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Summary of Preliminary Concepts for a Port of Alaska Resilient Microgrid

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ABSTRACT

The Port of Alaska in Anchorage enables the economic vitality of the Municipality of Anchorage and State of Alaska. It also provides significant support to defense activities across Alaska, especially to the Joint Base Elmendorf-Richardson (JBER) that is immediately adjacent to the Port. For this reason, stakeholders are interested in the resilience of the Port's operations. This report documents a preliminary feasibility analysis for developing an energy system that increases electric supply resilience for the Port and for a specific location inside JBER. The project concept emerged from prior work led by the Municipality of Anchorage and consultation with Port stakeholders. The project consists of a microgrid with PV, storage and diesel generation, capable of supplying electricity to loads at the Port a specific JBER location during utility outages, while also delivering economic value during blue-sky conditions. The study aims to estimate the size, configuration and concept of operations based on existing infrastructure and limited demand data. It also explores potential project benefits and challenges. The report goal is to inform further stakeholder consultation and next steps.

A limited release document of this report is available with additional information. This document is titled "Concepts for a Port of Alaska Resilient Microgrid" (SAND2020-9638).

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ACRONYMS AND DEFINITIONS

Abbreviation	Definition
ARR	Alaska Railroad
EPS	Electric Power Systems, Inc.
JBER	Joint Base Elmendorf-Richardson
Port	Port of Alaska
PV	Photovoltaic
RCA	Regulatory Commission of Alaska

1. INTRODUCTION

The Port of Alaska (Port) in Anchorage, Alaska is investigating projects to increase the resiliency of its electric power supply, while also providing benefits during normal, "blue sky" conditions. The combination of renewable energy (Photovoltaic and energy storage) and local diesel generation within the Port footprint was the primary focus of the study. The generation and distribution would be configured as a microgrid, capable of supplying power to the Port tenants in the event of a long-term outage from the serving utility, currently Anchorage Municipal Light & Power (ML&P). The long-term outage that is being considered for this study is an outage lasting from multiple days to several weeks. A more resilient energy supply at the Port would have broader benefits given importance of Port operations with respect to civilian and defense activities critical to the City of Anchorage, the State of Alaska and beyond. Following stakeholder consultation[1], the project concept was extended to potentially add a back-up power source for a facility within Joint Base Elmendorf-Richardson (JBER).

Depending on design configuration and regulatory treatment, the microgrid could benefit Port tenants by reducing peak demand and hedging against future fuel cost. Technically, the energy resource could also support the utility grid reliability via net demand response.

This preliminary study evaluates the feasibility of a resilient microgrid at the Port that can serve as a back–up source for loads at the Port and JBER. Based upon loading data provided by the tenants of the Port of Alaska, EPS performed power flow studies to determine the size and characteristics of the on-site generation to supply power to the Port tenants. The level of analysis for this feasibility study does not include detail load characteristics

This report documents a preliminary feasibility analysis for an energy system that increases electric supply resilience for the Port. The project concept emerged from prior work and stakeholder consultation led by the City of Anchorage. The report describes the assumptions, the analysis results, including rough sizing and cost estimates, and notes the challenges expected if the resilient microgrid is further pursued. The report also describes the potential benefits as well as technical and non-technical challenges.

1.1. OVERVIEW OF THE PORT OF ALASKA

The Port of Alaska is located at the East end of the City of Anchorage against the Knik Arm of the Cook Inlet. Figure 2-1 shows an aerial view of the facilities. The Port handles 50% of all freight shipped into Alaska by all modes (marine, truck, and air) and facilitates the delivery of goods consumed by 90% of Alaska's population. The Port is Alaska's main fuel distribution and storage center. It handles half of the jet fuel consumed at the Ted Stevens Anchorage International Airport (ANC), the second busiest air cargo hub in the U.S. and fifth busiest in the world. In total, the Port supports more than $14 billion in commercial activity.

Figure 2-1. Aerial View of the Port of Alaska

The Port is also important from a military perspective. It is designated as one of the Nation's 17 Commercial Strategic Seaports. The Port is adjacent to JBER and plays a major role in the supply of cargo and fuel to JBER via secure haul road and pipelines. Combined with the Alaska Railroad, the Port also provides logistics support for military operations in the Alaska region (Figure 2-2).

