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DRAFT

CRUISE SHIP DOCK ELECTRIFICATION STUDY

PND ENGINEERS, INC.

McKINLEY RESEARCH GROUP, LLC
Formerly McDowell Group

HAIGHT & ASSOCIATES

CITY & BOROUGH OF JUNEAU
ALASKA'S CAPITAL CITY
DOCKS & HARBORS

CRUISE SHIP DOCK ELECTRIFICATION STUDY

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EXECUTIVE SUMMARY

In July 2020 we began a study to determine the feasibility of constructing and implementing facilities at the new CBJ Alaska Steamship and Cruise Ship Terminal docks to provide renewable electrical energy to the cruise ships visiting Juneau each summer. Our prescribed objective is to reduce greenhouse gases (GHG) in Juneau.

In 2001, the world's first shore power deployment system was constructed on the Franklin Dock to serve cruise ships. The facility has been operated successfully by Princess Cruise Line since that time utilizing electrical energy provided by AEL&P from their hydroelectric power plants. This study is using the Franklin Dock deployment system as the model for those viewed for the Alaska Steamship and Cruise Ship Terminal docks.

Background

Juneau has been blessed with renewable electrical energy since the early days of the mining industry. Hydroelectric power plants were initially constructed to support a world class, robust mining industry. Since those days, more plants have been constructed to serve the needs of the growing community.

AEL&P has progressively worked to utilize all the energy available from their hydroelectric power plants with the advent of interruptible energy sales.

They are capturing energy to serve these customer loads from the excess water in the powerplant reservoirs that is typically spilled. The cruise ship shore power deployment system at the Franklin Dock participates in this program.

AEL&P

Juneau's electrical system is configured with five hydroelectric power plants and an array of transmission and distribution lines. It incorporates a region extending from Thane to Amalga Harbor including Douglas and most of North Douglas. A feeder extends from the system to provide interruptible energy to the Greens Creek Mine on Admiralty Island. The system includes a series of fossil fuel powered generators scattered through the community to provide standby power in the event of power outages from the hydroelectric power plants.

AEL&P can support all the firm capacity needs of Juneau with their present hydroelectric power plants. During years with average precipitation, they can also support most of their present interruptible energy loads. However, during years with less than average precipitation, the interruptible energy loads are not fully supported.

Throughout the year, the engineering staff at AEL&P monitor climatic conditions to determine the availability of interruptible energy. Critical factors that they analyze include the amount of precipitation, the time of year in which large volumes of precipitation occur, the amount of snow received on the mountains above the reservoirs, and temperatures which are necessary to melt snow for the reservoirs. Their analysis assists them in projecting the amount of water that will be retained in the reservoirs throughout the year. Coupling their analysis with typical electrical energy sales, they determine the amount of excess energy available for interruptible sales based on Rule Curves for each of the reservoirs. Their analysis is reviewed and updated periodically throughout the year.

The transmission lines from Snettisham are well maintained with capacity for the present firm and interruptible loads. These lines can support additional loads. Recently the aerial line from Snettisham to Taku Inlet was upgraded to be more resilient to avalanches. New submarine cables were installed across Taku Inlet and the original cables were retained for standby service.

The transmission lines from Thane into downtown have capacity for the present loads and can support additional loads during the summer. These lines are programmed for maintenance projects during the summer which will require periodic reduction of service to a single transmission line. This will limit their load capacity. These projects include reconductoring and servicing the underground cable crossings through the Thane avalanche area.

Three hydroelectric power plants are in various stages of planning, engineering, and permitting. Two of these facilities are in the works at AEL&P and one is being developed by Juneau Hydro. These plants have the potential capacity to support Juneau's needs for many years to come. The timing to construct these power plants is dependent on the community's growing needs.

Other customer loads that will or could possibly impact the capacity of Juneau's renewable resources include electrifying the mass transit and touring buses, shore power for Norwegian Cruise Lines at their proposed new dock, the Willoughby Heating District, and the Kensington Mine. The timing of their impact to Juneau's electrical system will define the schedule upon which new hydroelectric power plants will be constructed.

Cruise Ships

Many of the cruise ships visiting Juneau are fitted with electrical connection capability. And many of the ships without such capability are being retrofitted, as are the ships in construction. Most of the present ships, excluding Princess Cruise Line ships, are fitted with their shore power portal on the starboard side of the ship. This lends well to connectivity at the Alaska Steamship Dock, but not at the Cruise Terminal Dock due to normal mooring arrangements. Some ships are fitted with their portals on the port side and a few with portals on both sides which allows them to be connected at the Cruise Terminal. As more ships are retrofitted with portals on both sides or on the port side, this dock will become better utilized.

Our study evaluates connections and energy consumption by the ships based on the ship mooring schedule for 2022. As more ships become fitted with port side connection portals and ship moorage agreements are updated, the potential energy sales are estimated to increase substantially. This profile is based on the adequate availability of energy.

Even though it appears the additional energy requirements by cruise ships is small in comparison to the overall loads served by AEL&P, energy for interruptible loads might not be available all the time due to transmission line maintenance and climatic conditions as discussed earlier. Those periods of unavailability might occur in the early summer or the late summer, all dependent on the timing of the conditions. As noted in the Economic Analysis section of this report, energy is projected to be available for cruise ship use at least 25 percent of the time.

Shore Power Design

Shore power can be provided to both the Alaska Steamship Dock and Cruise Terminal Dock from a single substation. The substation will be located close to the transmission lines located on the hillside above the Juneau Tram depot. Feeders will be routed from there to shore power deployment platforms near the south end of the Alaska Steamship Dock and the north end of the Cruise Terminal Dock. The deployment system will be modernized from the one located at the Franklin Dock to use a movable crane with a retractable boom on a floating dock, allowing connection to varying ship portal locations and types.

The type of substation transformers and control systems will utilize technically advanced types to facilitate easier ship connection to the utility's system. The substation transformer at the existing Franklin Dock substation will be replaced with the more advanced type which will also permit all three docks to be served simultaneously.

The complete cost of construction for both docks is estimated to be $24.9M. CBJ has resolved to support the project with $4.9M while a grant application has been submitted for the remaining $20M. The project can be constructed in phases with power for one dock constructed first and the second at a later date. The construction of the first dock must include

some of the overall costs at the substation to facilitate both docks, thus that cost will be higher than the cost for the second.

Economic Analysis

A basic premise established for this study is that the implementation of shore power facilities for the cruise ships will not impact the current tariffs to AEL&P's customers. To accommodate this principle, the cost of construction must be funded by outside sources, i.e., CBJ and grant sources. Additionally, the cost of operations and maintenance must be incorporated into the cruise ship moorage fees. AEL&P's costs must remain constant and Juneau's electrical rates.

Based on typical ownership arrangements with utilities, and with AEL&P, the utility owns the facility up to and including the point of revenue metering. The customer owns all the facility from that point of demarcation to their loads. For the CBJ's docks, the revenue meters will be located at the substation, thus most of the operations and maintenance costs for the deployment system will be CBJ's responsibility.

As previously noted, the energy is sold to the Princess Cruise Line ships on an interruptible basis. Much of our analysis is based on this model. Under this scenario, AEL&P sells interruptible energy only when it is available. This is excess to their system and the proceeds from the sales are returned to support the low cost of energy to the firm customers. The rates charged to the cruise ships is lower than their estimated costs for onboard generation.

Purchasing firm energy for the cruise ships presents a complex set of circumstances. Assuming firm energy is available, the cost of energy to the cruise ships will increase. If energy is not available, interruptible energy for the Greens Creek Mine and other interruptible customers will be curtailed. From a greenhouse gas perspective, this just shifts the production of them from the ships to the other locations in the region.

There are other costs which will impact the firm customers which cannot be addressed with this study. To fully implement a firm energy profile, AEL&P will be required to upgrade their transmission line infrastructure. Initially until additional hydroelectric power plants are constructed, they will have to provide some of the required energy with their diesel fired power plants.

Air Quality

Providing hydroelectrically produced energy to the cruise ships will significantly reduce greenhouse gases in Juneau, particularly in the port area and downtown. Our study estimates the volume of such gases based on anticipated cruise ship time in port connected to shore power. However, a basic premise is that it is desirable to simply reduce greenhouse gases, not shift them to another location in Juneau.

Recommendations

The country and the world, and most particularly Juneau, are moving from the use of fossil fuels toward renewable, clean sources of electrical production for customer use. The emphasis is being driven by the slow decline in availability of fuels and the obvious destruction of our environment due to greenhouse gases produced by their use. Some excess energy is presently available for shore power connections to cruise ships visiting Juneau to further reduce greenhouse gases.

We recommend CBJ proceed to construct shore power facilities for both the Alaska Steamship Dock and the Cruise Terminal Dock. The design should begin as soon as possible with construction starting when funds become available. Even with the initial lower use of the connections, a substantial amount of greenhouse gases will be reduced. With the deployment systems in place, the potential sales of energy can be facilitated as more ships with appropriate connectivity are available.

It is recommended to construct the deployment systems for both docks with a single project to gain some economy of scale. However, if the project must be phased into two projects or seasons, we recommend the construction of the portion of the system served from the Alaska Steamship Dock be completed first. This dock will provide the best immediate reduction of greenhouse gases.

The purchase of electrical energy should be made initially as an interruptible customer. In the future as more hydroelectric energy sources are developed and the infrastructure is updated to support the community, conversion to becoming a firm customer should be considered.

Conclusion

Our study provides a detailed analysis of the hydroelectric energy available for Juneau, the consumption of energy by the community, and the needs to support the cruise ships visiting Juneau. We are providing a detailed description of the facility required to serve the ships at the CBJ docks, an estimate of costs, and an economic analysis. Notably, we illustrate the quantity of greenhouse gases can be reduced in Juneau with the implementation of shore power.

We look forward to implementation of shore power for the cruise ships at the CBJ docks and the resulting reduction of greenhouse gases.

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Electrical Engineer
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HAIGHT
& ASSOCIATES

INTRODUCTION

The objective of this study is to determine the feasibility of two onshore power deployment facilities at City & Borough of Juneau's (CBJ) two cruise ship docks to reduce cruise ship gas emissions while the ships are in port. The CBJ Assembly adopted the Juneau Climate Action & Implementation Plan (CAAIP) by Resolution 2593 on November 14th, 2011. The objective of the plan is to lower Juneau's greenhouse gas (GHG) emissions. The recommendation within the plan is to reduce community wide GHG 25 percent by 2032. The challenge addressed with this project is to participate in meeting this goal.

The construction of the two CBJ owned cruise ship berths was completed in 2016 and 2017 and included some infrastructure elements required to provide onshore power to the cruise ships. This study further develops a deployment system will be developed to connect cruise ships moored at these docks with electricity generated by the local utility's hydroelectric power plants. This will allow the ships to operate without their onboard fuel fired generators, utilizing locally generated renewable hydroelectric energy to reduce greenhouse gas (GHG) emissions in Juneau's port.

Study Objective

The objective of this study is to determine the feasibility of two onshore power deployment facilities at City & Borough of Juneau's (CBJ) two cruise ship docks to reduce cruise ship gas emissions while the ships are in port. The CBJ Assembly adopted the Juneau Climate Action & Implementation Plan (CAAIP) by Resolution 2593 on November 14th, 2011. The objective of the plan is to lower Juneau's greenhouse gas (GHG) emissions. The recommendation within the plan is to reduce community wide GHG 25 percent by 2032. The challenge addressed with this project is to participate in meeting this goal.

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Brief History

In 2001, the world's first cruise ship shore power facility was installed in Juneau at the Franklin Dock. It was installed as a collaborative project between Princess Cruise Lines and Alaska Electric Light & Power (AEL&P), the local utility. This privately owned facility has been in operation for 20 years providing electricity to the cruise ships from Juneau's renewable resource, hydroelectric plants. The result has been a reduction of consumption of fossil fuels which power the onboard generators, and thereby reducing GHG emissions.

Planning for the electrical system at the CBJ owned Alaska Steamship (AS) and Cruise Terminal (CT) Berths began in 2010 with a written Concept Design published in February 2011. The narrative included a brief description of proposed electrical shore connection deployment system which could be built in conjunction with new berths. The narrative included a brief description of the existing Franklin Dock facility and graphic displays of its energy consumption and power demand.

