Recovery Act: Tapoco Project: Cheoah Upgrade
Final Technical Report

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Proprietary Data Notice: N/A for this project.

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Lists of Exhibits

List of Acronyms

Acronym	Definition
APGI	Alcoa Power Generating, Inc.
ARRA	American Recovery and Reinvestment Act of 2009
BOP	Balance of Plant
Cf/s	Cubic foot per second
DOE	U.S. Department of Energy
EISA	Energy Independence and Security Act of 2007
FOA	Funding Opportunity Notice
GPD	Gallons per day
GSU	Generator Step up transformer
MW	Megawatt
MWhrs	Megawatt hours
NERC	North American Electric Reliability Corporation
NFPA	National Fire Protection Association
OCBs	Oil Circuit Breakers
OMB	U.S. Office of Management and Budget
OSHA	Occupational Safety and Health Administration
SF	Sulfur Hexafluoride
TVA	Tennessee Valley Authority

1 EXECUTIVE SUMMARY

Purpose

Under Funding Opportunity Announcement Number: DE-FOA-0000120, Recovery Act: Hydroelectric Facility Modernization, Alcoa Power Generating Inc. (APGI), a fully owned subsidiary of Alcoa Inc., implemented major upgrades at its Cheoah hydroelectric facility near Robbinsville, North Carolina (see Exhibit 1).

Exhibit 1: Cheoah Hydroelectric Facility

Under this funding opportunity, APGI purchased four new high-efficiency turbines, generators, and transformers, upgraded the balance of plant equipment, and completed installation of two units within the performance period. In accordance with the objectives of the FOA, APGI's goals for the two-year project were to:

- Develop, deploy, and test hydropower projects that would modernize the existing hydropower infrastructure in the U.S. and increase both the quantity and value of hydropower generation, including environmental performance;
- Deploy turbines and control technologies to increase and maximize system generation at existing non-Federal hydroelectric facilities;
- Demonstrate improved environmental performance, such as a reduction in the rate of fish mortality at project sites or an increase in concentration of dissolved oxygen surrounding the project sites;
- Demonstrate improved quantity and quality (value) of energy produced, through increased efficiency and enhanced environmental performance;
- Demonstrate that generation will increase by at least 5% at the facility;
- Produce substantial new electric generation within two years from project initiation; and
- Promote and enhance the objectives of the Recovery Act, especially job creation and/or preservation, and economic recovery in an expeditious manner.

Scope

The overall project included upgrades to Units 1− 4 turbines and generators at the Cheoah hydropower plant, along with process and utility systems such as: transformers, switchgear,

power and control wiring, piping and fire protection. Under the DOE-funded portion of the program, Alcoa replaced two units within the program's time frame.

The Cheoah Powerhouse was built in 1919 with four generators, Units 1 through 4. Unit 5, (not included in the scope of this project) was installed in 1949 and its generator was rewound in 1995. At the time of this application, the average age of the original Cheoah plant equipment exceeded 86 years. Having been in service 45 years beyond their design limits, components had a high probability of catastrophic failure. These four generators had an output of 22 MW each with a theoretical upgrade potential of 5.5 MW each. Wicket gates and turbine shafts were 86 years old and the runners were 58 years old.

Results

APGI achieved significant successful results that meet technical project goals and address the intent and objectives of the Recovery Act. Results are summarized below and discussed in detail in the body of this report.

Objective	Result
• Develop, deploy, and test hydropower projects that would modernize the existing hydropower infrastructure in the U.S. and increase both the quantity and value of hydropower generation, including environmental performance	• Added 40 to 50 years of expected useful life of the facility without requiring any modifications to the facility and without any significant regulatory delay; • Improved Site Access / Storage / Parking • Implemented Geotechical Stabilization • Improved system protection for NERC compliance
• Deploy turbines and control technologies that increase and maximize system generation at existing non-Federal hydroelectric facilities	• Generation capacity increased from 44MW to maximum output of 66MW for two units • Purchased and installed new high-efficiency turbines, generators, and transformers, and upgraded the balance of plant equipment, including: o Field coils o Insulation o Exciter o Generator shaft o Guide bearing o Brake ring o Runner o Transformers o Switchgear o Power and control wiring o Piping o Fire protection
• Demonstrate improved quantity and quality (value) of energy produced, through increased efficiency and enhanced environmental performance	• Air-cooled generator step-up transformers eliminate cooling water requirements for transformers by 122,000 GPD • Replacing GSU transformers decreased total oil volume in high voltage equipment by 39,180 gallons • Installing new high pressure lift units reduced hydraulic oil on-site storage by 20,000 gallons • Modern, upgraded turbines provide 50% increase in generating capacity • Oil/Water Separator Tank eliminates risk of oil entering the waterway • Eliminated Asbestos insulation

• Demonstrate that generation will increase by at least 5% at the facility	• Generating capacity increased by 50% – from 44MW to maximum output of 66MW for the two units funded by DOE;[1]
• Produce substantial new electric generation within the project period	• The two units funded by DOE were operational 29 months after the project restarted.
• Improve health and safety conditions at the facility	• Installed fire protection system for unit protection and control room protection • Installed SF6 Gas Insulated Switchgear minimizing Arc Flash Hazard per NFPA 70E • Installed secondary access to Cave Area eliminating an OSHA confined space • Improved lighting throughout facility for increased visibility • This 280,000+ labor-hour program had zero loss time incidents
• Promote and enhance the objectives of the Recovery Act, especially job creation and/or preservation, and economic recovery in an expeditious manner	• The project averaged approximately 80 full time equivalents employed since September of 2010 • The project was 'shovel-ready' with a pre-established schedule, team of contractors, valid purchase agreements for equipment, and completed regulatory approvals to begin construction immediately • The project directly supports: green economy growth and sustainment, the use of renewable energy resources, and recreational opportunities. • Demonstrates private industry/government cooperation for sustainability of renewable energy for future generations

Exhibit 2: Summary of Project Results

Conclusions/Recommendations

The Cheoah Upgrade was a strong candidate to support the goals of the American Recovery and Reinvestment Act (ARRA) of 2009. The project was shovel-ready with a pre-established schedule, team of contractors, valid purchase agreements for equipment, and completed regulatory approvals to begin construction immediately. This project also supported the objectives of the Recovery Act's guiding legislation the Energy Independence and Security Act (EISA) of 2007, which supported projects that reduced the United States' reliance on foreign sources of energy and reinvests in major domestic industries that are critical for national security. Alcoa's Cheoah facility directly supports the sustainment of major aluminum fabrication operations in Alcoa, TN. Operating at full capacity, this facility supported approximately 700 jobs and was a critical asset to the nation's manufacturing base for fabricated aluminum products. In addition, the project reduced the plant's dependence on fossil fuels by 60 percent, reduced the risk of oil spillage, and directly supported; green economy growth and sustainment, the use of renewable energy resources, and recreational opportunities.