Figure 2-2. Port of Alaska Support for Defense Mission

The Port of Alaska facilities include both administrative Port installations as well as operational tenants. There are currently eight major tenants on the Port facility in addition to the Port of Alaska itself. Major refined fuel storage and pipeline infrastructure are located within the Port footprint. The Alaska Railroad has a railhead terminal integrated with Port operations. The main supply of fuel supply for rail operations is located at the Port.

1.2. Current Port of Alaska Electrical Distribution System Overview

The electrical distribution system serving the Port loads operates at 34.5kV primary voltage. . It consists of a main feeder from an ML&P substation that enters the Port area using overhead line construction. From there, it transitions underground to serve the Port facilities. The feeder includes several padmount switches and sectionalizing points. Customers are served from the distribution loop via local laterals out of the padmount switches that connect to customer service points. In addition, the utility recently completed a second normally open underground tie into the Port primary main distribution loop from a separate utility feeder.

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2. GENERAL ASSUMPTIONS

2.1. Port Study Assumptions – Electrical Load Related

The Port facilities include administrative buildings as well as operational tenants. There are currently eight major tenants on the Port facility in addition to the Port of Alaska administrative and operations facilities.

For these types of load studies, peak loading information, consisting of kW demand and power factor, along with periodic load profiles such as daily and seasonally load characteristics is needed as a basis.

However, the only data available for the Port tenants is the peak kW demand usage on a monthly basis, and their monthly energy consumption.

Data for five of the tenants as well as the Port loads were obtained from utility metering data. Based upon historical feeder data received from the utility, EPS estimated the loading of the remaining three tenants. Finally, JBER provided an estimate of the peak JBER load near the Port that should be considered in the feasibility study. The estimated aggregated peak load is indicated in Table 3-1 below.

Table 3-1. Tenant Peak Loading Information Summary

<table>
<tr><th>Peak Load Type</th><th>Sum of Peak Loading (in kW)</th></tr>
<tr><td>Actual Historical Meter Data – Port Tenants</td><td rowspan="4">6730</td></tr>
<tr><td>Estimated Peak Loads – Remaining Tenants</td></tr>
<tr><td>Peak Load at JBER to be supplied</td></tr>
<tr><td>Total Sum of Peak Loads</td></tr>
</table>

Detailed data and load profiles for the Port and JBER loads are not available; additional assumptions are required to better characterize the Port combined loads and the generation required to support those loads.

The peak loads in Table 3-1 are the non-coincident peak loads of each facility, meaning these peaks will occur at different times for different facilities. The coincident peak loading of the study area was estimated using a coincident factor to convert the non-coincident peaks of the individual loads into a coincident peak demand of the study area. EPS estimated a coincident factor of 70% based upon overall feeder peak load information provided by the utility.

All of the load information was provided in kW, as that is the real power metered by the utility. To perform a load flow analysis and estimate the overall system size requirements, it is necessary to also account for the reactive power (kVAR) demand. For the purposes of this study, a power factor of 0.85 was assumed. EPS also assumed that any large Port loads have power factor compensation to meet this assumption; it will be required for microgrid operation.

The minimum daytime load will govern the maximum size of a PV facility serving the micro-grid. The minimum 24-hr load will govern the maximum size of diesel generation used to serve the micro-grid when islanded from the utility system. In order to estimate minimum 24-hour load, a ratio of peak to minimum loading of 4:1 was assumed.

Finally, to account for likely future Port or tenant upgrades, a ten-year load growth factor of 20% was assumed. This load growth factor assumes that over the next ten years, the electric load consumption at the Port will increase by 20% to account for new development, infrastructure upgrades, and other modifications to facilities that will increase Port electric demand.

Table 3-2 below summarizes the assumptions discussed above.

Table 3-2. Load Assumptions

Factor	Value
Coincident Factor	70%
Power Factor	0.85
Peak to Minimum Load Ratio	4:1
Load Growth Factor	20%

2.2. Other Assumptions

In addition to the electric load assumptions listed above, several additional factors and assumptions were needed as a basis for the technical analysis and feasibility of this project. These assumptions are as follows:

- Existing state and utility regulatory requirements do not allow for any portion of the utility system to be islanded and energized or operated by anyone other than utility[2]. Therefore, any islanded or microgrid system operated by the Port tenants would need to consist of facilities on the load side of a utility meter and disconnect. (This could be a primary meter and disconnect).
- Under current Alaska retail tariffs, any export of power from a PV system on the customer side of the meter will need to have an interconnection agreement between the utility and the customer. Although the PV system will be sized to attempt to match the expected daytime loading of the Port, it is anticipated that an interconnection agreement will be needed if the PV system is located on the customer side of the utility meter to allow for some energy export across the meter.