In 2016 during the construction of the AS and CT Berths, CBJ contracted a team that included PND Engineers, Inc. and Haight & Associates, Inc. to conduct a Feasibility Study which outlined the major elements required to implement an electrical shore connection system for the cruise ships moored to those berths. The 2016 study focused primarily on the characteristics of the facility, but also briefly addressed the probable use of the facility by the cruise ships and AEL&P's electrical capacity.

In 2020, CBJ Docks & Harbors established a team to further evaluate the electrical shore connection system. This study delves further than previous studies into the characteristics of the facilities for both berths by providing a Preliminary Design. Additionally, the cruise ship configurations and power/energy requirements are better illustrated; AEL&P's generation and transmission capacities are identified, the effective costs and rates are analyzed, and the reduction to GHG emissions are determined.

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Objective

A primary objective for the Juneau community is to reduce GHG emissions as identified in the Climate Action and Implementation Plan adopted by the CBJ Assembly in 2011. Reducing cruise ship power plant operations in the Port of Juneau using hydroelectric shore power supports this objective. This study addresses the following key topics:

- Understand and identify the energy needs to provide shore power to the cruise ships.
- Understand and identify the community's electrical capacity available to support new shore power requests.
- Determine and convey a technical direction to install a shore power deployment system with Preliminary Design drawings.
- Determine the costs to implement a shore power deployment system to CBJ docks.
- Determine and convey the economics of implementing a shore power deployment system.
- Determine and convey the reduction of greenhouse gas emissions in the Port of Juneau by providing shore power.

HISTORY / BACKGROUND

Hydroelectric Generation in Juneau

The Juneau gold belt mining industry pioneered the early development of hydropower in Juneau. Their developments provided energy to support mining and mills to extract gold from low grade ore bearing rock. Juneau's early hydroelectric facilities included Annex Creek (1915), Salmon Creek (1914), and Gold Creek Power Plants (1894). These plants have been upgraded over time and are still in operation today.

Juneau's burgeoning power needs in the 1950s and 1960s necessitated the search for a long-term and low-cost power source. Long and Crater Lakes, located about 30 miles southeast of Juneau were subsequently determined to contain developable hydroelectric resources. In 1967, construction began on the Long Lake hydroelectric project by the U.S. Army Corps of Engineers. In 1973, 47.2 megawatts (MW) of power were delivered to Juneau from the Long Lake project. In 1990, the nearby Crater Lake facility was brought on-line, contributing an additional 31 MW of capacity. The Long Lake and Crater Lake facilities collectively power Snettisham Hydroelectric Plant.

In 2009, the Lake Dorothy Hydroelectric Plant, Phase I was completed. It added 14.3 MW to Juneau's capacity.

Juneau's five hydroelectric power plants now provide a combined 102.7 MW peak capacity to the community.

Cruise Ship Electrification

The privately owned onshore power deployment facility was constructed and placed into operation on the Franklin Dock in the Port of Juneau in 2001 as noted previously. The system has the capacity to support a cruise ship load of over 16 MVA. This facility remains in operation today and is used solely by Princess Cruise Line ships.

The facility includes the following primary features:

SUBSTATION: The substation, which is owned by the utility, AEL&P, is located on the mountainside above the Franklin Dock. It is powered from one of the 69 KV

transmission lines routed from the Thane Substation into Juneau. The substation includes 69 KV switches, a stepdown transformer with 12.5 KV, 11.2 KV, and 6.6 KV output capability. The 12.5 KV feeder originally powered an electric steam boiler designated to support the cruise ship heating system. The boiler plant is no longer operating and has been replaced with a power factor correction capacitor bank, owned by Princess Cruise Line. A single feeder to the cruise ships is rated to operate with either 11.2 KV and 6.6 KV output sharing a single set of windings in the transformer. The outputs are connected via two interlocked medium voltage circuit breakers allowing only one voltage to operate at any one time. There is a single combined disconnect and grounding switch on the dock near the connection deployment

equipment. The voltage is selected based on the ship's rated connection.

CRUISE SHIP FEEDER: The cruise ship feeder is composed of three sets of conduits, each with three 15 KV cables and neutral conductor from the substation to the switch located on the Franklin Dock. The conduits are buried to the dock and mounted to the side of the dock to a disconnect & ground switch located on the dock. From the switch, four 15 KV Type G/GC cables are routed across the deck and onto an overhead structure with a festooning system. The Type G/GC cables are a highly flexible, industrial type suitable for this installation.

FESTOONING SYSTEM: The festooning system is an overhead structure with a trolley like system supporting and suspending the cables. The system allows the cables to adjust a short horizontal distance along the side of the ship as well as vertically to the shore power connection port. The cables are raised and lowered using a hoist as the tides change. This system has presented many challenges as cruise ships have gotten larger, due to the spacing from the fixed pier to the ship and the large tide swings. A jib was added to assist in swinging the cables to the ships, but it is a manual system that can be difficult to use when loaded with heavy cables. On certain ships, during extreme low tides the cables are too short to connect safely to the ship.

In 2012 the international standard, IEC/ISO IEEE 80005-1, High Voltage Shore Side Electricity (up to 20MVA per vessel) was developed. This standard was updated in 2019. While based roughly on the original system installed in Juneau, years of knowledge gained by Princess Cruise Lines has been incorporated into the standard which would apply to new installations.

LOCAL UTILITY

System Description

The electrical system supporting Juneau and its surrounding area is owned and operated by AEL&P and is comprised of a network of power plants, transmission lines, substations, and distribution lines. A map of the locations of the hydro power plants and the main transmission lines into Juneau is included in *Appendices: A – Juneau Regional Map*.

The primary source of electrical energy is from the hydroelectric power plants detailed in Table 1 below:

Hydroelectric Plant	Peak Capacity (MW)	Typical Annual Energy Production (MWH)
Snettisham (Crater & Long Lakes)	78.2	295,000
Lake Dorothy, Phase I	14.3	75,000
Salmon Creek	5	31,000
Annex Creek	3.6	24,000
Gold Creek	1.6	5,000
Totals	102.7	430,000

Table No. 1: Existing Power Plant Capacities, Energy Production in an Avg Water Year

AEL&P maintains diesel standby generators to support Juneau when hydroelectric power is not available. The Juneau electrical grid is a relatively long system. served by a single 44-mile-long transmission line from the Snettisham Hydroelectric Plant which carries most of Juneau's electrical load. In the event of an unplanned outage or planned maintenance, it may not be possible to supply hydroelectric power to all customer loads. The standby plants are distributed throughout Juneau's road system to be located closer to customer loads.

When needed, some or all of Juneau's electrical needs can be supplied from these plants. The standby power plants include those at Lemon Creek, Gold Creek, Industrial Boulevard, and Auke Bay. The total generation capacity is 107.5 MW.

AEL&P manages electrical generation to support three classifications of customers: firm, interruptible (non-firm), and dual fuel. Firm customers will always be supplied with electrical energy, however the supply to interruptible and dual fuel customers may be curtailed when the water levels in the reservoirs are low or during power outages.

The Snettisham and Lake Dorothy power plants are connected by transmission line to the Thane Substation which is located approximately four miles south of downtown Juneau. This transmission line operates at 138 Kilovolts (KV) with much of it configured using aerial lines supported on towers. A segment of the line is routed along the bottom of the Taku River with oil cooled submarine cables. The Annex Creek Hydroelectric plant is also connected to the Thane Substation with a 23 KV transmission line routed from the Annex Creek Hydroelectric plant over Powerline Ridge to the Sheep Creek Valley and subsequently the Thane Substation. The Thane Substation converts the transmission voltages from these power plants to a transmission voltage of 69 KV which then connects to the 10 distribution substations located along Juneau's road system. There are two 69kV transmission lines routed from Thane Substation through downtown Juneau.

69 KV Line No. 1 is routed to feed power to the Second Street Substation on Gastineau Avenue, and then connects back to Line 2 at the Lower Salmon Creek Substation. This power line is configured with aerial lines supported by wooden structures. It has a short segment of underground cable routed across the avalanche zone on Thane Road.

69 KV Line No. 2 is routed parallel to Line No. 1 from the Thane Substation to the Lower Salmon Creek Substation with some exceptions as it passes through downtown Juneau. This line feeds the Franklin Dock Substation, Capital Avenue Substation, West Juneau Substation, the radial line to Admiralty Island and continues to the Lower Salmon Creek Substation where is connects back to Line 1.

From the Lower Salmon Creek Substation, a single 69 KV transmission line is routed through the Lemon Creek and Mendenhall Valleys before it ends at Lena Substation.

This line connects the remaining distribution substations and standby powerplants.

12.5 KV distribution circuits are routed from each of distribution substations throughout the community using aerial and underground distribution feeders.

Capacity

AEL&P's ability to furnish hydroelectric energy to the community is dependent on the capacity of their hydroelectric plants and the amount of precipitation stored in the reservoirs. As previously noted, the bulk of hydroelectric power is produced by the plants whose energy is routed through the Thane Substation. Thus, the capacity of the 138 KV and 69 KV transmission lines is an important consideration to the expansion of electrical loads in Juneau.

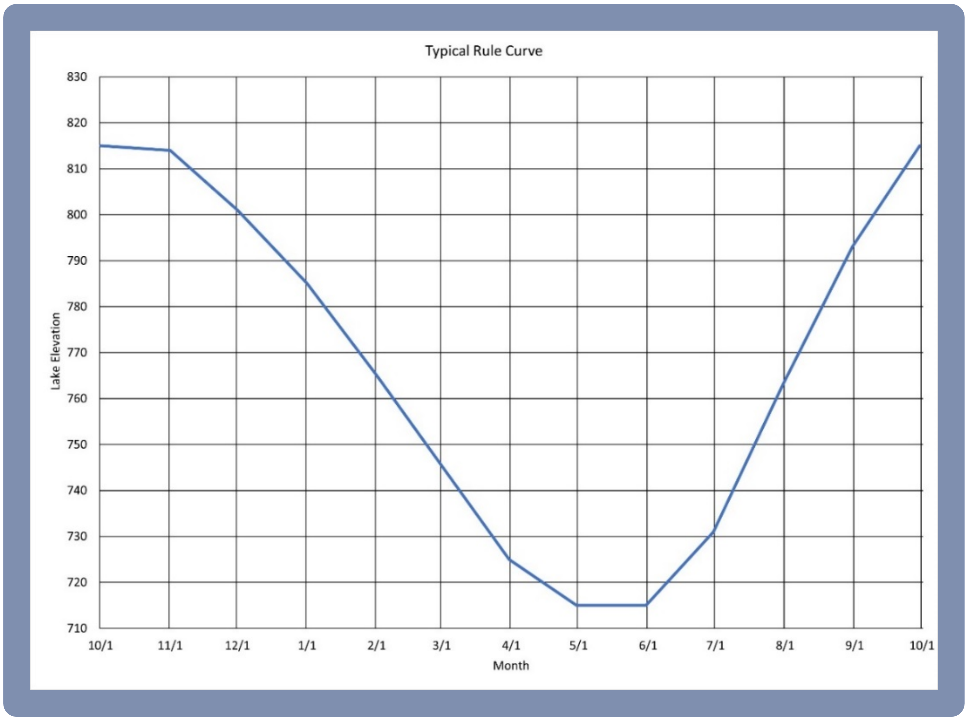
Generation

The available energy from a hydroelectric plant is dependent on the amount of water stored in its reservoir. The amount of water stored is dependent on precipitation, snow storage and runoff to the lake, and how much water is being used to generate electricity for the community.

Reservoir capacity is measured in acre-feet, which is the volume of water contained in an area of one acre with a depth of one foot. The amount of potential energy in an acre-foot of water in the lake is based on the elevation of that "acre-foot" relative to the power plant's turbine-generator. At the maximum lake level, the energy content of an acre-foot of water is highest whereas at the minimum level, the energy content is of an acre-foot is the lowest.

AEL&P utilizes "Rule Curves" for the reservoirs which supply their hydroelectric plants. The "Rule Curves" are based on historic inflows from precipitation and provide a guideline on how to operate the reservoir to optimize energy production over a water year. AEL&P strives to maintain reservoir levels above their "Rule Curve" to ensure the maximum amount of energy can be generated from each plant.