[1] Annual generation will be determined by rainfall totals in the watershed. However, the advantage of the increased generation upgrades will be realized under high flow conditions and being able to use the available watershed flows during peak load hours.

2 INTRODUCTION

Under Funding Opportunity Announcement Number: DE-FOA-0000120, Recovery Act: Hydroelectric Facility Modernization, Alcoa Power Generating Inc. (APGI), a fully-owned subsidiary of Alcoa Inc., implemented major upgrades at its Cheoah hydroelectric facility near Robbinsville, NC. The Tennessee Valley Authority (TVA) assessed and designated the Cheoah modification project the highest priority in the Tapoco system. Because the average age of the equipment at this facility exceeded 90 years – four or five decades beyond typical unit life – catastrophic failure was imminent, making the upgrade critical for maintaining this vital component of the local electrical power generation system. The original units had an output of 22 MW each.

Exhibit 3: Upgraded Powerhouse

For this effort, APGI made upgrades to two units (Exhibit 3) with work continuing outside this program on two additional units.

Additionally, the project replaced process and utility systems such as; transformers, switchgear, power and control wiring, piping and fire protection. The upgrade had a theoretical target to increase capacity from 22 MW to 27.5 MW each, for a capacity of 110MW, bringing the total facility capacity to 140 MW. However, after commissioning the first two units, actual capacity is 33MW/unit. Exhibits 4 – 8 show original and upgraded units, rotors, and transformer, and switchgear.

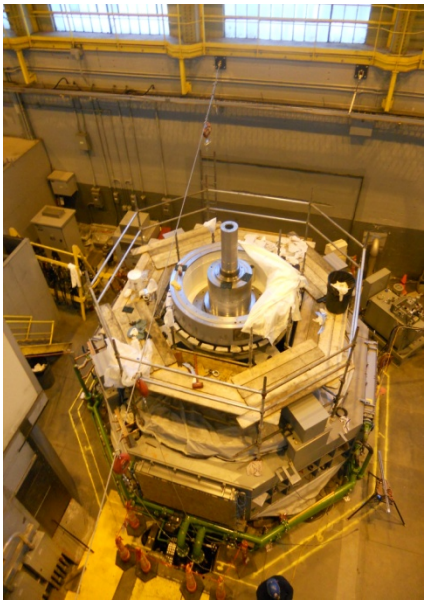


Exhibit 4: Original and Upgraded Units

Exhibit 5: Original and Upgraded Rotors

Exhibit 6: Original and Upgraded Transformer

Exhibit 7: Original and Upgraded Switchgear

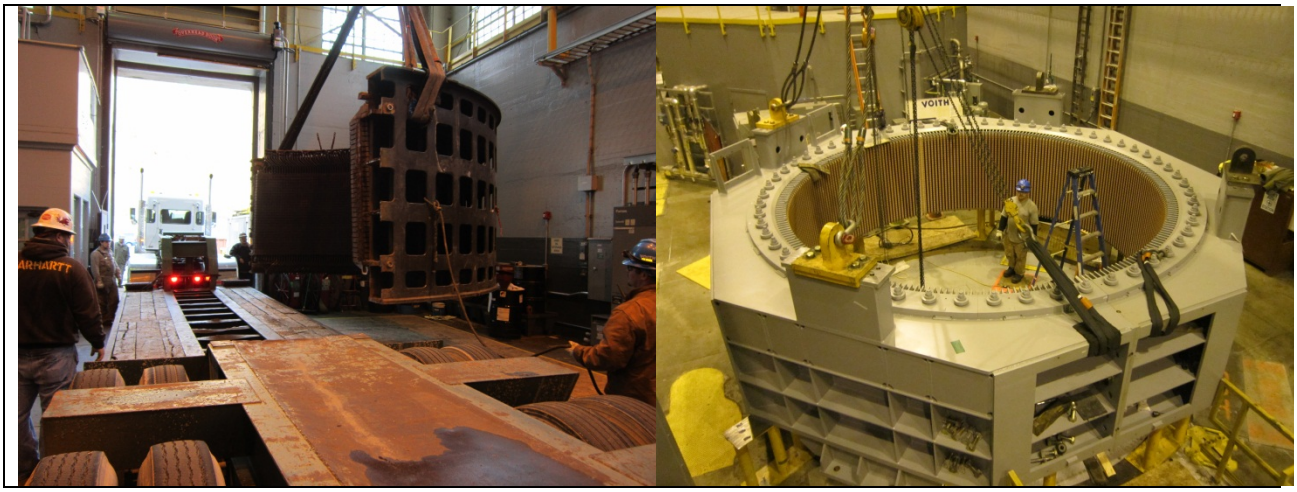


Exhibit 8: Original and Upgraded Stator

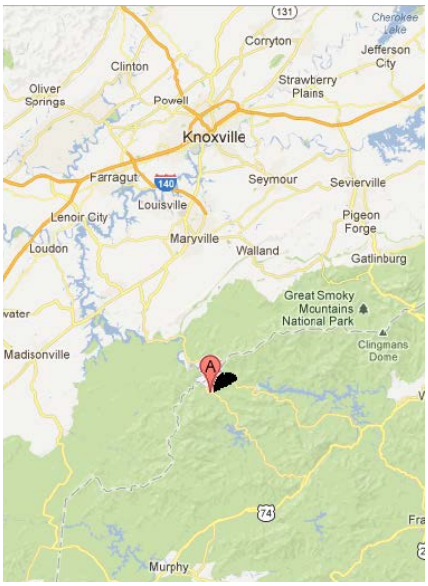
APGI's overall tasks included:

- Purchasing four new higher-efficiency turbines, generators, and transformers;
- Upgrading the balance of plant equipment; and
- Completing installation of two of the units within 29 months of funding.

