo Location: *3*	*2571 Church Road; Address given for 970.00008 (no form found)*



Photo Location: *4*	*3461 Salt Point Road; 970.00009- Seneca Lake Wine Cellar*



Photo Location: *5*	*4489 Rt. 14; 970.00012*	
Compressed Air Energy Storage (CAES) Report	***ERM***	*State Route 14A* *Reading, Schuyler County, NY*



Photo Location: *6*	*4555 Rt. 14; Address given for 970.00016 (no form found)*	
Compressed Air Energy Storage (CAES) Report	***ERM***	*State Route 14A* *Reading, Schuyler County, NY*



Photo Location: *7*	*2625 Spencer* Road; Address given for 970.00015 (no form found)



Photo Location: *17*	*Cemetery*



Photo Location: *20*	*3851 Rt. 28*

Compressed Air Energy Storage (CAES) Report	***ERM***	*State Route 14A Reading, Schuyler County, NY*



Photo Location: *22*	*3921 Rt. 14A*

Compressed Air Energy Storage (CAES) Report	***ERM***	*State Route 14A Reading, Schuyler County, NY*



Photo Location: *23*	*Rt. 14A*

Compressed Air Energy Storage (CAES) Report	***ERM***	*State Route 14A Reading, Schuyler County, NY*



Photo Location: *25*	*3811 Rt. 14*

Compressed Air Energy Storage (CAES) Report	***ERM***	*State Route 14A Reading, Schuyler County, NY*

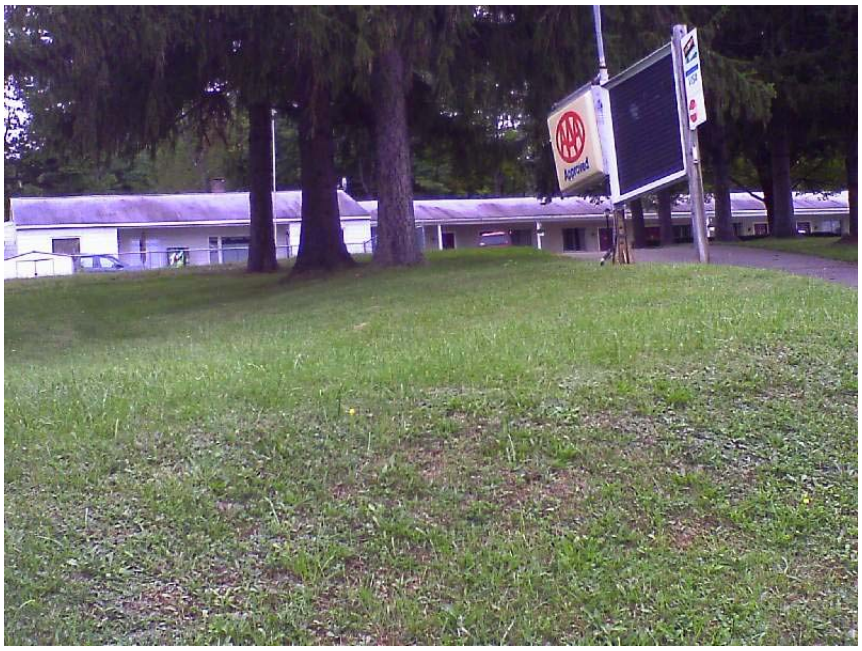


Photo Location: *26a*	*3815 Rt. 14- Chieftan Motel*

Compressed Air Energy Storage (CAES) Report	***ERM***	*State Route 14A Reading, Schuyler County, NY*



Photo Location: *26b*	*Rt. 14*

Compressed Air Energy Storage (CAES) Report	***ERM***	*State Route 14A Reading, Schuyler County, NY*



Photo Location: 10	*Approximate center of proposed substation location, looking east.*

Compressed Air Energy Storage (CAES) Report	***ERM***	*State Route 14A Reading, Schuyler County, NY*



Photo Location: 10	*Approximate center of proposed substation location, looking south.*

Compressed Air Energy Storage (CAES) Report	***ERM***	*State Route 14A Reading, Schuyler County, NY*



Photo Location: 10	*Approximate center of proposed substation location, looking west*

Compressed Air Energy Storage (CAES) Report	***ERM***	*State Route 14A Reading, Schuyler County, NY*



Photo Location: 10	*Approximate center of proposed substation location, looking north*

Compressed Air Energy Storage (CAES) Report	***ERM***	*State Route 14A Reading, Schuyler County, NY*



Photo Location: 16	*Looking into project area from Rt. 14A, looking south – plant location*	
Compressed Air Energy Storage (CAES) Report	***ERM***	*State Route 14A Reading, Schuyler County, NY*



Photo Location: 13	*Looking northwest within project area – plant location*	
Compressed Air Energy Storage (CAES) Report	***ERM***	*State Route 14A Reading, Schuyler County, NY*

Route 14A
Route 14A
Watkins Glen, NY 14891

Inquiry Number: 3161481.1
September 09, 2011

The EDR Aerial Photo Decade Package

EDR® Environmental Data Resources Inc

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800.352.0050
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EDR Aerial Photo Decade Package

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Date EDR Searched Historical Sources:

Aerial Photography September 09, 2011

Target Property:

Route 14A

Watkins Glen, NY 14891

Year	***Scale***	***Details***	***Source***
1942	Aerial Photograph. Scale: 1"=1000'	Panel #: 42076-D8, Reading Center, NY;/Flight Date: October 08, 1942	EDR
1957	Aerial Photograph. Scale: 1"=750'	Panel #: 42076-D8, Reading Center, NY;/Flight Date: May 06, 1957	EDR
1960	Aerial Photograph. Scale: 1"=1000'	Panel #: 42076-D8, Reading Center, NY;/Flight Date: May 04, 1960	EDR
1985	Aerial Photograph. Scale: 1"=1000'	Panel #: 42076-D8, Reading Center, NY;/Flight Date: April 29, 1985	EDR
1994	Aerial Photograph. Scale: 1"=604'	Panel #: 42076-D8, Reading Center, NY;/Composite DOQQ - acquisition dates: April 22, 1994	EDR
2006	Aerial Photograph. Scale: 1"=604'	Panel #: 42076-D8, Reading Center, NY;/Flight Year: 2006	EDR
2008	Aerial Photograph. Scale: 1"=604'	Panel #: 42076-D8, Reading Center, NY;/Flight Year: 2008	EDR


INQUIRY #: 3161481.1
YEAR: 1942
= 1000'
N


INQUIRY #: 3161481.1
YEAR: 1957
= 750'
N
EDR Environmental Data Resources Inc


INQUIRY #: 3161481.1
YEAR: 1960
= 1000'
N


INQUIRY #: 3161481.1
YEAR: 1985
= 1000'
N
EDR Environmental Data Resources Inc