Below is a typical "Rule Curve":



Graph No. 1: Rule Curve

AEL&P collects data and maintains records illustrating their typical dry year, average year, and wet year annual capacities. Table No 2 below identifies the capacities determined for their water sources.

Lake	Dry Year Capacity (MWH)	Average Year Capacity (MWH)	Wet Year Capacity (MWH)
Long Lake (Snettisham)	155,000	195,000	230,000
Crater Lake (Snettisham)	90,000	100,000	125,000
Lake Dorothy, Ph I	63,000	75,000	90,000
Annex Lake (Annex Creek)	22,000	24,000	28,000
Salmon Creek Reservoir	23,000	31,000	38,000
Gold Creek	4,000	5,000	7,000
Total	**357,000**	**430,000**	**518,000**

Table No. 2: Hydro Powerplant Annual Energy Production

Data from AEL&P identifies the firm customer capacity as the minimum available energy, in other words, a dry year. The wet year capacity is the maximum available during a high precipitation year. This will vary seasonally based on the amount of precipitation received as rain versus that from snow runoff. The identified average capacity is typical for most years.

Understanding the impact of water level on hydroelectric generation is critical to understanding how the generating capacity varies throughout the year. When reservoir levels are low, the water pressure to the hydroelectric turbines is less than that when the reservoir water levels are high. The generator's power capacity (MW) is less at a given water flow. Therefore, more water is required to produce a megawatt-hour of energy during those times of low water.

The cruise ship season largely coincides with the lowest reservoir levels, meaning that more water is used to generate electricity during that season. This decreases the overall energy production from the hydroelectric plants during a typical water year. In a wet year, this is offset by the additional precipitation, but during a dry or average water year it can result in insufficient energy production for interruptible and potentially even firm loads.

Transmission

The bulk of the energy supplied to Juneau (86% in a typical year) is produced at the Snettisham and Lake Dorothy Hydroelectric powerplants and delivered to Thane Substation via a 138KV transmission system. The Snettisham and Lake Dorothy transmission lines tie together at the East Terminal Switchyard. The Snettisham line utilizes 795 Drake ACSR rated for 907 amperes while the Lake Dorothy line uses 556 Dove ACSR rated for 726 amperes. A submarine cable runs across the Taku Inlet between East and West Terminals (sites equipped with towers, switches, and assorted equipment involved with transitioning from submarine cables to aerially supported conductors). A significant portion of the line between West Terminal and Thane substation was relocated due to recurring storm damage and upgraded to 1590 Falcon ACSR rated for 1,359 amperes. Several spans of the original Drake remain.

There are two sets of submarine cables. Each set has 4 cables with one cable serving as a spare in the event of a failure. The first set was installed during construction of the original transmission line (1973). One of the four cables has failed. A second set was installed in 1999 with the original set of cables retained as a backup. The original set has a capacity of approximately 300 amperes while the newer set is rated for 635 amperes. The ampacity of the submarine cables is lower than the overhead conductors. Considering their reactive capacitance and voltage drop, the power capacity is probably less than 65 MW on the original set of cables and 135 MW on the newer set of cables.

Every three years, the original cables are placed back in service for several days to verify they still serve as viable spares. When the new set of cables are placed back in service, the spare cable is rotated into service. This exercise is scheduled during the summer months and limits capacity from their primary power plants due to the lower capacity of the original set of submarine cables.

The voltage from Snettisham and Lake Dorothy is reduced to 69 KV with two transformers, operating in parallel at Thane Substation. The transformers were installed with the original facility construction, and each are rated for a maximum load of 59 MVA. Either transformer can serve one or both 69 KV transmission lines departing Thane Substation. The capacity of each 69 KV transmission line is 80MW but due to the radial nature of the transmission system and placement of loads, voltage levels in the Mendenhall Valley become an issue if the system feeder loads exceed 55MW with only one transmission line in service.

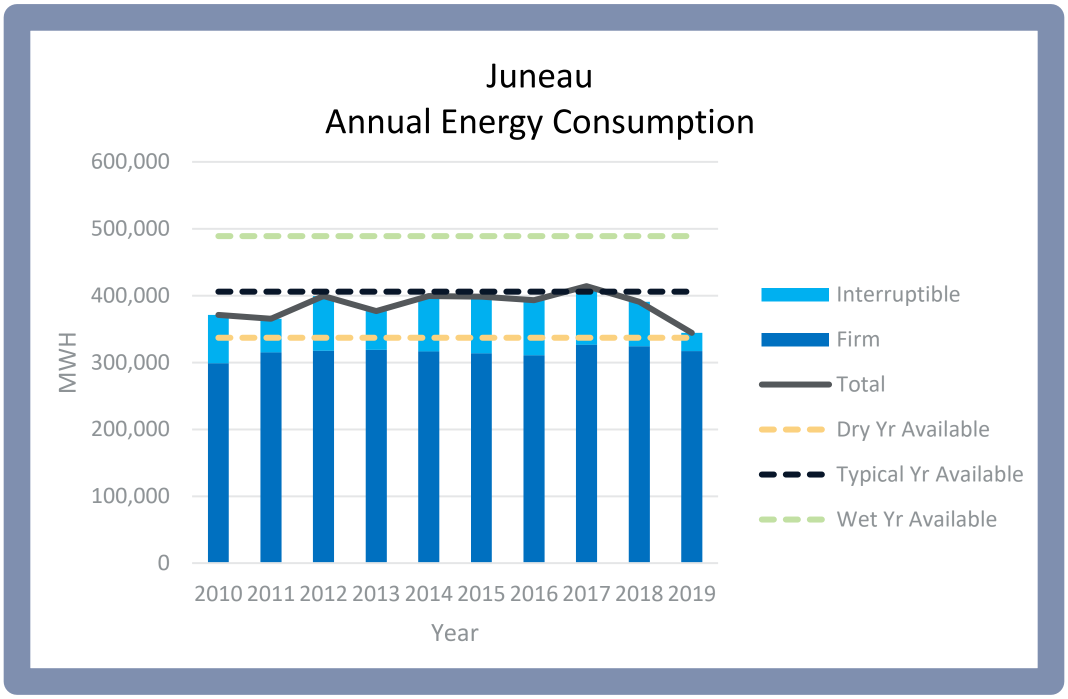
The capacity of the 138 KV and 69 KV transmission lines is an important consideration to the expansion of electrical loads in Juneau. The transmission lines from Snettisham and Thane Substation into downtown Juneau are adequate to support the addition of cruise ship connections at the CBJ docks with hydroelectric plant power. If it is necessary to support the cruise ships with power from the diesel plants to meet firm power requirements, an additional 69 KV line will have to be constructed from the Lemon Creek powerplant to the Salmon Creek Substation.

AEL&P expresses their objective of maintaining full system capacity during the colder and wetter months which occur in the fall, winter, and spring. To maintain that level of service, they perform most of their line maintenance activities in the summer. The work requires de-energizing all or portions of the transmission lines periodically. AEL&P schedules this work to occur when their loads are the lightest. This coincides with the best weather for working on the lines and reduces the diesel generation needed to meet firm customer loads.

The 69 KV transmission lines are configured with switches to allow consolidation of the community loads to a single transmission line as needed to address line outages and maintenance. With the operation of a single 69 KV transmission line, AEL&P has capacity to serve all their firm customers during the summer, but at times need to interrupt service to their interruptible customers including Greens Creek and the Franklin Dock cruise ship shore power.

System Energy Consumption:

Using data acquired from AEL&P, Juneau's monthly energy consumption for ten years, 2010 through 2019, was analyzed. The data included the total consumption by firm customers and by interruptible customers. This data is inclusive for all residential, commercial, institutional, and industrial customers connected to AEL&P's system. The data is illustrated with the following graph:

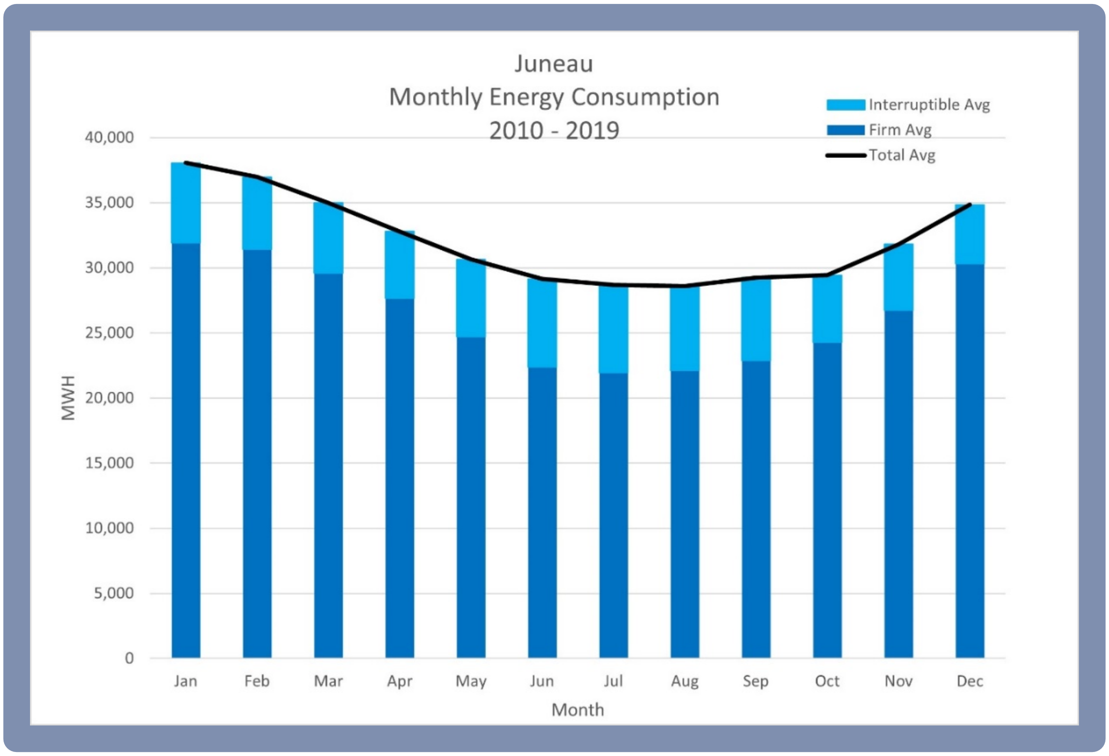


Graph No. 2: Juneau Annual Energy Consumption

*The annual energy available to Juneau excludes the energy required for system operations and losses. See Estimated Community Energy Consumption on page 18.

The energy consumption for both firm and interruptible customers is totaled presenting the normal energy consumption in Juneau. Also included in the graph above are the "Firm", "Average", and "Wet" year hydroelectric power plant capacities. Notably, the capacity for a dry year remains adequate to support the firm customer power needs in Juneau, but not all the interruptible power needs. Both the firm and the interruptible customer needs are supported with some excess capacity during an average year.

Juneau's energy consumption varies with the seasons of the year. Typically, the greatest consumption occurs during the winter with the least occurring during the summer. The following graph illustrates the average monthly consumption over a ten-year period.



Graph No. 3: Juneau Average Monthly Energy Consumption 2010 - 2019

*The annual and monthly energy consumption graphs with their data tables are included as Appendices, C1 – Juneau Annual Energy Consumption & C2 – Juneau Average Monthly Energy Consumption, 2010-2019.

Future Energy Consumers

The future brings new energy consumers. Some of these customers might require firm power and others might accept interruptible service. Major planned projects identified below that are anticipated to add loads of varying significance to AEL&P. Some of these projects are currently under construction. All the identified large loads in this list displace fuel burning systems with electricity. Known potential projects are as follows:

Electric Buses for Capital Transit: CBJ plans to replace diesel powered buses with electric buses over the next few years. Their long-term goal is to replace 18 buses. Bus charging stations are being installed at their maintenance station on Bentwood Lane, plus some stations at their transit centers. The total load is unknown at this time, but it is anticipated to be less than 2 MW. This load will be present year around. Capital Transit will be a firm power customer.

Tour Buses: Planning is proceeding to replace some of the fuel powered tour buses with electric buses. This will include the installation of charging stations at their storage/ maintenance shops as well as in their parking areas near the cruise ship docks. The extent and timing of their transition is unknown currently. These loads will occur during the tour season (summer) and will require firm power connections.