At the project's initiation, Cheoah was one of the four hydroelectric developments in Alcoa's Tapoco system. Collectively, the four developments had current capacity of 360 MWs and an estimated average annual generation of 1,544,000 MW hours (MWhrs). The Tapoco system supplied Alcoa's Tennessee Operations approximately 45% of its annual power requirements, and feeds TVA's power grid for general distribution.[2]

3 BACKGROUND

There are approximately 2,400 hydropower facilities in the U.S., many of which have not undergone a significant upgrade in decades. These older facilities present a great opportunity to expand clean energy across the country, allowing us to rapidly increase generation capacity through the installation of new high-efficiency equipment. Cheoah represents the first tranche of upgrades for powerhouses of a similar age and operating beyond their original expected useful life (in excess of 45 to 50 years) across the nation. Cheoah should thereby create a baseline of industry lessons learned and best practices for dealing with minimal site modifications to older and/or historic facilities while achieving target capacity improvements.



[2] In the fall of 2012, the Tapoco system was sold to Brookfield Renewable Energy Partners, L.P.

3.1 Pre-Project Cheoah Facility

The Tapoco Project is a four-development hydroelectric system development located in the western portion of the Little Tennessee Watershed on the Little Tennessee and Cheoah Rivers in Graham, Swain, Blount, and Monroe Counties in North Carolina and Tennessee. The Tapoco Project is licensed by the Federal Energy Regulatory Commission as Project No. 2169, and its four developments – Santeetlah, Cheoah, Calderwood, and Chilhowee – have a combined licensed capacity of 380.1 megawatts, which not only serves Alcoa's Tennessee Operations but serves the power needs of TVA's entire user community.

Tapoco was created to manage the water power resources of these rivers to provide power for Alcoa's aluminum smelting and rolling operations in Alcoa, Tennessee (Tennessee Operations), which have existed in the foothills of the Great Smoky Mountains for more than 75 years. Today, Tennessee Operations, shown in Exhibit 9, is one of the most modern aluminum fabricating facilities in the world.

Exhibit 9: Alcoa's Tennessee Operations

Cheoah was the first of the Tapoco developments constructed and was completed in 1919. The development consists of a dam and powerhouse. The Cheoah dam impounds a Cheoah Reservoir having a normal full pool area of approximately 644 acres and a drainage area of 1,608 square miles. The normal full pool elevation of Cheoah Reservoir is 1276.8 feet (USGS). The Cheoah powerhouse is located immediately downstream of the intake section on the left bank, parallel to the Little Tennessee River. The powerhouse contains five vertical Francis turbines directly connected to generators. Four of the units (Unit Nos. 1, 2, 3 and 4) were original to the powerhouse when this project was initiated. The fifth unit (Unit No. 5) was added in 1949, is independent of the other four, and was not part of this modernization project. The original licensed capacity of the five units was 144.7 MW, and the total station hydraulic capacity was 9,436 cubic feet per second (cf/s). Water for Cheoah Units 1-4 is withdrawn through an intake located in rock at the left abutment of the facility, at a centerline depth of 46.5 feet below the normal full pool elevation of the reservoir. A schematic layout of the plant is shown in Exhibit 10.