- It is envisioned that the microgrid will have a diesel-fired generator, in addition to PV and energy storage, to provide reliable power to critical loads during extended utility outages. This normally calls for the installation of new dedicated diesel generators and fuel storage. One potential local generation source under consideration for this project is existing Alaska Railroad (ARR) diesel-electric locomotives. The locomotives would be used as generators during extended utility outages. The locomotives could be used in place of or in addition to stationary diesel generators. The ARR currently has facilities that utilize a single locomotive to provide back-up power for the facility. In these installations, the locomotive into the building electrical system through a rectifier-UPS-inverter system. Each locomotive has approximately 750 kW of generation capability. Therefore, the following assumptions have been made for these locomotives:
  - The microgrid could be designed to connect multiple ARR locomotives as described above. Each locomotive is approximately 750 kW.
  - The locomotives would not have any capability of being synchronized or paralleled directly to the microgrid or utility AC bus, therefore each locomotive would be DC connected to the battery energy storage system via a rectifier to provide charge or energy to be delivered concurrently or later via the microgrid energy storage inverter and step-up transformer.
- Consideration should be given to installing diesel generators in place of or in addition to plug-in infrastructure for diesel-electric locomotives. This option opens the possibility to interface on the AC side for grid-connected or microgrid operation, without relying on the energy storage converter. Dedicated generators will also be assumed to be fueled by existing Port fuel storage facilities.
- It is assumed that a new distribution feeder, approximately 2 miles long, would need to be constructed across JBER property from the microgrid location to serve the specific JBER load. It is also assumed that the line construction will be 34.5 kV to match the utility and Port primary distribution voltage. As the JBER load is currently served from the JBER infrastructure at 12.5 kV, step-down transformers near the JBER facility will need to be included. In addition, the line will need some type of fault detection and clearing system when operated as a microgrid.
- Line conductors, switches, and other primary distribution equipment will be based upon standard sizes and devices in use on the utility's current 34.5 kV distribution system.
- The locomotives and inverter-based generation have limited capability for providing fault current and motor-starting on the micro-grid. As many of the Port loads are large motor loads, detailed engineering studies will be required to determine the required characteristics of the proposed microgrid.
- Based upon the current level of data available and the feasibility level view targeted in this study, differentiation of critical loads from the metered data of each tenant of the Port is not possible or necessary. For the purposes of sizing potential generation, it is assumed that the normal metered loads of each tenant are critical to the extended operation of the Port. Further studies should refine the nature of the tenant loads for the purposes of determining more detailed requirements of the microgrid infrastructure.

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3. DESCRIPTION OF THE PROPOSED PROJECT

3.1. Proposed System Configuration

A grid interactive microgrid system for the Port of Alaska has two main objectives; the first and primary goal is to provide resilient power for the critical facilities of the Port. The second goal is to provide economic value for the Port tenants under normal operating conditions.

The microgrid envisioned for the Port would consist of an energy source capable of accomplishing the second goal, combined with a generation resource that could operate under catastrophic conditions when the utility source of power is unavailable. The microgrid concept includes solar PV source to provide that economic benefit, as it would be operated in conjunction with an energy storage system to provide power that would offset the utility demand during periods of peak electric usage. The most likely emergency generation source is diesel-fired emergency generation, such as provided by ARR locomotives. However, to provide the resiliency during a catastrophic event where loss of utility power extends for several days or weeks, fuel storage for the diesel generation must be considered as well. For the purposes of this study, it is assumed that all loads of the Port are critical for its operation over several weeks, therefore the system will be designed to accommodate the full load of the Port.

Current regulatory and utility policies imply that both the PV system and the emergency generation would need to be located downstream of the utility tie-point, both for multiple tenants to benefit from demand reduction provided by the PV system, and to gain the resiliency of operating as a microgrid with that generation.