Norwegian Cruise Lines Shore Power: Norwegian Cruise Lines is planning the construction of a new dock adjacent to the existing Coast Guard dock. They intend to include a shore power connection facility supporting a single cruise ship. It is anticipated the load characteristics will be like those for the CBJ docks. Norwegian Cruise Lines will likely be an interruptible customer, although it is possible that the cruise line will request a firm power connection.

Willoughby District Heating Plan: A concept plan has been developed recently to construct a heating plant to provide heat to several large facilities within or adjacent to the Willoughby District in downtown Juneau. The plant is proposed to be sited between Egan Drive and US Coast Guard, Station Juneau. It will utilize heat pumps with seawater for its thermal source. This plant will present a load to the system that varies with the seasons, winter being the greatest load and summer the least. The load characteristics are anticipated to be similar to cruise ship connections.

Kensington Mine: Juneau Hydro is working with AEL&P to extend a power line from the AEL&P service area to Kensington Mine. This connection is intended to provide hydroelectric energy to the mine year around. The loads are anticipated to be nearly constant through all seasons.

Future Hydroelectric Generation:

Several hydroelectric sources are available for development to support Juneau with additional energy capacity. Following is a table of three possible hydroelectric plants, their generation capacity, and their estimated energy production:

Possible Future Hydroelectric Plants	Peak Capacity (MW)	Estimated Annual Energy Production (MWH) *
Sweetheart Lake	19.8	116,000
Lake Dorothy Ph II	30	94,000
Sheep Creek (Chas' heeni)	3.3	13,300
Total	53.1	223,300

* Based on a typical precipitation year.

Table No. 3: Possible Future Hydroelectric Plants

Sweetheart Lake: Juneau Hydropower acquired their FERC permit in 2016 and USFS Special Use permit in 2017. The site is located approximately 33 miles south of Juneau with drainage into Gilbert Bay (Port Snettisham). This hydroelectric plant is planned to be connected to the existing 138 KV power line routed from Snettisham to the Thane Substation.

Lake Dorothy, Ph II: Construction of Lake Dorothy, Ph I was completed in 2009. It utilizes water from Lake Dorothy, Lieuy Lake, and Bart Lakes with a penstock connected directly into Bart Lake. Phase II will supplement the facility with two additional generators and a penstock into Lake Dorothy at a higher elevation. The site is located 17 miles southeast of Juneau along Taku Inlet. This power plant is presently connected to the 138 KV power line from Snettisham to the Thane Substation.

Sheep Creek (Chas' heeni): AEL&P has completed feasibility studies to develop a small-scale hydroelectric plant using water from the Sheep Creek Valley. This will be a run-of-the-river type project with the power plant located near the shore of Gastineau Channel, below the Thane Substation. A 4,750 foot long penstock will be routed from a small diversion dam in Sheep Creek Valley down to the powerplant.

CRUISE SHIPS

Information has been acquired from the cruise ship industry to determine the characteristics of the ships, their typically scheduled visits to Juneau, and their probable demand for electrical energy. This information is being further used to develop Preliminary Design Drawings for the Shore Power Connection Facility, to analyze the impact to AEL&P, and to evaluate the possible effect on the community's electrical rates. Unfortunately, data could not be collected for all cruise lines or ships. The data acquired for most of the ships adequately allows preliminary design and analysis.

Shore Power Connectivity

The characteristics of many of the cruise ships that currently visit Juneau are presented in a tabular form, Appendix B – Ship Profiles. These characteristics include the length of the vessels, the position of the electrical connection portal with reference to their distance from the stern, the side(s) of the ship where the connection portal is located, their maximum electrical demand, and their connection voltage.

Ship Configurations

The Franklin Dock is configured to support the Princess Cruise Line ships. Their ships are configured with the connection portal on the Port side of the ship toward the stern. The location of the portal varies in distance from the stern. The length of the ships and their positioning at the dock allows them to connect most of the time, except during extremely low tides.

The cruise ships that will typically tie to the CBJ As and CT berths have varying connection portal locations. Of the ships scheduled to visit Juneau in 2022, most of their portals are located on the starboard side (21) while some are located on the port side (5). A few have connection portals on both sides of the ship (4). The CBJ berths are floating type thus improving connection opportunities during extreme low tides.

The AS berth includes a floating dock measuring 400 feet in length, designed for neo-panamax cruise ships. The ships typically moor with their Starboard side facing the dock. This minimizes water turbulence to the Merchants Wharf and floatplane dock when the ships arrive and depart.

The CT berth has a smaller floating dock measuring 300 feet in length. This provides less frontage to the side of the ships limiting their ability to adjust their positioning for gangway placement and water & sewer line connections. The larger ships typically moor with their Port side facing the dock easing their approach and departures to the dock. It is possible that smaller ships can moor with their starboard side to the dock.

Voltages/Feeders
The Princess Cruise Line ships are powered at either 6.6 KV or 11.2 KV. The ships for the other cruise lines are configured similarly at the same voltages.

The feeders to the ships at the AS and CT berths are planned to be configured similarly to those installed at the Franklin Dock. A single feeder will be able to supply either 6.6 KV or 11.2 KV power to the ship. The feeder will be configured with several sets of parallel, multiconductor, cables. The multiconductor cables will be limited in size to maximize their flexibility for ease of handling and tidal changes.

Each set of 15 KV rated cables from the substation to the disconnect switch on the dock will include an isolated neutral cable. These conductors will be routed from the Transformer Neutral Grounding Resistor to the ship.

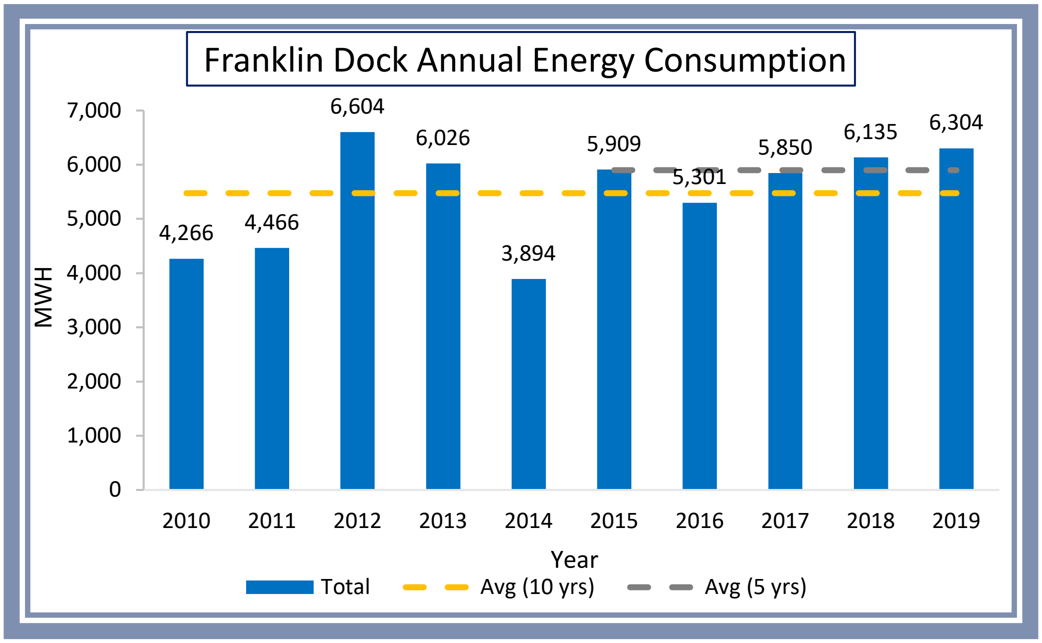
A disconnect and a ground switch will be located on the deployment dock adjacent to the deployment equipment. They will provide visual reference showing the cables are de-energized and grounded prior to connecting the cables to the ship.

Power Demand
The Princess Cruise Line ships are designed to support loads of 8 to 12 MW. With some exception, most of the ships for the other cruise lines are designed for peak loads of 4 to 7 MW from shore power. The exceptions are a few which have capability of peak loads up to 9 MW.

Energy Profiles

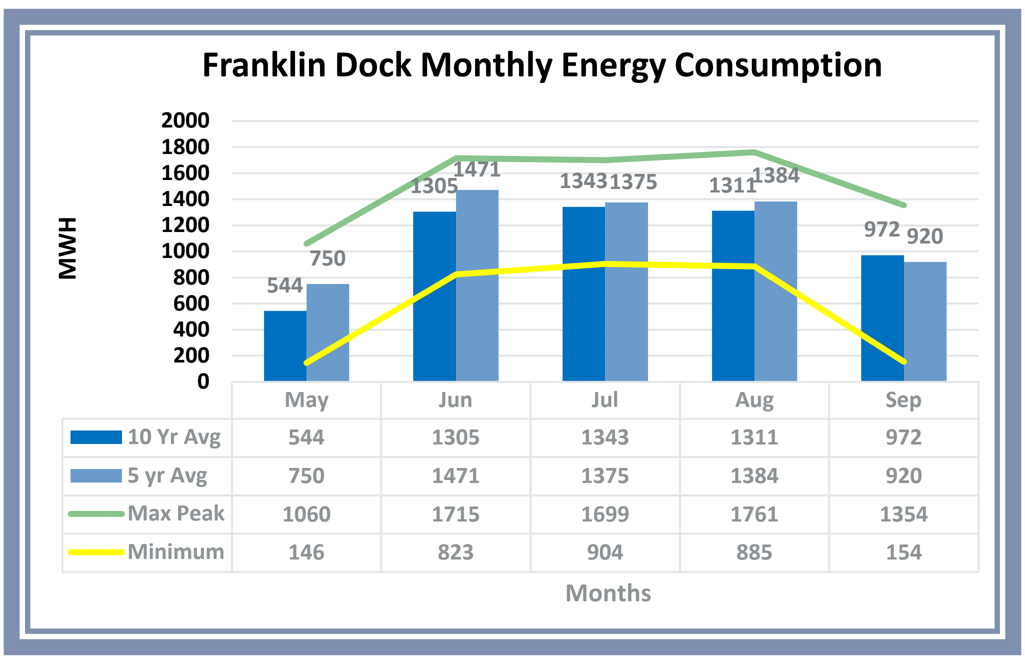
Historic
Franklin Dock energy consumption has been collected since 2001. This data is being presented as a point of reference for energy consumption at the CBJ docks. This report uses data from 2010 through 2019. During the early years of the facility, only some of the ships moored at the dock were able to connect to shore power, so the most recent 10-year period of data is most representative.

The following annual energy consumption graph and table for the Franklin Dock illustrate total energy consumption for each year of a ten-year period. Notably the first two years were relatively low. It is possible that there was not as much demand for connections during that time. The average noted consumption is 5,476 MWH over the ten-year period. The five-year average increases to 5,900 MWH per year.



Graph No. 4: Franklin Dock Annual Energy Consumption

The monthly energy consumption graph and table for the Franklin Dock are presented here to illustrate the energy consumption through the cruise season. As noted, the consumption ramps up from a low in May to a consistent amount for a three-month period during mid-summer, then ramps down in September.