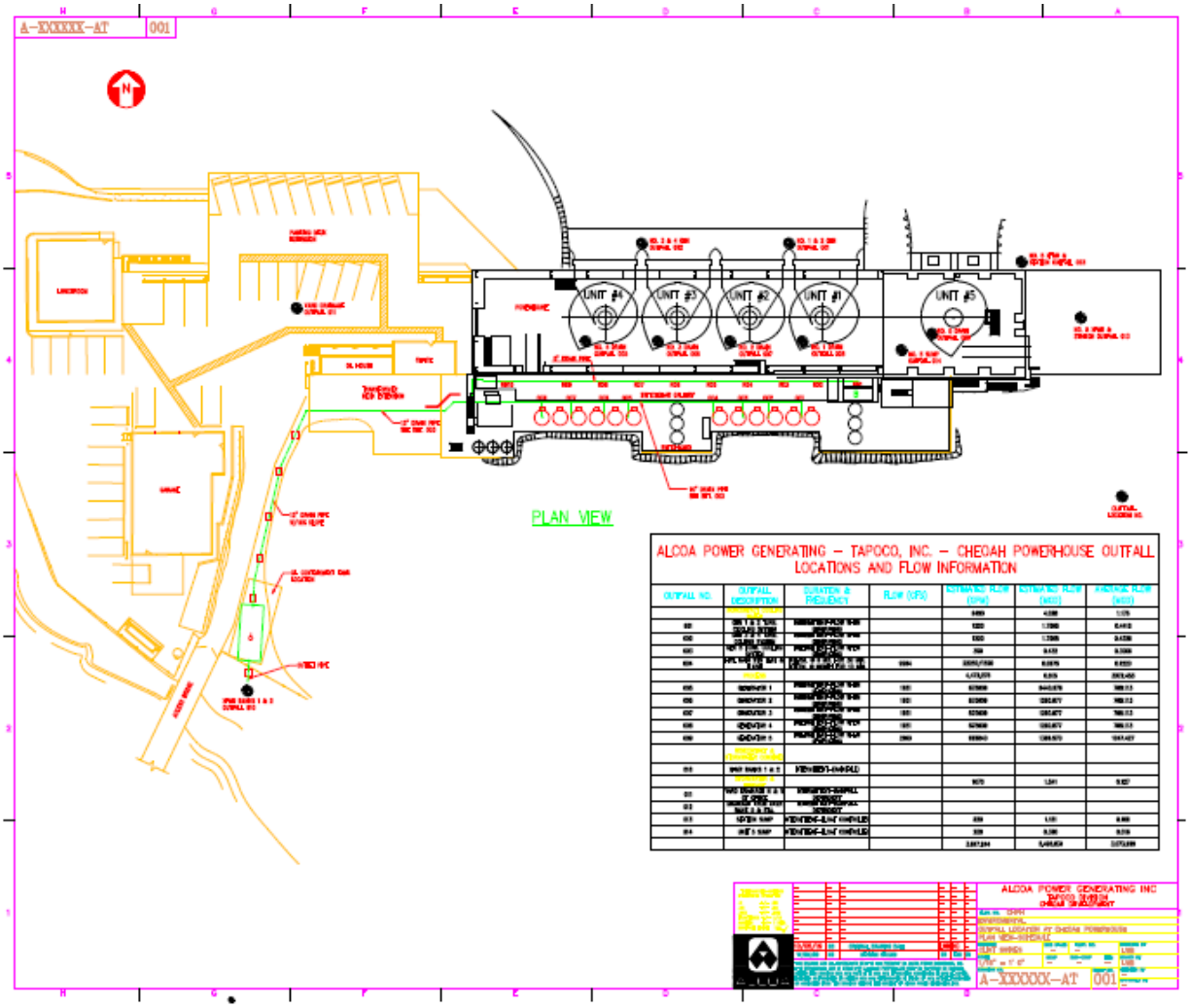


Exhibit 10: Cheoah Hydropower Plant Schematic Layout

Cheoah is operated in a run-of-river mode following the daily-cycle, peaking operations of the TVA's Fontana Facility located upstream of Cheoah. Fontana serves as the primary flow control facility for the lower Little Tennessee River and TVA assists Tapoco in determining the daily operation of the Tapoco developments to best match expected flow releases from Fontana.

Because of its limited storage capacity, Cheoah Lake is operated with minimal fluctuations in water levels. This reservoir is operated with daily storage of water inflow and with a maximum drawdown of seven feet. There is no seasonal drawdown.

3.2 Project Plan

Beginning in 2006, APGI initiated efforts to undertake major upgrades to the Cheoah facility. The Cheoah Powerhouse was built in 1919 with

four generators. An additional unit (Unit 5) was installed in 1949 and its generator was rewound in 1995. Having been in service 45 years beyond their design limits, Units 1 through 4 were at high risk of catastrophic failure. Exhibit 11 compares the original (1919) wheel pit with the upgraded wheel pit.

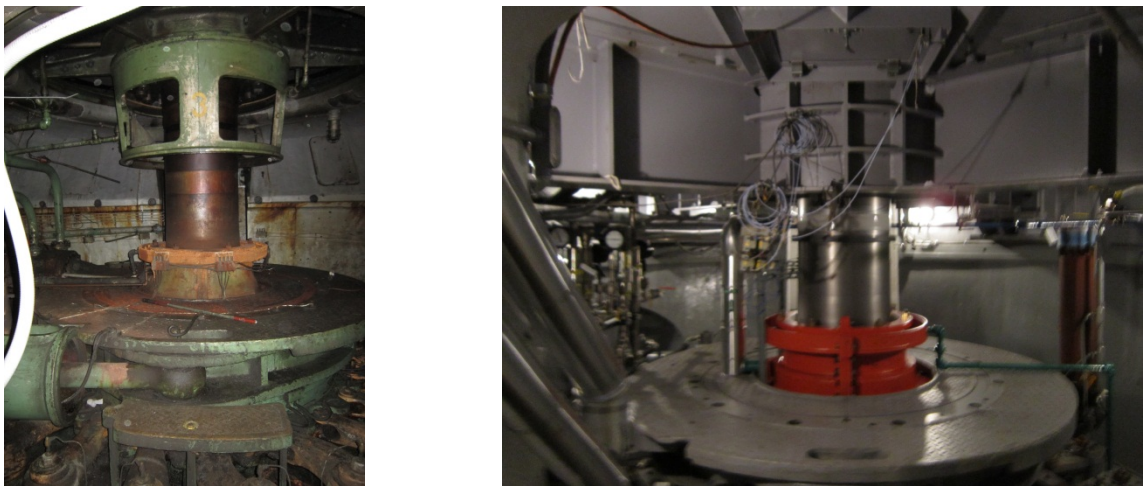


Exhibit 11: Original and Upgraded Wheel Pit

Without the modification to Cheoah, TVA was facing a greater system-wide risk, as failure at Cheoah would have affected operations both upstream and downstream. Upgrading these facilities was critical for maintaining the local electrical power generation system.

AGPI sought and received corporate approval for a site-wide upgrade of four of the five units at its Cheoah facility in 2006. In February 2008, the Alcoa board of directors approved $120 million in funding to support site-wide upgrades, including the purchase and installation of four new generators and turbines and the upgrade of the power sub-station, main transformers, and high-voltage switches to facilitate a 25% increase in electrical power generation provided by these new units.

In March 2009, this project was placed on hold for an unspecified period due to the global financial crisis, a 50% drop in aluminum prices, and a resulting corporate need to conserve cash. The four units were in immediate need of upgrade and replacement due to their age (average 90 years old) and the continuing risk of catastrophic failure (as experienced with Unit 2 in February 2007). Alcoa was committed to completing these upgrades, but without upgrades for the foreseeable future until the global financial market made a full recovery to pre-2008 levels.

The Alcoa team included AGPI and Fluor as well as Voith Hydro for the fabrication and assembly of the generators and turbines. This project focused on the delivery and installation of two units and related site engineering. It also continued beyond the DOE-funded period, to install and commission the additional units.

The Tapoco system was undergoing facility upgrades to replace an aging infrastructure and install next generation systems capable of achieving major increases in generation capacity and enhancing environmental benefits for wildlife sustainment. As part of the Tapoco system,

Cheoah is an instrumental component of the larger Tennessee Valley Authority (TVA) and is one of four hydroelectric facilities operating within the Tapoco system. The TVA system includes 29 conventional hydroelectric facilities and one pumped-storage facility for the production of electricity. The system also includes 8 U.S. Army Corps of Engineers facilities on the Cumberland River. The majority of the hydroelectric facilities that comprise the TVA system are older than 50 years and are candidates for major system upgrades to improve generation capacity with the installation of new generators and turbines. In the late 1990s, Alcoa worked directly with the TVA to identify and define potential upgrade opportunities within the Tapoco system. The study concluded that Cheoah would benefit most from upgrades and replacement of generators and turbines. APGI worked closely with the TVA to transfer lessons learned from our upgrades to the Cheoah facility. Additionally, our team members, Fluor and Voith Hydro, have been committed to disseminating pre and post-installation results to the TVA to help baseline future generator and turbine options for additional hydroelectric facilities within the larger TVA system.