Based on the assumptions discussed in the previous section, there are two options to accomplish the objectives:

a. The microgrid would include a privately-owned distribution system that would allow participating tenants to use it as their primary power source. The private microgrid would also be connected to the utility via a primary master meter and disconnect in such a way that all microgrid assets and microgrid-connected tenants are on the load side of the utility master meter and disconnect. The existing utility distribution system would be left in place to serve the non-participating tenants, or could become a backup source for the microgrid participants with some minimal modifications to the tenant services. During blue-sky conditions, Port tenants would accrue peak demand reduction benefits under an appropriate agreement administrated by the microgrid operator. Grid support services and excess energy from the microgrid could be delivered to the utility under a separate interconnection agreement.

b. Alternatively, the facilities would consist of new microgrid infrastructure connected to the existing primary utility feeder and would be operated by the utility during both blue-sky conditions (grid-connected) and outages (islanded). This would require adding switchgear at the microgrid isolation point. This option would not require the installation of a new distribution system to serve the loads. Under this scenario, allocation of peak demand reduction benefits to participating Port tenants may not be possible unless a new tariff mechanism is established.

These options are further discussed below.

3.1.1. Baseline Port Microgrid Configuration

A privately owned primary distribution loop for the Port participants who choose to participate in the PV and resilient microgrid is the first option under consideration. The Port and participating tenants would have their current electric meter combined into a shared primary meter at the point of utility connection into the new primary distribution loop. Allocation of the primary meter demand and energy would require some additional hoops to jump through as currently, only recognized utilities can buy and resale electric power. The PV and local generation would be tied into this new distribution loop to provide resiliency and demand reduction benefits for all of the participating tenants. The existing utility primary distribution system serving the Port would likely remain in place to serve any non-microgrid participating tenants, and possibly be used as a back-up power source by the participating tenants.

In addition to the local Port distribution loop, a primary power line would be constructed to tie into JBER loads that would be served in the event of an extended outage affecting the JBER loads of interest. This tie would remain de-energized during normal operations when utility power to the specific JBER facility is available via existing infrastructure. Supplying back-up power to the JBER facility of interest will require an additional agreement between the microgrid operator and JBER, potentially subject to approval by the Regulatory Commission of Alaska (RCA). This also may require a connection at the Port between the JBER tie line and the Port primary utility feeder so that the utility could provide direct power to the JBER facility in the event that the JBER power distribution system is experiencing an outage but the microgrid tie is energized. The local JBER facility would likely require a source transfer switch to switch between the microgrid tie and JBER utility infrastructure power.

3.1.2. Alternate Port Microgrid Configuration

The micro-grid configuration described under the base configuration operation meets the current utility and regulatory requirements, but it requires construction of a redundant primary distribution loop, including switches and distribution transformers owned by the microgrid members. The utility already has a 34.5 kV loop in place to serve the Port. Duplicating these facilities would increase the cost of the capital investment and decrease the cost/benefit ratio of the project.

Alternatively, instead of constructing an entirely new distribution system, another option is to tie all of the new components (PV, generation, and new connection to a specific JBER facility) into the existing utility-owned system, provided there is greater participation by the utility in the project to operate the system during microgrid mode.

In this case, the scope of the resilient microgrid project would only consist of the new local generation and energy storage facilities, the costs of integrating them into the utility system, the isolation devices at the boundaries of the microgrid, and the optional new 34.5 kV tie line to JBER.

This alternate depends on full participation in the project by the serving utility to enable microgrid operation. They will require control in dispatching the PV and associated battery energy storage system onto their 34.5 kV feeder. Some form of agreement with the utility will need to be completed by the Port tenants with the utility to utilize the PV source to offset demand for the peak usage periods of those tenants during blue-sky conditions.

The Port tenants, JBER, and the utility will also need to complete an agreement as to how the Port and JBER loads will be isolated and the microgrid operated in the event of extended outage on the normal utility system source. An important design criteria for the microgrid will be how long diesel generation should be expected to operate without fuel deliveries and how available railroad locomotives are during these conditions.

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4. ANALYSIS RESULTS

4.1. Generation Sizing

To size the local generation, EPS estimated the total peak load, the minimum day-time, and minimum load that will be served by the Port micro-grid. The Peak kW was calculated by applying the coincident factors to the total peak load of the Port. The total current load was then increased by 20% to allow for anticipated load growth. A power factor of 85% was then applied to determine peak KVA requirements of the Port and JBER that will be served by the micro-grid. Table 5-1 shows the results of these calculations.