	May	Jun	Jul	Aug	Sep
10 Yr Avg	544	1305	1343	1311	972
5 yr Avg	750	1471	1375	1384	920
Max Peak	1060	1715	1699	1761	1354
Minimum	146	823	904	885	154

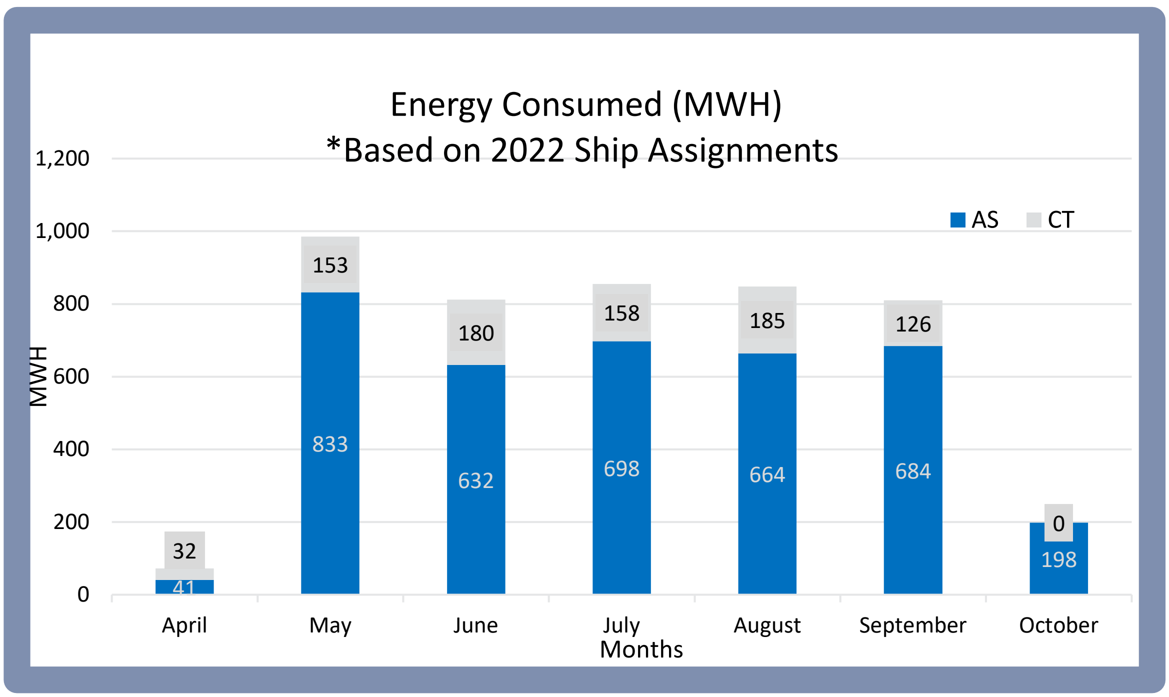
Graph No. 5: Franklin Dock Average Monthly Energy Consumption

Estimated

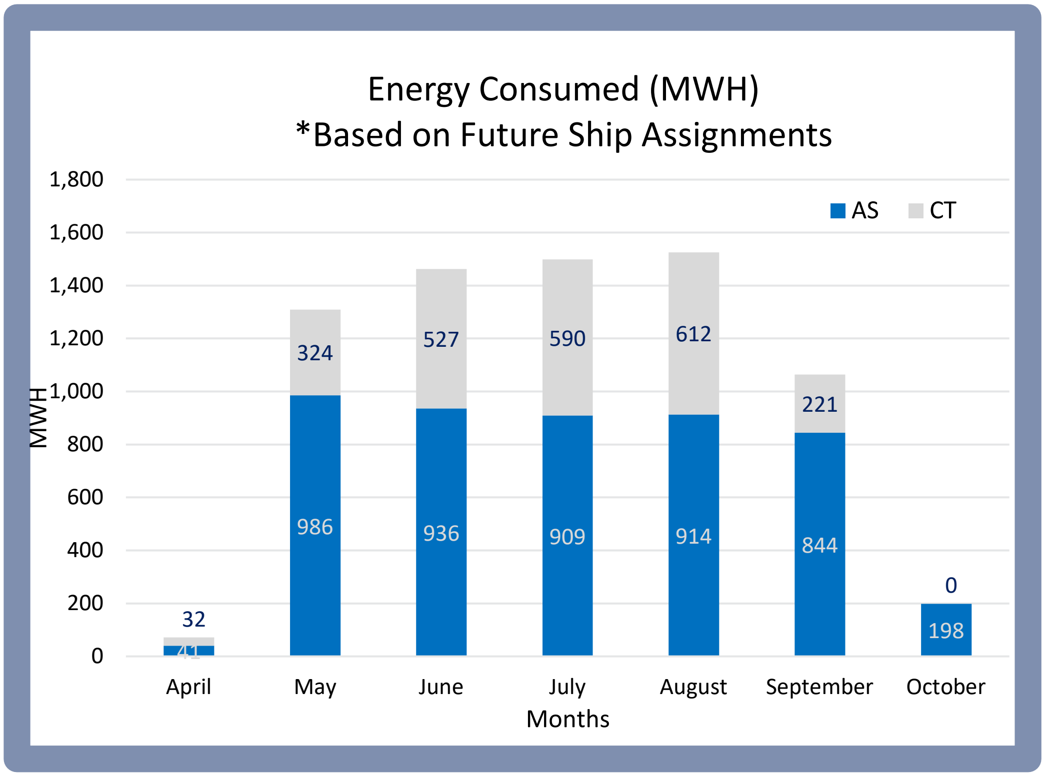
The cruise ship schedule for 2022 was used to estimate the anticipated energy consumption at the CBJ AS and CT berths, along with data collected from the cruise ship lines with respect to their maximum connected loads. The projected estimates include the following factors:

- The scheduled ship's ability to connect to power.
- The position of the ship's electrical connection port with respect to the dock while moored. Only the ships with the connection ports facing the dock can be connected.
- The time the ship can be connected to power while moored to either CBJ dock. The time connected was calculated by subtracting one hour for connection and one hour for disconnection from the total time in port.
- Based on Franklin Dock's annual consumption of 5,900 MWH and estimated time connection of 1,173 hours per season, their average consumption is 5 MWH per hour. This is approximately 50% of their peak load of 9 to 11 MW. The ship operations at the CBJ docks should be similar even though the maximum connection capacity is less than the Princess Cruise Line ships at the Franklin Dock. The ships typically moored to the CBJ docks have a peak load of 4 to 7 MW. Thus, an average load of 4.5 MW was used to estimate energy consumption at the CBJ docks.

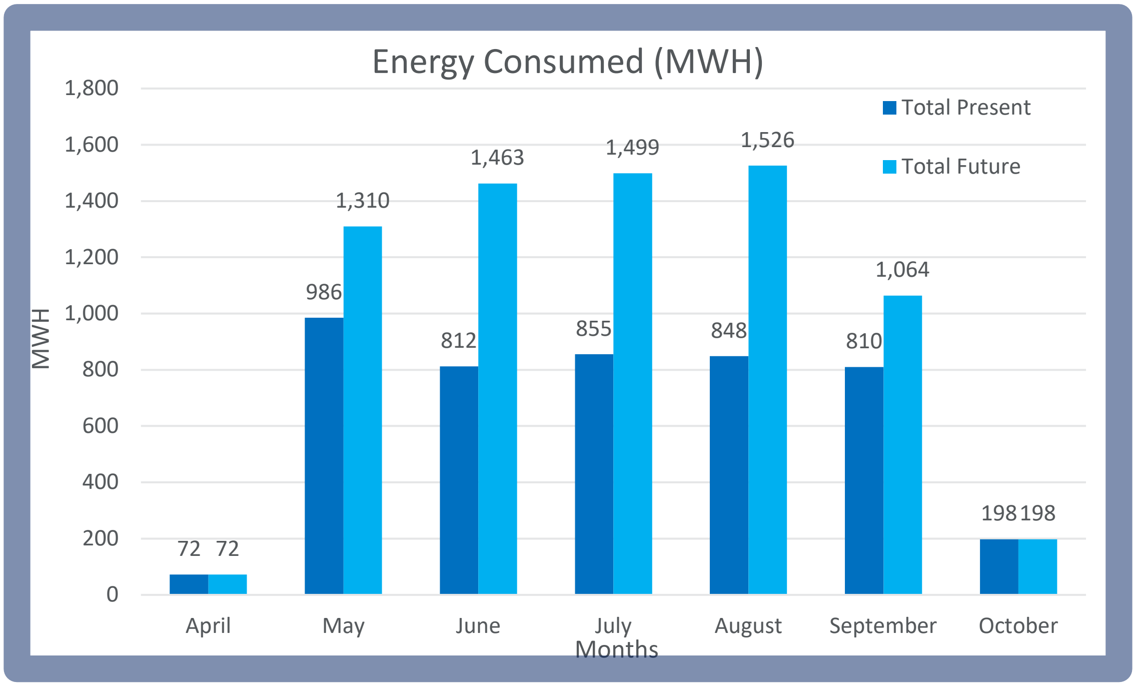
The CBJ AS and CT berth estimated energy consumption graph and table are presented below. The seasonal traits are like those illustrated for the Franklin Dock but with a consistent monthly consumption rate over a five-month period.



Graph No. 6: Cruise Ship Estimated Energy Consumption Based on 2022 Ship Assignments



Graph No. 7: Cruise Ship Energy Consumption base on Optimal Future Assignments



Graph No. 8: Comparative Cruise Ship Energy Consumption - Present vs Optimized

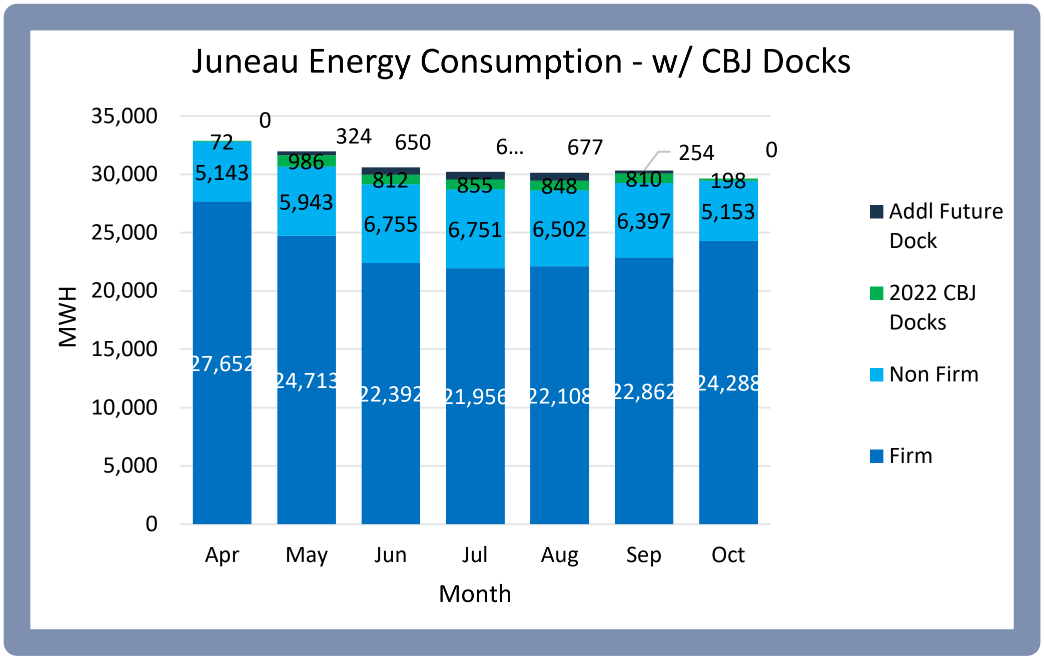
Three graphs present energy consumption at both CBJ docks for the present 2022 cruise ship season and for the optimized use of the docks in the future. As illustrated Graph Nos. 6 & 7, the anticipated energy consumption at the AS berth is greater that the consumption for the CT berth. Graph No. 8 illustrates the comparison of total energy consumed with the 2022 ship assignment schedule versus optimized assignments to gain more onshore power connections.

The data illustrated on Graph No. 6 is based strictly on the cruise shop schedule provided by the cruise industry. With this illustration, only those ships that have connection capability while appropriately moored at the docks are included. Other ships with connection capability, but not scheduled to be moored to allow connection are excluded. The total energy consumption for the 2022 season is estimated to be 4,581 MWHs

The data illustrated on Graph No. 7 is based on the optimal possibility that connectable ships can be shifted with non-connectable ships or ships can be reoriented to expose their connection ports to the dock. This is an extremely optimistic scenario in that some ships cannot be reoriented or that not all ships can be shifted. With this scenario, the total energy consumption at the CBJ docks will be 7,133.

This is an increase of 2,552 MWHs beyond the initial 2022 energy consumption.