No regulatory delays existed as Alcoa had already submitted and complied with required regulatory measures for construction and upgrades at the Cheoah facility. The site was ready to accept construction activities immediately in line with the objectives of ARRA.

3.3 Approach

Alcoa's Cheoah project included six technical tasks and a project management task, as summarized below.

Task 1 – Complete Detailed Engineering Documentation

Alcoa began detailed engineering independently in March 2008 with the original full authorization of the project. These efforts were slowed significantly when all other aspects of the project were put on hold in 2009 because of the world economic crisis. Since the restart of the project concurrent with the initial award of the ARRA grant, detailed engineering was restarted in 2010. The effort has seen the successful integration of the first two hydroelectric units, auxiliary and support equipment.

Task 2 – Project Mobilization

This task focused on project mobilization and restart. Activities included manufacture of the four generator step-up transformers. Because much of the supporting equipment required for the upgrade had been fabricated or was ready for production; this task enabled us to take delivery of those components, in order to begin construction. Generator and turbine manufacturing also occurred during this task as well, which accommodated installation in later tasks. Also during this task, we prepared Cheoah for the ongoing construction effort.

Task 3 - Begin Pre-Outage Construction and Complete Unit 2 Demolition

This task consisted of facility infrastructure construction that was necessary to support the unit upgrades. Specifically, this task included:

- Geotechnical stabilization of the powerhouse parking lot, to accommodate the heavy truck loads and cranes required to unload and transport equipment.

- Extension to the parking deck, which provided additional lay-down area for traffic and to facilitate construction.
- Extension of the substation transformer deck, to enable removal of the existing sub-station equipment and installation of the new equipment.

Additionally, we completed Unit 2 demolition, including:

- Removal of auxiliary equipment, piping and associated breakers and switches.
- Demolition of the generator and turbine.
- Abatement of lead and asbestos.

Task 4 - Unit 1-4 Substation Outage
Due to the age and condition of the existing equipment, to realize the 5.5 MW upgrade potential per unit, the substation had to be upgraded to handle the increased capacity. This involved removing the existing single-phase transformers, bus work, line switches and oil circuit breakers (OCBs). Specifically, the project scope included:

- Removing the current equipment;
- Raising and replacing the existing bus structure with a new conductor;
- Replacing the OCBs with new ABB SF-6 breakers;
- Installing new, higher capacity three-phase transformers to replace the single phase GSU transformers;
- Replacing the manual line switches with safer motor-operated switches;
- Installing new cooling water piping to maintain the operability of the new units, and installing temporary cooling piping to service the existing units;
- Install a new fire deluge system to protect the transformers;
- Upgrading the substation's oil containment system to add further protection to the environment in the event of a transformer oil spill; and
- Adding one outfall for storm water.

Upon mechanical completion of the sub-station, start-up and commissioning of the sub-station was a parallel activity with the start-up and commissioning of Unit 2.

Task 5 - Unit 2 Installation
Installing the new Unit 2 turbine and generator, as well as performing the major balance of plant equipment (BOP) work for the unit consisted of:

- Installation of new governor, lubrication and generator exciter systems;
- Major hardware and software upgrades to the generator control system; and
- Installation of arc flash-rated electrical circuit breakers, switches and new generator cabling.

Unit 2 was released for commercial operation on September 6, 2012.

Task 6 - Unit 1 Outage and Installation
The scope of this task followed the same procedures as Unit 2, described above in Tasks 3-5.

Unit 1 was released for commercial operation on September 7, 2012

Task 7 – Project Management

Alcoa's ongoing project management task included:

- Subtask 7.1: Project Startup: The project initiation entailed an internal kickoff meeting with all active members of the project team as well as communication of project objectives, tasks and timelines.
- Subtask 7.2: Project Implementation: Upon project award notification, the execution plan and schedule were finalized and communicated to all team members and project consultants to allow commencement of parallel project activities.
- Subtask 7.3: Project Administration: This entailed overseeing the items detailed in our technical tasks, as well as coordinating regular internal meetings to ensure rapid identification and resolution of any barriers to timely progress on project objectives.
- Subtask 7.4: Project Reporting: Alcoa complied with all Recovery Act reporting requirements according to the Office of Management and Budget (OMB) guidance, updated by the DOE F 4600.2 or other related Recovery Act guidance.
- Subtask 7.5: Meetings and Project Briefings: Alcoa held briefings for DOE that explained the plans, progress and results of the technical effort.

4 RESULTS AND DISCUSSION

APGI has completed upgrades to two units, including turbines and generators and associated auxiliary equipment such as; transformers, switchgear, power and control wiring.

Currently, these two units are fully in operation and have an output of 33MW per unit against a design requirement of 27.5MW. Ultimately, this modification provides a 50% increase in generating capacity for these units and adds 40 to 50 years of expected useful life without requiring any additional modifications to the facility and without any significant regulatory delay. This upgrade increased capacity from 22 MW to a maximum output of 33 MW each, for maximum capacity of 132MW, bringing the total facility capacity to 162 MW.

Exhibit 12 provides steady state operating data for the two units during commissioning. As the tables show, the unit performance at variable loads exceeds target MW capacity.

Plant HW (feet)	Plant TW (feet)	Plant Head (feet)	Servo Stroke (percent)	Gen Output (MW)
1150.89	963.50	187.39	100.0%	32.95
1150.99	963.17	187.82	94.8%	32.00
1151.04	963.08	187.96	89.7%	30.96
1151.09	962.94	188.15	84.9%	29.70
1151.15	962.74	188.41	79.9%	28.52
1151.31	962.87	188.44	75.3%	26.55
1151.37	962.95	188.42	70.5%	24.31
1151.42	962.87	188.55	65.5%	21.83
1151.48	962.71	188.77	60.3%	19.08
1151.54	962.51	189.03	55.2%	15.47
1151.51	962.51	189.00	50.4%	13.40
1151.65	962.50	189.15	44.8%	10.82
1151.72	962.16	189.56	40.6%	9.07
	Average	188.51		

Plant HW (feet)	Plant TW (feet)	Plant Head (feet)	Servo Stroke (percent)	Gen Output (MW)
1151.42	962.55	188.87	16.2%	1.60
1151.59	962.40	189.19	40.0%	8.38
1151.66	962.37	189.29	45.0%	10.41
1151.70	962.34	189.36	50.1%	12.64
1151.74	962.38	189.36	55.2%	14.81
1151.76	962.44	189.32	60.3%	17.02
1151.76	962.49	189.27	65.2%	20.63
1151.80	962.44	189.36	70.1%	23.14
1151.82	962.40	189.42	75.3%	25.50
1151.85	962.37	189.48	80.2%	27.73
1151.91	962.38	189.53	85.0%	29.43
1151.95	962.38	189.57	89.9%	30.59
1151.99	962.38	189.61	95.1%	31.69
1152.01	962.41	189.60	99.9%	32.66
	Average	189.37		

Exhibit 12: Steady State Operating Data

The generator efficiency for the upgraded units is approximately 98.3% as shown in Exhibit 13.