Minimum Port loading was estimated by using a sum of the peak demand loads, and then dividing those peaks by the ratio of peak to minimum loads. For this total, EPS assumed that all the facilities are seeing their minimum loads at the same time. A total minimum kVA was then calculated based upon the assumed power factor. The results of those calculations are shown in Table 5-2 below. It is highly recommended that actual demand data and more accurate load growth estimates based upon planned projects for the tenants be used for any follow-on analysis of this project.

Table 5-1. Estimated Peak Port Load Calculations

Calculation Description	Calculated Result
Sum of Peak kW of Port Facilities	6730 kW
Estimated Peak Load with Coincident Factor	4710 kW
Estimated Peak Load with Future Load Growth Multiplier	5650 kW
Estimated Peak KVA based upon assumed Power Factor	6850 kVA

Table 5-2. Estimated Minimum Port Load Calculations

Calculation Description	Calculated Result
Sum of Peak kW of Port Facilities	6730 kW
Estimated Minimum kW based upon minimum load ratio	1680 kW
Estimated Minimum kVA based upon assumed power factor	1980 kVA

The generation sources for the Port micro-grid consist of the on-site PV installation, a battery energy storage, and diesel generation. Diesel generation was selected as there is a readily available source of fuel at the Port.

First, the PV was sized to match as close as possible normal operating conditions and the estimated minimum loading based on a prior PV feasibility study[3]. This method was used for sizing the PV installation in order to meet the assumptions that significant PV power will not be exported back onto the utility 34.5kV distribution system and would thus mitigate some regulatory issues. Based upon these criteria, a 2 MW suggested size for the PV installation is recommended. The previous study determined that the Port property as a potential deployment site can accommodate up to 2 MW of PV.

For the purposes of this study, the diesel generation was sized large enough to accommodate the peak load of the Port, as well as the connected JBER facility. For this condition, the assumption is that during an extended outage (days) the PV generation is not available and the battery energy has been depleted. This assumption reflects both the high-latitude location (low power output during winter/storms) as well as the requirement of continuity of power supply for an extended period of time. This is a preliminary approach that can be extended at a later time when more data becomes available. Therefore, based upon the calculated peak kVA, a total of 6.85 MVA of onsite diesel generation is required. This also assumes that the metered loads of the tenant facilities will all be powered during an extended outage; future studies should further refine whether any Port loads are not critical to emergency operations and can be disconnected during microgrid operation.

As discussed above, generation capacity could come from diesel-electric locomotives, dedicated diesel generators or both. A single large generation unit is not recommended, however, as a generator of this size may have issues with wet stacking under the minimum anticipated load conditions. Therefore, EPS recommends a pair of permanent on site diesel generators for this micro grid. For the purposes of this study and the estimates, EPS has selected a pair of diesel generators sized at 3.5 MVA each, allowing each unit to operate down to 1050 kW without wet-stacking concerns.

Existing Alaska Railroad diesel locomotives have also been suggested as a generation source, however, those generators do not have the characteristics required to start the large motors of the Port, nor do they have the controls or protection required to operate as the main reference voltage for a microgrid of the size and characteristic of the Port. It may be possible to configure a set of multiple locomotives to be able to replace one of the two large permanent generators, or more likely, to be used to increase the load capabilities of microgrid if additional demand occurs at the Port or JBER.

A more in-depth analysis is needed to determine the appropriate sized of the energy storage system. The storage type and size will be based on economics during blue-sky conditions (i.e. reduction of demand peaks in the minutes to hours time frame), with consideration of technical requirements during microgrid conditions. The capacity of the converter (kVA) and the amount of electrical storage (kWh) could be selected to displace a certain peak load magnitude for a certain time duration. Access to more detailed demand data is required to perform this analysis.

4.2. Additional Analysis

In addition to sizing the generation, EPS used the estimated peak and minimum loading in a model of the Port electrical distribution system and ran load flows of the system to look for any abnormalities and verify voltage levels were within acceptable limits. No issues occurred within the steady state load flows of either the peak loading or minimum loading.

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5. PROJECT BENEFITS

The main goal of this project is to provide resilient power to supply the infrastructure of the Port of Alaska. The Port is a critical facility to the State of Alaska as a whole as the vast majority of food and goods delivered to the State offload at the Port. Any long term shut down of Port services could cause major disruption for the population served by it.

Adding local generation to the Port of Alaska facilities as a back-up source of power will vastly improve the resiliency of the electric grid serving the Port infrastructure and decrease the reliance on the overall electric utility system to maintain operation of the Port of Alaska, and this redundant generation source will provide that benefit.