Estimated Community Energy Consumption
Graph No. 9 illustrates the effect of supplying energy for cruise ships connected at the CBJ AS and CT berths and the overall impact on the total community energy consumption. This graph includes the community's firm and interruptible loads plus the calculated energy requirements for the cruise ships at the CBJ berths in 2022 using the data for Graph Nos. 3 and 6. The 2022 data is supplemented with the optimal consumption increase (2,552 MWHs) anticipated for future growth as ships are retrofitted with connection portals and mooring assignments are modified using data from Graph No. 8



Graph No. 9: Juneau Energy Consumption including the CBJ Docks

Juneau's hydroelectric capacity based on the amount of captured precipitation every year ranges from 357,000 MWHs on a dry year to 518,000 MWHs on a wet year. The average annual capacity is 430,000 MWHs. The total amount of electrical energy generated at the hydroelectric power plants from 2011 through 2019 ranged from 357,000 MWHs (2019) to 431,000 MWHs (2017). The average over that period was 408,000 MWHs.

The total sales of firm and interruptible energy from 2010 through 2019 averaged 385,279 MWHs per year with a range of 344,312 MWHs (2019) to 414,155 MWHs (2017). The difference between the amount of energy generated and the consumption of energy by the customers is due to energy consumed for system operations and facility losses. This energy consumption for system operations and losses averages approximately 23,000 MWHs per year (5.6% of energy generated).

From 2011 through 2019, there were four years when excess energy was available from the hydroelectric power plants. During that time there were four years when sales to interruptible customers were curtailed. In an analysis by McKinley Research, Appendix E – CBJ Cruise Dock Electrification Cost Analysis (refer to the section, AEL&P Generation Analysis). Based on this analysis, 6,000 MWHs of excess energy was available at least four of the nine years.

The excess energy possibly available for cruise ship consumption in any year is dependent on the time of year when precipitation is usable. During cold winters with heavy snowfall and late springs, excess water is not available until mid to late summer leaving the spring short. During warm winters when precipitation is impounded in the reservoirs in the spring and early summer, the late summers may be short of adequate energy. Thus, the excess energy usable for cruise ship electrification will be less than 6000 MWHs. Based on availability on 4 of 9 years and a cruise season that extends 5 of 12 months of the year, the conclusion is energy will be available for the cruise ships approximately 25 percent of the time from the present hydroelectric power plants.

Electrical

The primary hydroelectric power plants are connected to Juneau with two 69 KV transmission lines routed into the town through the uplands above the new CBJ docks. Electricity will be fed from one of these transmission lines to the water side facility and will include several components. These are defined in sequence leading from the transmission line to the power connectors for the ships. The system must comply with IEC/ISO/IEEE 80005-1 Standards. A map illustrating the layout of the overall electrical system at the Port of Juneau is included in the Appendices as *D1 – Port of Juneau Map.*

Existing AEL&P
Franklin Dock Substation:

To facilitate connections to additional cruise ships, the existing transformer serving the Franklin Dock must be replaced. To easily synchronize the cruise ships to the system, the voltage produced by the substation transformer must match the voltage generated onboard the cruise ship. With a single cruise ship connected to the system, AEL&P has been able to adjust the system voltage enough match the narrow operating voltage range of the cruise ship. However, with additional ships connected to the system, the system voltage can't be adequately adjusted to facilitate the connection. The solution is to replace the existing transformer with one that includes a load tap changing (LTC) feature, thus enabling voltage adjustment to reduce impacts to the utility system.

New AEL&P
Substation for AS and CT Berths:

A new substation will be located on the hillside southeast of the end of Gastineau Avenue. This site is located adjacent to the two existing 69KV transmission lines. The substation will consist of 69KV switchgear and protective relays, transformer(s), and secondary circuit breakers and protective relays. The substation must be adequately sized to power cruise ships at both the AS and CT berths with two separate transformers. The transformers will be rated approximately 10 MVA each, producing output voltages of 11.2 KV and 6.6 KV. A Neutral Grounding Resistor will be used for each transformer secondary neutral along with Power Factor Correction capacitor banks for each cruise ship feeder. All the substation equipment will be air cooled and located above ground with security fencing around the perimeter.

15KV feeder to South Franklin Street:

The hillside between the substation and South Franklin Street is steep with areas of loose rock and overburden. It is a difficult area to install underground conduit. For each ship electrification facility, this portion of the system may include four 6-inch diameter conduit (8 total) and one 2 inch diameter conduits (2 total) installed above ground on structural stands. The conduits will include 15KV rated cables for power and cables for instrumentation and control. The conduits will terminate into a new vault on the uphill side of South Franklin Street.

15KV Feeder from South Franklin Street to Shore:

Twelve 6-inch conduits are presently installed below grade from the location of the proposed new vault on the uphill side of South Franklin Street to an existing manhole near the shore adjacent to the Juneau Tram. Twelve more conduits extend from this manhole beneath the shore and open under water at approximately -5 feet MLLW. This system of conduits and manholes are ready to receive cables to power two ships. The 15KV cables identified earlier will extend from the substation to the existing shore manhole where they will be terminated to a junction. The fiber optic cable(s) will extend to this same manhole and onto the shore power deployment float.

15KV Submarine Cable to the Power Deployment Floats:

Submarine cables specifically designed for underwater conditions will be routed from the shore manhole underwater to the power deployment float. They will be connected to the substation cables on 15KV terminals inside the manhole. The cables will be coiled on the sea bottom below the power deployment float allowing it to move with tide changes. These cables will be suspended from the float and supported on a structure specifically designed to support their weight. The cables will terminate in 15KV switches located on the float.

Power Deployment Float Switchgear:

The switchgear on the power deployment floats will be enclosed in a cabinet mounted to the float near to the cable deployment equipment. The cabinet and enclosed equipment will be suitable for the corrosive marine environment. The switchgear will include a disconnect switch and ground switch, combined to isolate, and ground the cables to the ship when they are being handled. The switch will be collaboratively controlled by the ship crew and AEL&P line crew.

15KV Feeder to the Ship:

Extra heavy duty cables rated for use in mines will be routed from the switchgear to the ship via a cable deployment device. The cables are quite flexible and include connectors on the ship’s end. The cables will be installed in covered cable trays from the switchgear or junction to the deployment device. The cable deployment device will support and move the cables to and from the ship as required to connect and disconnect shore power. This type of system, as opposed to a festooning type of system like the one located on the Franklin Dock, eases cable hand-off, and reduces the need for cable attendance due to tidal changes.

Options Considered:

The system configuration and layout described above is one of several possible options. Based on engineering experience and characteristics of the dock, this seems the most appropriate, however; with implementation of design, other options and sub-options should be considered. Options that were discussed while developing this configuration include the following:

Feeder route from shore to the floating cruise dock: As noted above the feeder is described to be routed directly to the sea bottom and then up to the power deployment float. A route following the approach dock and down the transfer bridge to the main floating cruise dock, and then following a structure to the power deployment float is possible. With this route, the cables used will be the flexible mine type described above to allow for movement at both ends of the transfer bridge and on the transfer structure to the power deployment float. This route is not favored at the CT berth due to the need to allow a portion of the approach trestle to be removable.

Feeder Voltage: Thoughts have been presented regarding moving the higher voltage service to the shore. With this option, the transformers originally planned to be in the substation would be located at the shore. This reduces the substation requirements on the hillside near Gastineau Avenue, and it reduces cable size and subsequent losses between such substation on the hillside and the shore. The conduits and manholes presently installed beneath South Franklin Street and the cruise ship staging area will allow for the higher voltage cables. Criteria that must be considered with this option will include the type of transformer used and its associated location. Per code and regulation, commonly used oil cooled transformers are not allowed over water. Thus, space must be identified within the cruise ship staging area. The transformers are quite large and will cause visual concerns as well as present challenges to disturbances to the existing facility.

Shore-tie Cable Deployment System: The cable deployment system involves a crane style cable positioning device. This has become a preferred method of deployment at most ports along the west coast. Optionally, a festooning type of system like the one installed at the Franklin Dock is possible. This involves additional stationary marine structures at the dolphins with the festooning system constructed above. It will also involve an extension of the approach dock to the dolphins as required to support the feeder cables or routing the submarine cables up dolphin legs to a platform at the catwalk elevations. The required switchgear will be mounted to an extension of the approach dock or platform. With this option, a power deployment float is not required. This type of structure is anticipated to be more expensive, and the cables require continual attendance while connected to the ship due to tide changes.

Power Deployment Floats

The shore power system will be supported by power deployment floats, separate from the presently installed mooring floats, that will be accessed from aluminum gangways mounted to the nearby catwalks and approach dock. The power deployment floats will be fabricated with concrete pontoons or steel pipe construction and will be anchored in place with steel pipe piles and pile frames. The power deployment floats will offer the cable deployment systems a consistent elevation relative to the ships electrical connection portals providing for

improved handoff and retrieval of the shore power cables. The cable deployment equipment will move along the face of the power deployment float, and it will have extendable booms capable of providing an extensive range of reach and ability to accommodate vessels with varying portal configurations.

Low voltage power will be provided from the shore electrical facilities for the cable positioning device and light for the power deployment float. This will involve a separate 480-volt feeder with user voltage panels on the floating docks.

Cost of Construction

Budgetary estimates are attached with this report illustrating probable costs of to install shore power to each berth. The first set of estimates are based on building the AS berth before the CT berth. The cost of most of AEL&P's substation must be included with the first berth that is constructed. Based on that criterion, the cost for the AS berth, if it is constructed first, is estimated to be $13.8M and the CT berth is estimated to be $11.1M.

If the CT berth is constructed first followed by the AS berth, the estimated cost for the CT berth is $13.3M while the cost of the AS berth is estimated to be $11.6M.

The total cost of construction of cruise ship dock electrification at both docks is estimated to be $24.95 M. These estimates include direct costs expected for the Franklin Dock substation upgrade, the new CBJ dock substation, feeders, switchgear, and all devices required for this installation. It does not include costs that might be borne by AEL&P to upgrade their generation or transmission infrastructure.

ECONOMIC ANALYSIS

Previous economic analysis measured the value of CO_2 emissions reductions associated with electrifying the two CBJ docks at $78 million. That value weighs heavily in benefit/cost analysis conducted to support applications for federal grant funding for the project. This analysis focuses on local-level economics, particularly rate-payer implications of investing in dock electrification infrastructure, including three components:

- Cost recovery analysis
- Interruptible power supply and demand
- Cost implications of establishing the docks as firm customers

Cost Recovery Analysis

As noted above the cost to install shore power facilities for the two CBJ docks is estimated at $24.95 million. CBJ has expressed a commitment to contribute $4.9 million, bringing the capital cost modeled in this analysis to $20.05 million. Annual operating and maintenance (O&M) costs are assumed to total $200,000 initially, increasing at a rate of 2% annually. Actual costs will vary depending on a variety of factors, including how maintenance responsibilities are divided between the customer and the utility.

Revenue required to recover construction and O/M costs depends on whether the asset is privately or publicly financed. Analysis of private financing assumes the asset is owned by a rate regulated private entity:

- Declining rate base model
- Period of depreciation: 20 years
- Property and income taxes paid
- Return on equity (equity-share weighted): 6.95%
- Cost of debt: 4.67%
  (cost of debt allowance 1.95%)
- Based on AEL&P rate structure
- CBJ contribution of $4.9 million reduces capital cost to $20.05 million

Public ownership assumes it is owned by CBJ. Cost analysis assumptions include:

- Cash flow model
- Tax exempt
- 100% debt financed, with cost of debt of 4.67%
- Debt term: 20 years
- CBJ contribution of $4.9 million reduces capital cost to $20.05 million

Based on these assumptions, revenue required to fully cover capital and O/M costs were calculated for private financing and public (local) financing, as shown in the following table.

	Year 1	Year 5	Year 10	Year 20	Ann. Avg.
Privately Financed	$3,690	$3,197	$2,581	$1,358	$2,521
Publicly Financed	$1,764	$1,781	$1,803	$1,856	$1,807

Table 4. CBJ Dock Revenue Requirement ($thousands)

The per KWH rate required to generate annual revenues necessary to cover capital and O/M costs will depend on the volume of sales to cruise ships. As described previously in this report, based on the 2022 ship docking assignments, annual sales would total 4.6 million KWH. With optimal future berthing assignments, annual sales could total 7.13 million KWH. That level of sales would (optimally) be achieved within four years.

A third, high case scenario is also considered, based on sales forecasts made by the Juneau Commission on Sustainability (JCOS). In that scenario, sales grow from 9 million KWH initially to 15.6 million kWh by year four. While sales of 9 million KWH in the first few years after dock electrification is not realistic, the analysis is useful in illustrating the volume of sales that would be required to support full-cost private or public financing.