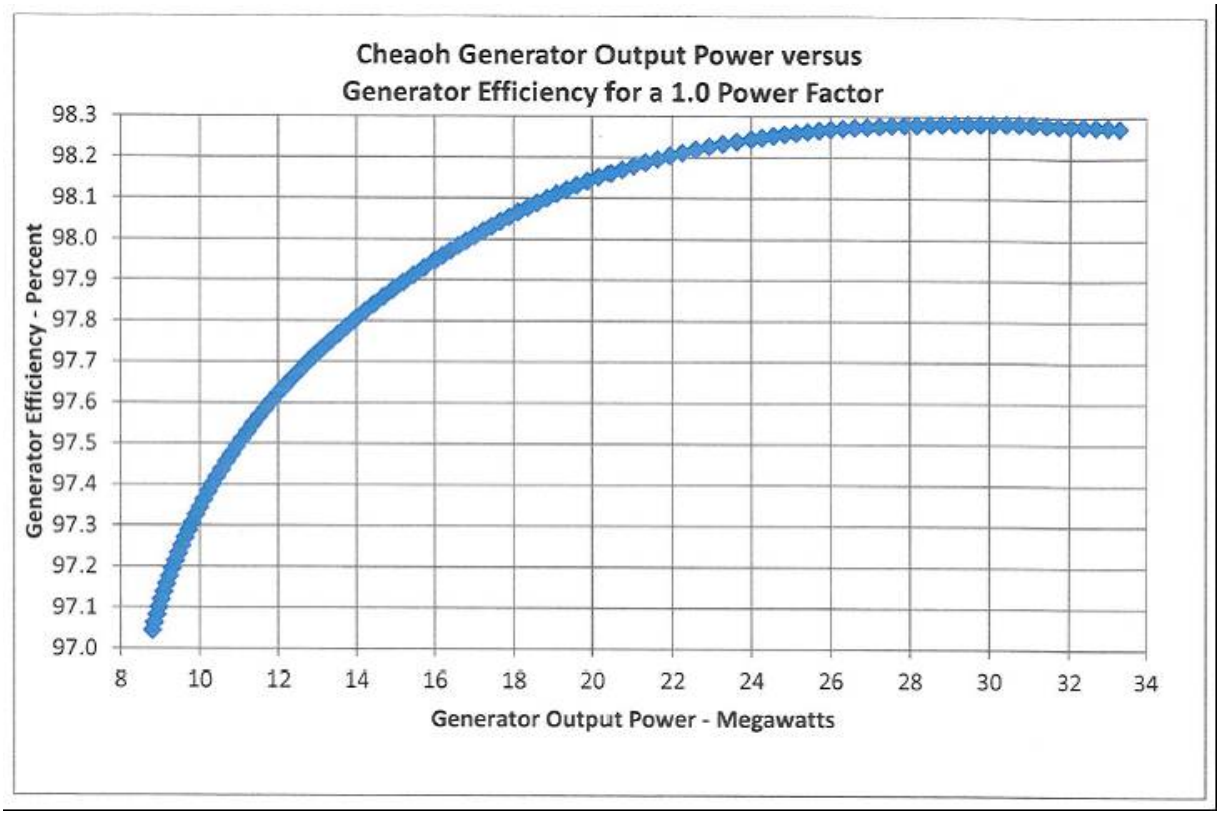


Exhibit 13: Cheoah Generator Output Power versus Generator Efficiency

Additional results are presented in Exhibit 14.

Objective	Result
• Develop, deploy, and test hydropower projects that would modernize the existing	• Added 40 to 50 years to the facility without requiring any modifications to the facility or significant regulatory delay; • Improved Site Access / Storage / Parking

hydropower infrastructure in the U.S. and increase both the quantity and value of hydropower generation, including environmental performance	• Implemented Geotechnical Stabilization • Improved system protection for NERC compliance.
• Deploy turbines and control technologies that increase and maximize system generation at existing non-Federal hydroelectric facilities	• Generation capacity increased for Units one and two from 44MW to 66MW • Purchased and installed new high-efficiency turbines, generators, and transformers, and upgraded the balance of plant equipment, including: o Field coils o Insulation o Exciter o Generator shaft o Guide bearing o Brake ring o Runner o Transformers o Switchgear o Power and control wiring o Piping o Fire protection
• Demonstrate improved quantity and quality (value) of energy produced, through increased efficiency and enhanced environmental performance	• Air-cooled generator step-up transformers eliminate cooling water requirements for transformers by122,000 GPD • Replacing GSU transformers decreased total oil volume in high voltage equipment by 39,180 gallons • Installing new high pressure lift units reduced hydraulic oil on-site storage by 20,000 gallons • Modern, upgraded turbines provide 50% increase in generating capacity • Oil/Water Separator Tank eliminates risk of oil entering the waterway. • Eliminated Asbestos insulation on Units 1 – 4.
• Demonstrate that generation will increase by at least 5% at the facility	• Generating capacity increased by 50% – from 44MW to 66MW;
• Produce new electric generation within the project period	• Units 1 & 2 were operational 29 months after the project restarted.
• Improve health and safety conditions at the facility	• Installed fire protection system for unit protection and control room protection • Installed SF6 Gas Insulated Switchgear minimizing Arc Flash Hazard per NFPA 70E • Installed secondary access to Cave Area eliminating an OSHA confined space • Improved lighting throughout facility for increased visibility • Project has completed 280,000+ man hours with zero loss time incidents
• Promote and enhance the objectives of the Recovery Act, especially job creation and/or preservation, and economic recovery in an expeditious manner	• The project averaged approximately 80 full time equivalents employed since September of 2010 • The project was 'shovel-ready' with a pre-established schedule, team of contractors, valid purchase agreements for equipment, and completed regulatory approvals to begin construction immediately • The project directly supports: green economy growth and sustainment, renewable energy resources, and recreational opportunities. • Demonstrates private industry/government cooperation for sustainability