In addition to the obvious benefit of increasing the resiliency of the electric supply to the Port, there are several secondary benefits that will come out of this project. The first of these is the inclusion of PV energy at the Port facility. This will provide the benefit of adding a renewable energy resource for the Port of Alaska as well as the utility distribution system as a whole. When combined with the battery energy storage, it will also provide a direct economic benefit to the tenants of the Port of Alaska during normal operations, or "blue sky" conditions, by offsetting their power usage from the utility during peak electric usage, which should result in an overall decrease in electric utility costs.

The tie into JBER will give the joint base an additional electrical power source to provide a redundant and resilient power source for the JBER facility. Further, although scope of this project is limited in nature to feeding the JBER facility load at 12.5 kV via a step down transformer, the main backbone of the electric power transmission system on JBER is a 34.5kV sub-transmission system, same as the utility primary distribution feeder for the Port. If JBER determines that additional load might be best supplied with back-up power by this microgrid, it will be possible to tie directly into the JBER 34.5kV system to supply a larger JBER load.

Finally, although generation is sized to carry the estimated peak load of the Port of Alaska, should the utility become the operator of the microgrid for the Port, it is possible that the microgrid could be utilized to serve additional utility customers during a catastrophic utility system outage, provided that surplus power is available.

To the extent that the microgrid energy resources are able to operate in parallel with the utility grid, they could provide local voltage support or net demand reduction during utility contingency scenarios. The microgrid could also be designed to provide system restoration support, including black start.

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6. RISKS AND CHALLENGES

Although the project will provide many tangible benefits, there are also substantial risks and challenges the project will need to overcome, including the significant cost of the new generation and additional infrastructure.

In addition to the challenge of raising the funding for the project, there are several technical and non-technical challenges as well.

The technical challenges for this project are centered on the operational side of the added generation and switching infrastructure. The ownership model and utility coordination requirements will determine who has operational control of the switching infrastructure. Communication infrastructure and protocols will need to be set up so that each entity involved (Port, JBER and the utility) has the proper visibility (and control where applicable) to ensure that power is flowing as intended without causing safety or operational concerns for the other entities. This includes isolation, electrical feeder and generation protection, and generational control.

In addition to those communications challenges, it is worth discussing the fact that an event that would cause catastrophic loss of electric utility power may have a similar effect on the operation of the local microgrid. For example, one scenario that is often discussed as a cause of an extended outage scenario is a major earthquake. If an earthquake is damaging enough to cause a significant outage on the Anchorage electric power utility system, there could be significant local damage that would affect the operation of the microgrid, such as damage to the fuel delivery system, the battery energy storage system, or the distribution feeder circuit. Seismic analysis has not been included in this feasibility study. It is recommended that the system be designed adequately for the resilience scenario of interest.

Finally, because the loads served by this microgrid include some significantly large crane motors and pumps, any microgrid generation will need to be able to start these motors without causing significant voltage issues to the other loads and tenants of the Port. The battery energy system included in this project should help considerably with that challenge, as it can be used to provide voltage and frequency support for those large motor starting scenarios. More detailed data is needed to address this design detail. The analysis should take into consideration opportunities to implement operational modes that reduce demand during microgrid operations, such as soft start and coordinated operations. Such considerations could substantially reduce the size of microgrid components for the islanded scenario.

Non-technical challenges and risks for the project include the various agreements that will need to be completed between the various stakeholders of this project. If the microgrid is privately owned and operated, this agreement would be between the various tenants of the Port and JBER as to how to split the costs of installation, operation and maintenance, as well as the costs of the combined primary electric service meter between the participating tenants.

If the microgrid is operated by the utility, then the agreements would be between the Port tenants, JBER, and the utility as to the operating parameters for the on-site generation in both "blue sky" and electric grid failure scenarios, taking into consideration existing State of Alaska and utility regulatory requirements.

REFERENCES

[1] Rigor Workshop hosted by the AF Office of Energy Assurance (OEA), May 2019.

[2] ML&P 2010 Interconnection & Operating Requirements for Non-utility Generation, Page 4, Paragraph 108; effective September 2019.

[3] DeerStone Consulting, Solar Photovoltaic Pre-Feasibility Study for the Port of Anchorage, August 28, 2017.

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