	Year 1	Year 5	Year 10	Year 20	Ann. Avg.
Conservative: 2022 Ship Assignments	4.6	4.6	4.6	4.6	4.6
Mid-case: Optimal Ships Assignments	4.6	7.1	7.1	7.1	6.7
High case: JCOS Forecast	9.0	15.6	15.6	15.6	14.6

Table 5. Electricity Sales to Cruise Ships at CBJ Docks (GWH)

The following table illustrates the per KWH rates required to cover capital and O/M costs, based on the revenue needs and sales estimates tabulated above. As a point of reference, the rate currently charged to interruptible power consumers is 11.8 cents per KWH and the cost for ships to generate on-board power is estimated at about 14 to 20 cents per KWH.

	Year 1	Year 10
Private Financing		
2022 Sales Basis	$0.99	$0.72
Optimal Configuration Sales Basis	$0.99	$0.46
High Case Sales (JCOS)	$0.50	$0.21
Public Financing		
2022 Sales Basis	$0.47	$0.48
Optimal Configuration Sales	$0.47	$0.31
High Case Sales (JCOS)	$0.24	$0.14

Table 6. Rates Required for Cost Recovery, Not Including Cost of Electricity ($/KWH)

The cost for cruise ships to generate their own power depends on fuel prices. For purposes of this analysis, low, medium, and high fuel price scenarios are defined. The range of forecast prices is based in part on Energy Information Administration forecasts for retail on-highway diesel fuel, as well as the price paid most recently by AEL&P.[1] Prices incorporated into this analysis range from $1.75/gallon in year one of the low case to $3.19/gallon in year twenty of the high case, as detailed in the following table. It should be noted that information on actual prices paid by cruise lines was not available and is complicated by bulk discounts, hedging strategies, and different diesel fuel types, among other factors. The prices assumptions here are likely on the high side, which makes the analysis conservative with regard to cost differences between self-generation and dock electrification.

	Year 1	Year 5	Year 10	Year 20	Ann. Avg.
Low Diesel	$1.75	$1.75	$1.75	$1.75	$1.75
Medium Diesel	$1.75	$1.89	$2.09	$2.55	$2.13
High Diesel	$2.19	$2.37	$2.61	$3.19	$2.66

Table 7. Diesel Fuel Prices ($/gallon)

At the fuel prices outlined above, the cost for ships to generate their own electric power ranges from about 14 cents per KWH to 20 cents per KWH. This does not include the relatively small portion of the annual cost to maintain on-board generators that might be attributed to usage while at the dock.

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https://www.eia.gov/outlooks/steo/report/prices.php

	Year 1	Year 5	Year 10	Year 20	Ann. Avg.
Low Diesel	$0.137	$0.137	$0.137	$0.137	$0.137
Medium Diesel	$0.137	$0.148	$0.163	$0.199	$0.166
High Diesel	$0.171	$0.185	$0.204	$0.249	$0.208

Table 8. Cruise Ship Self-Generation Costs ($/KWH)

The following table illustrates annual and cumulative differences, at various ownership, power sales, and fuel price assumptions, between the cost of providing shore power and the cost of on-board generation. The analysis documents that neither private or local public investment pass benefit/cost testing under any reasonable sales or fuel price assumptions.

Federal grant support will be required to make investment in shore power infrastructure economically feasible for the CBJ. In recognition of this, the CBJ has applied for a $20.05 million grant through the U.S. Department of Transportation 2021 RAISE Discretionary Grant program.

	Year 1	Year 10	Year 20	Cumulative
Private Ownership				
2022 Sales Basis: Low Diesel	-$3,605	-$2,495	-$1,272	-$48,712
Medium Diesel	-$3,605	-$2,373	-$986	-$46,020
High Diesel	-$3,448	-$2,186	-$758	-$42,216
Optimal Config. Sales Basis: Low Diesel	-$3,605	-$2,448	-$1,224	-$47,900
Medium Diesel	-$3,605	-$2,257	-$779	-$43,730
High Diesel	-$3,448	-$1,966	-$424	-$38,074
High Case Sales (JCOS): Low Diesel	-$3,521	-$2,290	-$1,067	-$44,970
Medium Diesel	-$3,521	-$1,875	-$95	-$35,886
High Diesel	-$3,212	-$1,240	$679	-$23,651
Public Ownership				
2022 Sales Basis: Low Diesel	-$1,679	-$1,718	-$1,770	-$34,430
Medium Diesel	-$1,679	-$1,595	-$1,484	-$31,739
High Diesel	-$1,522	-$1,408	-$1,256	-$27,935
Optimal Config. Sales Basis: Low Diesel	-$1,679	-$1,670	-$1,722	-$33,619
Medium Diesel	-$1,679	-$1,480	-$1,277	-$29,449
High Diesel	-$1,522	-$1,188	-$922	-$23,793
High Case Sales (JCOS): Low Diesel	-$1,595	-$1,512	-$1,565	-$30,689
Medium Diesel	-$1,595	-$1,097	-$593	-$21,605
High Diesel	-$1,286	-$462	$181	-$9,370

Table 9. Savings/Loss Associated with Full-Cost Shore Power versus Self-Generation ($000)

Dock electrification could be funded by a mix for federal grant funds and local public debt financing. No amount of local debt would be economically viable, defined as that amount for which debt service plus AEL&P's interruptible rate (11.8 cents/KWH) together would be no more (or not meaningfully more) than the cost to produce energy on-board with diesel fuel. Revenue requirements associated with annual operating and maintenance costs, when translated to a per KWH basis, are greater than the estimated savings between on-board generation and AEL&P's interruptible rate.

	Year 1	Year 5	Year 10	Year 20	Ann. Avg.
O&M	$200	$216	$239	$291	$243

Table 10. CBJ Dock Revenue Requirement to Cover Operating and Maintenance Costs ($thousands)

	Year 1	Year 10	Year 20
No Debt Service, O&M Only			
2022 Sales Basis	$0.04	$0.05	$0.06
Optimal Configuration Sales Basis	$0.04	$0.03	$0.04
High Case Sales (JCOS)	$0.02	$0.02	$0.02

Table 11. Rates Required to Cover Annual Operating and Maintenance Costs, Not Including the Cost of Electricity ($/KWH)

	Year 1	Year 10	Year 20	Cumulative
No Debt Service, O&M Only				
2022 Sales Basis: Low Diesel	-$114	-$153	-$206	-$3,144
Medium Diesel	-$114	-$31	$80	-$453
High Diesel	$42	$156	$309	$3,351
Optimal Config. Sales Basis: Low Diesel	-$114	-$106	-$158	-$2,333
Medium Diesel	-$114	$85	$288	$1,837
High Diesel	$42	$376	$643	$7,493
High Case Sales (JCOS): Low Diesel	-$31	$52	$0	$597
Medium Diesel	-$31	$467	$971	$9,681
High Diesel	$278	$1,102	$1,745	$21,916

Table 12. Savings (Loss) Associated with Shore Power versus Self-Generation, Assuming Full Grant Funding (O&M Costs Only) ($thousands)

The preceding analysis is based on electrification of both CBJ docks. Analysis of the AS berth alone, which has total construction costs of $13.8 million, produces the same basic results, which is that federal grant support is necessary.

	Year 1	Year 10	Year 20	Cumulative
Private Ownership				
2022 Sales Basis: Low Diesel	-$1,579	-$1,073	-$533	-$21,080
Medium Diesel	-$1,579	-$951	-$247	-$18,474
High Diesel	-$1,451	-$764	-$19	-$14,948
Optimal Config. Sales Basis: Low Diesel	-$1,579	-$1,026	-$485	-$20,433
Medium Diesel	-$1,579	-$835	-$40	-$16,489
High Diesel	-$1,451	-$544	$315	-$11,447
Public Ownership				
2022 Sales Basis: Low Diesel	-$724	-$728	-$728	-$14,741
Medium Diesel	-$724	-$606	-$606	-$12,136
High Diesel	-$596	-$419	-$419	-$8,609
Optimal Config. Sales Basis: Low Diesel	-$724	-$680	-$680	-$14,095
Medium Diesel	-$724	-$490	-$490	-$10,151
High Diesel	-$596	-$199	-$199	-$5,108

Table 13. Savings/Loss Associated with Full-Cost Shore Power versus Self-Generation ($000), AS Berth Only

Interruptible Power Supply and Demand

The preceding analysis assumes that sufficient power is available to fully meet CBJ cruise ship dock demand. That would most likely not be the case based on the current structure of AEL&P's interruptible power program. Interruptible power is excess hydroelectric energy that would otherwise be wasted (in the form of spilled reservoir water). Interruptible power is available on a prioritized basis, first to Dual Fuel customers, then Princess Cruises Lines (user of Franklin Dock), and finally Greens Creek Mine. Dual Fuel costumers have total maximum demand of about 7,000 MWH, Princess Cruises 6,000 MWH, and Greens Creek 76,000 MWH. In a typical year with no curtailments, AEL&P sells about 84k MWH of power to interruptible customers. CBJ docks would follow Dual Fuel, Princess Cruise Line, and Greens Creek in priority access to interruptible power.

Interruptible sales capacity is variable and uncertain, depending on available excess hydropower – a function of seasonal rain and snow and reservoir levels. Over the past decade, interruptible sales were curtailed in 2011 (January through August), in 2013 (January through April), and the fall of 2018 through the beginning of 2020. As noted previously in this report, AEL&P would anticipate supporting cruise ships only 25 percent of the time presently. Availability of interruptible power could increase with the construction of additional hydroelectric power plants, though that would only be warranted with an increase in firm load.

One important aspect of the interruptible power program is that revenues from interruptible sales are used to discount firm rates. It is to the benefit of all firm rate payers in Juneau that interruptible sales be maximized while firm rates are optimized (with no more development of firm capacity than needed to meet current firm demand).

Firm Cost Analysis

As part of AEL&P's firm customer base, all CBJ docks would have uninterruptible power supply. However, the economic costs and benefits of establishing CBJ docks as firm customers are complex and require analysis of long-term future demand for electric energy in Juneau, the capacity of existing hydroelectric energy generating facilities and transmission infrastructure to meet that demand, and the cost to construct new facilities or otherwise secure additional energy if required to meet future firm demand (such an analysis is beyond the scope of this study). AEL&P is obligated to have adequate infrastructure to provide energy to all its firm customers.

Over the past ten years AEL&P's firm load has grown at an average annual rate of 0.3%. While a higher rate of growth is expected in the future, AEL&P does not anticipate need for additional hydroelectric facilities within the next ten years.[2] AEL&P has identified Sheep Creek and Phase 2 of the Lake Dorothy projects as its next expansion steps, as demand warrants. Juneau Hydropower, Inc.'s Sweetheart Lake hydroelectric project also has potential to meet Juneau's future firm and interruptible customer needs.

Electric sales to firm customers have averaged 318,000 MWHs per year over the last nine years, ranging from 311,000 MWh to 326,000 MWh annually. Sales to firm customers are highly seasonal, with 46% higher sales in January than July. Each customer type has different seasonality; among commercial customers January is 17% higher than July; government 25% higher, and residential 86% higher. Residential sales account for 74% of the seasonal swing in sales to firm customers.

Adding CBJ docks and Princess Cruise Lines (Franklin. Dock) to the firm load would represent a 4% initial increase in average May through September firm sales, based on recent years.

As noted elsewhere in this report, providing cruise ships with firm energy may require construction of another 69KV transmission line to provide necessary transmission redundancy. This would have significant construction cost and firm rate payer implications.

Firm power status for the cruise ship docks could have other implications for firm rate payers. With docks as firm customers, there could be less power available to Greens Creek during periods when surplus (interruptible) energy is insufficient to meet mine demand. That could reduce total interruptible power sales, reducing offsets to all firm rate payers. Further analysis of effects on all rate payers is warranted.

The original 2005 agreement between AEL&P and Greens Creek to sell and purchase interruptible power was set to expire August 31, 2021. On December 16, 2020, AEL&P filed for a one-year extension with subsequent one-year renewals. The Regulatory Commission of Alaska (RCA) approved the extension, with an effective date of February 1, 2021.