Exhibit 14: APGI's Cheoah Hydropower Upgrade Results

4.1 Project Challenges

Typically, because of limited space and economic considerations, hydropower upgrade construction projects are done in sequential phases. Alcoa's Cheoah project was unique because

the goal was to upgrade all four turbines in a very short time frame, and in particular, complete the overall project engineering design and installation of units one and two within 29 months. A number of technical, programmatic, economic, logistics, and safety challenges were known at the outset and others were encountered through the life of the project. Major challenges addressed by the team include:

Technical Challenges
Space limitation made meeting current standards a challenge

Programmatic Challenges
- Limited local labor because of skill base and remote location
- Daily coordination of specialty and ongoing functions of multiple contractors

Economic Challenges
- Impact of project size on revenues
- Project was halted because of economic climate and required restart after receipt of DOE/ARRA funding
- As a government program Alcoa had to establish ARRA compliant systems for accounting, Davis Bacon, etc., causing administrative delays

Logistics Challenges
- Size of equipment limited by access bridge
- Limited lay-down (staging) area
- Implementing and maintaining an on-time delivery system
- Inventory stored fabricated parts from various locations

Safety
- Operating a large major construction project in a confined area
- Access of many subcontractors and large numbers of personnel working on site
- Continuous training for all crafts

Ultimately, the project team, including Alcoa, Fluor, and Voith worked cooperatively to overcome all challenges, achieve results that met all DOE Recovery Act objectives, and complete the project on time, and under budget.

5 ACCOMPLISHMENTS

The Cheoah Upgrade was a strong candidate to support the goals of ARRA. The project was ‘shovel-ready’ with a pre-established schedule, team of contractors, valid purchase agreements for equipment, and completed regulatory approvals to begin construction immediately. The project was delayed due to the global economic crisis and was aligned with the objectives of the Recovery Act to support stalled capital projects that support job creation and preservation in the renewable energy sector. This project also supported the objectives of the Recovery Act’s guiding legislation the Energy Independence and Security Act (EISA) of 2007, which seeks to support projects that reduce the United States’ reliance on foreign sources of energy and

reinvests in major domestic industries that are critical for national security. The following sections briefly summarize how this project is directly aligned to the goals of the Recovery Act.

Green Economy Growth and Sustainment

Cheoah is operated in a run-of-river mode following the daily-cycle, peaking operations of the TVA's Fontana Facility located upstream of Cheoah. Alcoa's Tapoco generation assets tie directly to TVA's power network, which is the nation's largest renewable energy system. Over the coming years, the TVA, Alcoa, and the U.S. Army Corp of Engineers will be challenged to conduct system-wide upgrades to the entire hydroelectric network. Through this project, Alcoa contributed directly to increasing the total power generating capacity of the TVA network and extend the life of Cheoah by another 40 to 50 years. The new generating units installed at Cheoah also represent state-of-the-art turbine technology and have been guaranteed by Voith Hydro to deliver no less than a 25% increase in generating capacity per unit. Therefore, as an extension of this activity, the Cheoah upgrade and modernization will contribute to maintaining manufacturing and technology leadership in the United States in the hydroelectric power industry.

Environmental Benefits

The new equipment increases turbine efficiency by approximately 91.9% for better use of available water, eliminate more than 60% of oil currently on site, provide secondary containment for transformers, eliminate water cooling of transformers and their discharge stream, eliminate greased bushings near the water passage, address lead paint and asbestos on the four units, and reduce the noise level on the generator floor of the powerhouse.

Sustainable Renewable Energy Resources

The complete Cheoah upgrade provides a 25% increase in hydroelectric production at this development and enable greater use of renewable energy in the region. These upgrades also renew the operational life of these aging systems and provide operational sustainability for the next 40 years.

Recreational Benefits

This facility and revenue from APGI funds recreation improvements to the North Carolina and Tennessee Wildlife, Fish and Game Commissions and the National Parks Service. Additionally, Alcoa provides funds for local recreation facilities including canoe portages, campsites, and related recreation areas.

Job Creation and Retention

APGI's Tapoco system and Cheoah directly supported APGI's operations in Alcoa, TN by providing affordable and stable electricity supply via a connectivity to the TVA and long-term purchasing agreements. Maintaining this preferred pricing system is essential to support aluminum manufacturing at this site. Without long-term price agreements, Alcoa would not be able to sustain operations in the region due to market price competition from overseas for manufactured products. Achieving

upgrades to Cheoah is tied directly to maintaining more than 700 manufacturing jobs in Tennessee.

Additionally, during this project, on-site construction created approximately 83 FTEs per month over the life of the project, with an average of 25 full-time positions at any given point in the schedule. Turbine and generator manufacturing, installation, and engineering at Voith Hydro in York, PA supported approximately 15 jobs based on a production contract with a value of roughly $59 million. The four generator step-up transformers were manufactured in St. Louis by ABB and support approximately 15 jobs for 6 to 12 months.

Job Creation/Sustainment and Economic Impact

This project created and sustained jobs in North Carolina, Tennessee, Pennsylvania, and Missouri in the construction and engineering, turbine manufacturing, hydropower operations, aluminum manufacturing, and aluminum recycling sectors. Exhibit 15 shows FTE utilization rates over the life of the project. Exhibit 16 provides an overview of how this project directly supported the creation and sustainment of jobs.

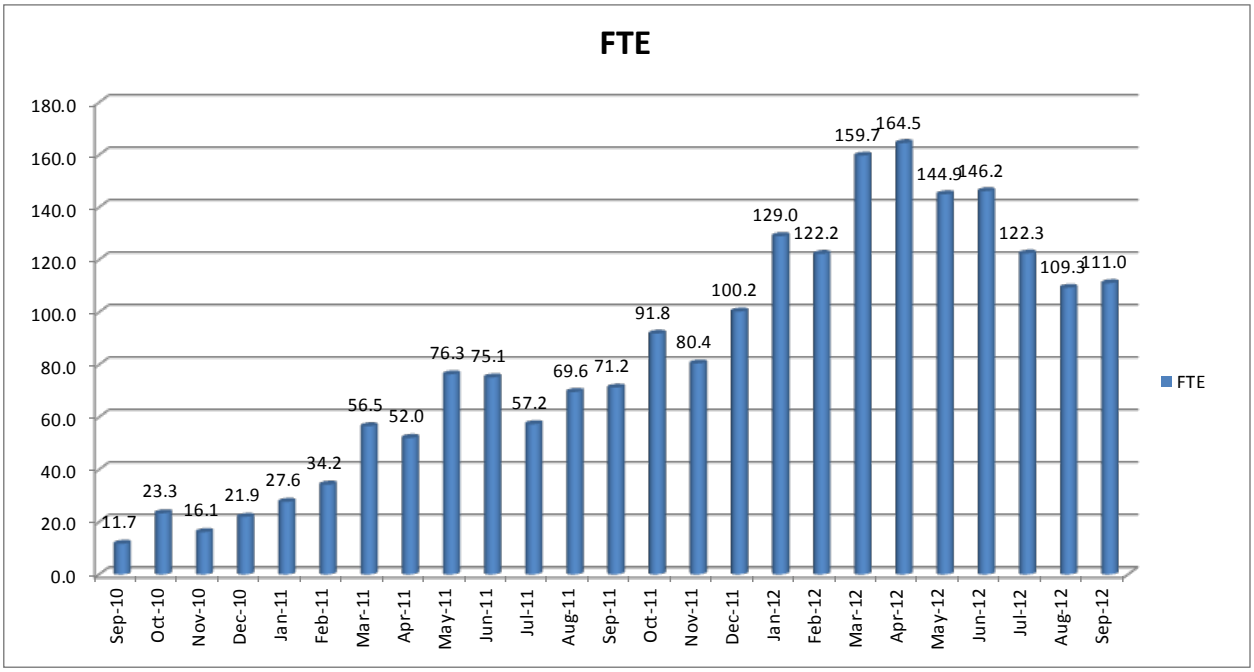


Exhibit 15: Project FTE Utilization

# of Jobs	Location	Description
40	Alcoa Power Generation Inc. (APGI), Robbinsville, NC	Sustained 40 full-time positions to operate, manage, and support this project.
83	Cheoah Dam, NC	Created 83 jobs in demolition, construction, and installation over the life of the project (3-4 years), with an average of 25 full-time positions at any given point in the schedule.
15	Voith Hydro, York, PA	Created and/or sustained 15 jobs over a 3-4 year period to manufacture and turbines for the Cheoah upgrades

15	ABB, St. Louis, MO	Created and/or sustained 15 jobs over a 6-12 month period to manufacture four generator step-up transformers
700	Alcoa Tennessee Operations, Alcoa, TN	Sustained 700 jobs
Total estimated jobs directly created or sustained:		**853**

Exhibit 16: Estimated Jobs Directly Created or Sustained by the Cheoah Upgrade Project

6 CONCLUSIONS

This 29-month project was exceptionally successful. The project met all technical, engineering, and management milestones on schedule. The Tapoco Division of APGI Hydro has four generating developments with a current capacity of 364 megawatts (MW). The 2012 Plan had gross generation of 1,200,000 MW hours (MWhrs). After completion of the Cheoah modernization, average annual gross generation will be closer to 1,450,000 MWhrs. This far exceeded DOE's FOA objective of a 5% increase. Index test results indicate that the turbine produced a maximum output power of 33.519MW at the 185 foot net head. This exceeds the guaranteed maximum output power of 30.235MW by 3.284MW or 10.9%.

In keeping with the goals of the Recovery Act, upgrading and modernizing this hydropower facility enabled the facility to provide an additional 40-50 years of a clean renewable U.S. resource in the local area.

7 RECOMMENDATIONS

This project provides a successful example of government/private industry partnership to complete a shovel-ready, renewable energy program. The program's technical plans, along with program plans and procedures provided an efficient and effective roadmap for implementing future hydropower modernization program. Alcoa's recommendation is to examine additional opportunities for DOE to partner with private industry to continue to modernize and take advantage of the power resources of the country's more than 2,400 hydropower facilities and expand clean energy across the country.

7.1 Lessons Learned

In addition to the technical objectives, one of the goals of this demonstration project was to provide an example of how modernization can be implemented successfully at other hydroelectric facilities. Clearly, modernizing aging hydroelectric facilities can bring significant economical, technical, and environmental benefits to this sustainable energy technology. Alcoa's lessons learned are included below.

Technical:

- Due to age of facility, meeting current code requirements presented additional challenges that had to be addressed.
- Due to limited space at the facility, stored and inventory of parts was problematic. Additionally, upgrading 4 identical units made material tracking extremely important.
- Due to the age of the overhead crane, more attention was needed to maintain operability.

Programmatic:

- Due to remoteness of location, access to local skilled labor was minimally available. Due to this limited access to craft, coordination between multiple specialty contractors was the implemented approach which required additional oversight and a strong schedule management approach.

Economic:

- Impact on revenue due to loss of generation is significant. Schedule should account for typical water flow to minimize this impact to greatest extent possible.
- For government programs, additional compliant system needed to be implemented after the project was established (accounting, Davis Bacon, etc.). The systems would be easier to implement at the onset of the project.

Logistics:

- Due to location remoteness and limitations on transport, equipment size and delivery logistics should be evaluated during the project development phase.
- Due to limited lay-down area at the site, a logistics plan for delivery must be implemented early in the project lifecycle.

Safety:

- Due to the age of the facility, challenges around confined space and access should be evaluated during the development phase of the project.
- Due to the necessity of utilizing many specialty contractors, interaction between contractors must be managed. Implemented a daily 'plan of the day' meeting involving leadership from all contractors proved to be the key to success.
- Due to the project location, requirement for many contractors, etc., continuous safety training and focus was required to achieve safety goals.