[2] AEL&P presentation to the CBJ Assembly, August 2021.

Firm versus Interruptible Rates

Of AEL&P's currently approved firm tariff schedules, CBJ docks would fit under Large Commercial and pay a demand charge on top of energy charges per KWH. Large commercial customers currently pay about $0.06 per KWH as well as a demand charge of $12.33 (winter) or $8.82 (summer) per KW of peak demand each month.

An analysis completed by Alaska Energy Engineering LLC, used 2018 and 2019 monthly energy sales data for Princess Cruise Lines to compare charges under interruptible versus large commercial rates. The analysis indicated that Princess Cruise Lines would have paid more for electricity in both 2018 and 2019 under the firm (Large Commercial) rate compared to the interruptible rate they actually paid. The difference was modest in 2018 ($70,000) and much larger in 2019 ($231,000). The difference between the two years was primarily a result of higher energy costs per kWh for firm customers in 2019 resulting from the cost of power adjustment (COPA). The COPA is calculated based on the cost of diesel power to generate power (when relevant) and the amount of credits flowing from interruptible revenues.

Cruise ships have never been firm customers for AEL&P, and the utility has indicated they would consider developing a tariff specific to cruise ships if they became firm customers. One reason to develop a new rate tariff would be in recognition of the fact that cruise ships are mobile and serving them presents unique risks compared to other firm customers. The cost of any infrastructure developed specifically to support firm cruise ship customers – if cruise ships did not visit CBJ docks in a given year – would be borne by other firm ratepayers. Also, without cruise dock-specific tariff, any costs incurred to serve electrified CBJ docks would result in higher rates for all customers in the Large Commercial rate class. All rate payers in a particular tariff class must be charged uniform rates; all operating and maintenance costs to serve Large Commercial rate payers are spread across that entire rate group.

AIR QUALITY

The Juneau Commission of Sustainability (JCOS) was created in 2007 by CBJ Assembly Resolution 2755. Their task is to support and promote the implementation of the CAAIP.

Cruise ship GHG emissions in the Port of Juneau have been a longtime concern. The Alaska Department of Environmental Conservation (ADEC), Air Quality Division is tasked with monitoring and maintaining air quality assurance. ADEC has been monitoring cruise ship gas plume opacity for many years, and maintains historical records dating to the late 1990's.

In 2019, ADEC conducted a study to assess the air quality impacts for the cruise ship industry. They implemented a grid of tightly spaced, low cost fine particulate matter (PM2.5) monitors and passive sulfur dioxide (SO2) samplers throughout Juneau. The results of their study can be found in their draft "Summary Report for the Juneau Saturation Study" published June 2020. The study identified emissions from several sources, including outdoor food vendors, slash burning, and wildfires in Western Canada.

ADEC found assessing short term air quality impacts from cruise ships to be difficult due to the varying inclusion of other emission sources. However, they did detect short term emissions plumes. The source of these plumes from the cruise ships is not defined regarding the portion generated by their propulsion engines and that from their onboard power plants.

ADEC is maintaining a program with sensors located in a grid in the downtown area. They provide data from these sensors on an hourly basis to the public at their dedicated website: https://dec.alaska.gov/air/air-monitoring/se-ak-sensor-data/

Anticipated Fuel Reduction with Shore Power Connections

Based on historical data, cruise ships are in the Port of Juneau approximately 6,800 hours per season. While in port, those without onshore power connections operate their onboard power plants. Those plants are powered with fuel fired generators.

For the past 20 years, the Princess Cruise Line ships that moor to the Franklin Dock have connected to onshore power and have reduced GHG emissions. With a typical season, they are connected approximately 825 hours. With this reduction of onboard power plant operation, it is estimated there is a fuel consumption avoidance of 461,000 gallons.

With cruise ships moored to the AS berth, based on the historic mooring schedules and the characteristics of the ships moored, it is estimated that onshore power connections may be utilized approximately 833 hours per season. That represents an estimated additional avoidance of 293,000 gallons of fuel consumption by onboard power plant operation.

With cruise ships moored to the CT berth and considering their historic mooring schedules and ship characteristics, it is estimated that onshore power connections may be utilized approximately 185 hours. This represents an additional avoidance of 65,000 gallons of fuel consumption by onboard power plant operation.

If it is possible to adjust cruise ship berth assignments and orientation to the docks, the overall reduction of onboard power plant operation might reach 1,585 hours in total. This represents an avoidance of 557,000 gallons of fuel consumption by onboard power plant operation for both CBJ docks.

The total effect including connections at the Franklin Dock will result in an avoided fuel consumption of 818,828 gallons with the reduction of onboard power plant operation. If it is possible to adjust mooring assignments and mooring orientations, that could increase to as much as 1,018,000 gallons.

Anticipated Gas Emission Reduction

Power plant fuel avoidance obtained by use of hydroelectric energy from onshore deployment connections will reduce gases harmful to the community. The primary gases eliminated include carbon dioxide (CO2), nitrous oxide (NOx), sulfur oxide (SOx), and particulate matter smaller than 2.5 micrometers (PM2.5). The following table illustrates the estimated reduction of fuel consumption and gas emissions:

		Avoided Fuel Consumption (gallons)	CO_2 (tonnes)	NO_x (tonnes)	SO_x (tonnes)	PM2.5 (tonnes)
2022 Moorage						
	AS Berth	292,852	2,987	89	65	8
	CT Berth	65,039	663	20	14	2
	Total	**357,891**	**3,650**	**109**	**79**	**9**
Possible Future Moorage						
	AS Berth	377,227	3,848	115	84	10
	CT Berth	180,000	1,836	55	40	5
	Total	**557,227**	**5,684**	**170**	**124**	**14**
	Avoided Gas Emissions (grams/grams (fuel) *Note		3.2	0.096	0.07	0.00728
	Avoided Gas Emissions - Calculated (tonnes/gal)		0.0102	0.000305	0.000222	0.0000257

*Note: The quantities of toxic gas and particulate was taken from a paper, "Evaluating Air Emission Inventories and Indicators from Cruise Vessels at Ports", written by German de Melo Rodrigues, Enrique Martin Alcalde, JC Murcia-Gonzalez, and Sergi Sauri in 2017

Table No. 14: Avoided Fuel Consumption & Greenhouse Gas Emissions

Availability of Electrical Energy

Based on historic data, an average of 5,900 MWHs of electrical energy was consumed each cruise season at the Franklin Dock over a period of 2015 through 2019.

Using the cruise ship schedule for 2022 along with information regarding onshore power connect-ability for these ships, it is estimated an additional 4,581 MWHs will be consumed at the proposed CBJ docks every cruise ship season.

Over time, it is anticipated more ships will be built or retrofitted with onshore power connections. With that anticipation and the possibility that ship moorage assignments can be updated to allow more connections and considering the energy conserving measures taken with the newer and retrofitted ships, it is estimated that the amount of energy consumed at the CBJ docks will increase to 7,133 MWHs per cruise ship season. This scenario could be reached within 10 years after completion of the shore power installations.

In their presentation to the CBJ Assembly in June 2021, AEL&P graphically illustrated their past, present, and anticipated future energy generation. In past years with normal precipitation and snow accumulation, there has been adequate energy to support all the firm and interruptible loads. AEL&P's forecast with one percent growth graphically indicates that without the addition of consumption by the CBJ docks, the community's (including the Greens Creek interruptible load) energy consumption will exceed the identified average year capacity by 2023 or 2024.

Similarly, in years with the least precipitation and snowfall experienced, AEL&P has adequate capacity without the consumption requirements for the CBJ docks to support all its firm and interruptible loads excepting Greens Creek through 2024. Based on the community's anticipated growth, they can support their firm loads in an average water year with hydroelectric generation for at least the next 10 years.

In 2010, AEL&P made a presentation to the National Hydropower Association about the economic strategy to build Lake Dorothy Phase I.[3] Their presentation included a graph that illustrated the actual energy consumption growth and anticipated growth based at 1.3 percent per year. The system capacity is illustrated with this energy curve showing the addition of each new hydroelectric power plant. This graph is 11 years old but helps understand the strategic time at which a new power plant might be constructed under those assumptions. The compound annual average firm load growth experienced over the past 10 years is 0.3%, illustrating that the 2010 load projections were

[3] https://www.hydro.org/wp-content/uploads/2017/08/AK-Electric-Light-and-Power-Lake-Dorthy-Project.pdf

higher than the actual growth experienced during that time frame.

As illustrated in their presentation to the CBJ Assembly in June, AEL&P manages the reservoir levels for each of their power plants to optimize energy production. Typically, the reservoir levels are low in the summer; during this period more water is required to generate each MWh of energy consumed and this is when the cruise ships will typically demand their electrical energy. Using additional water in the summer months can impact the reservoir levels in the fall and winter especially during dry water years.

Based upon historical precipitation existing hydroelectric generating capacity, and electrical demand, AEL&P projects they will be capable of offering electrical energy to the CBJ cruise ship docks only 25% of the time it is requested. It is expected this will improve over time as the firm load increases, requiring the construction of additional hydroelectric power plants. Such construction will likely facilitate additional capacity for interruptible loads.

During the summer, portions of the 138kV and 69 KV transmission lines are taken out of service for maintenance and system improvements. The reduces the transmission system's reliable capacity and can impair the ability of AEL&P to serve loads with hydroelectric energy. AEL&P typically interrupts their non-firm customers during this time or in the event of 138kV line work AEL&P interrupts non-firm customers and uses diesel generation to supply firm loads. This points to the case that with the present system, only interruptible electrical service is available to cruise ships. To provide firm service to cruise ships additional transmission infrastructure will be required.

Construction Features

Deployment systems will be installed on new pontoon type floating docks. The docks will be strategically positioned to optimally provide connections to all the cruise ships. The deployment systems will be fed with power from a new substation located on the uplands

above South Franklin Street, adjacent to AEL&P's 69 KV transmission lines.

The deployment system will be constructed to the AS berth first and CT berth second. The opportunities for connection at the AS berth are greater thus offering more immediate relief from greenhouse gas emissions. The cost to construct and implement the North Berth Deployment system is estimated to be $13.8M while the subsequent implementation for the South Berth is estimated to be $11.1M.

Economics

Economic analysis provides several key findings:

- Federal (or other) grant funding for construction is necessary for the project to make economic sense for the community and involved parties. Revenues from energy sales to cruise ships would only be adequate to cover annual operations and maintenance costs. Cost recovery would be through AEL&P rates or potentially through CBJ moorage fees.
- Simply adding the CBJ docks as interruptible energy buyers is problematic unless the ships have priority over Greens Creek; even then power supply is subject to curtailment. That uncertainty adds risk to any level of debt repayment.
- Establishing CBJ docks (and Franklin Dock) as firm customers is problematic because of the evident need for another 69KV transmission line to provide necessary transmission redundancy. Cost of the

additional line is unknown but likely very high and not recoverable from cruise lines or firm rate payers (absent an increase in firm rates).

- There is risk associated with any investment in infrastructure specifically intended to serve “mobile” buyers of energy. If for any reason cruise ship traffic dropped, the cost to pay for that infrastructure would fall to other firm ratepayers.
- If sufficient grant funding materializes, one course of action would be for AEL&P to modify its interruptible agreements, placing docks in front of Greens Creek in terms of priority access to interruptible power. Greens Creek would see a decline in its interruptible power supply and incur higher energy production costs as its reliance on diesel generation increases. Careful analysis would be required to estimate the magnitude of the decline in sales to Greens Creek, and therefore the impact on total interruptible sales, as the loss in Greens Creek sales may be greater than the gain in cruise ship sales. Firm rate payers may or may not be held harmless, depending on the amount of interruptible sales revenue available to offset firm rates. Assuming there is no debt to repay, during periods of curtailment no harm would be done in that regard by lack of interruptible sales revenue.
- If grant funding is not available to support electrification of both CBJ docks, investing in the north berth first may be the next best step. Grant fund needs would be less, as would any local matching contributions.

Air Quality

With electrification at the CBJ docks, it is anticipated there will be an initial reduction of fuel consumption for generation of 358 K gallons. In the future this could reach 557 K gallons. With this reduction of fuel consumption and increased use of renewable energy from AEL&P, greenhouse gas emissions will be substantially reduced.