Research & Technology Transfer

Alaska Department of Transportation & Public Facilities

ALASKA LOW EMISSION/ ELECTRIC FERRY RESEARCH ANALYSIS

Cultivating a Systems Approach to Sustainable Transportation by Implementing Climate Responsive Ferry Vessel Options

DATE: June 2023

PREPARED FOR:
Alaska Department of Transportation & Public Facilities
Statewide Research Office
3132 Channel Drive
Juneau, AK 99801-7898

FEDERAL PROJECT NUMBER: FHWA-AK-RD-4000(213)
STATE PROJECT NUMBER: HFHWY00281

PREPARED BY:

Southeast Conference

Elliott Bay Design Group

REPORT DOCUMENTATION PAGE	Form approved OMB No.

1. AGENCY USE ONLY (LEAVE BLANK)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
FHWA-AK-RD-4000(213)	June, 2023	Research

4. TITLE AND SUBTITLE

ALASKA LOW EMISSION / ELECTRIC FERRY RESEARCH ANALYSIS: ***Cultivating a Systems Approach to Sustainable Transportation by Implementing Climate Responsive Ferry Vessel Options***

5. FUNDING NUMBERS

6. AUTHOR(S)

Elliott Bay Design Group under contact to Southeast Conference

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

State of Alaska, Alaska Dept. of Transportation and Public Facilities
Research and Technology Transfer
3132 Channel Drive
Juneau, AK 99801-7898

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

HFHWY00281

11. SUPPLEMENTARY NOTES

Performed in cooperation with FHWA, Alaska DOT&PF, Southeast Conference

12a. DISTRIBUTION / AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
No restrictions	

13. ABSTRACT (Maximum 200 words)

Analysis of practical use of non-diesel range alternative fuels or electricity to power Alaska Marine Highway System ferries between certain AMHS ports of call. Analysis includes consideration of fuel types, refueling/recharging options, vessel design features to consider when using alternative fuels, vessel and route capacities, estimating quantity of avoided carbon dioxide emissions from use of alternative fuels, and potential shoreside benefits from electric storage banks.

14- KEYWORDS : Electricity; alternative fuel; emissions;

15. NUMBER OF PAGES
124

16. PRICE CODE
N/A

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	N/A

NSN 7540-01-280-5500

STANDARD FORM 298 (Rev. 2-98)
Prescribed by ANSI Std. 239-18 298-102

METRIC (SI*) CONVERSION FACTORS

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Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH					**LENGTH**		
in	inches	25.4		mm	mm	millimeters	0.039	inches	in
ft	feet	0.3048		m	m	meters	3.28	feet	ft
yd	yards	0.914		m	m	meters	1.09	yards	yd
mi	Miles (statute)	1.61		km	km	kilometers	0.621	Miles (statute)	mi
		AREA					**AREA**		
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yd^2	square yards	0.836	meters squared	m^2	km^2	kilometers squared	0.39	square miles	mi^2
mi^2	square miles	2.59	kilometers squared	km^2	ha	hectares (10,000 m^2)	2.471	acres	ac
ac	acres	0.4046	hectares	ha					
		MASS (weight)					**MASS (weight)**		
oz	Ounces (avdp)	28.35	grams	g	g	grams	0.0353	Ounces (avdp)	oz
lb	Pounds (avdp)	0.454	kilograms	kg	kg	kilograms	2.205	Pounds (avdp)	lb
T	Short tons (2000 lb)	0.907	megagrams	mg	mg	megagrams (1000 kg)	1.103	short tons	T
		VOLUME					**VOLUME**		
fl oz	fluid ounces (US)	29.57	milliliters	mL	mL	milliliters	0.034	fluid ounces (US)	fl oz
gal	Gallons (liq)	3.785	liters	liters	liters	liters	0.264	Gallons (liq)	gal
ft^3	cubic feet	0.0283	meters cubed	m^3	m^3	meters cubed	35.315	cubic feet	ft^3
yd^3	cubic yards	0.765	meters cubed	m^3	m^3	meters cubed	1.308	cubic yards	yd^3
Note: Volumes greater than 1000 L shall be shown in m^3									
		TEMPERATURE (exact)					**TEMPERATURE (exact)**		
°F	Fahrenheit temperature	5/9 (°F-32)	Celsius temperature	°C	°C	Celsius temperature	9/5 °C+32	Fahrenheit temperature	°F
		ILLUMINATION					**ILLUMINATION**		
fc	Foot-candles	10.76	lux	lx	lx	lux	0.0929	foot-candles	fc
fl	foot-lamberts	3.426	candela/m^2	cd/cm^2	cd/cm^2	candela/m^2	0.2919	foot-lamberts	fl
		FORCE and PRESSURE or STRESS					**FORCE and PRESSURE or STRESS**		
lbf	pound-force	4.45	newtons	N	N	newtons	0.225	pound-force	lbf
psi	pound-force per square inch	6.89	kilopascals	kPa	kPa	kilopascals	0.145	pound-force per square inch	psi

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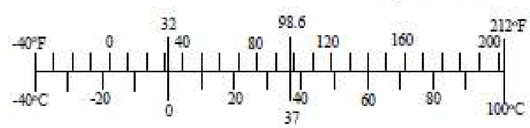

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REVISIONS

REV	DESCRIPTION	DATE	APPROVED
-	Final release.	06/21/23	---

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IFA ferry PRINCE OF WALES[1], an EBDG design built at Dakota Creek Industries in 2006.

[1] MV Prince of Wales - Wikipedia

Acronym List	
ABS	American Bureau of Shipping
AC	Alternating Current
ADA	Americans with Disabilities Act
AMHS	Alaska Marine Highway System
ASV	Alaska Standard Vehicle
BESS	Battery Energy Storage System
CA	California
CEDS	Comprehensive Economic Development Strategies
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
COPA	Cost of Power Adjustment
DC	Direct Current
DEF	Diesel Exhaust Fluid
DNV	Det Norske Veritas
DoD	Depth of Discharge
DOT&PF	Department of Transportation & Public Facilities
EBDG	Elliott Bay Design Group
EEXI	Energy Efficiency Existing Ship Index
EOL	End Of Life
EPA	Environmental Protection Agency
FTA	Federal Transit Administration
FHWA	Federal Highway Administration
GRT	Gross Regulatory Tonnage
HUD	Department of Housing and Urban Development
HVO	Hydrotreated Vegetable Oil
ICE	Internal Combustion Engine
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IFA	Interisland Ferry Authority
IIJA	Infrastructure Investment and Jobs Act
IMO	International Maritime Organization
ISO	International Organization for Standardization
ITB	Island Tug & Barge
J40	Justice40
LCI	Load-Commutated Inverter
LCO	Lithium Cobalt Oxide
LFP	Lithium Iron Phosphates
LNG	Liquified Natural Gas
LTO	Lithium Titanium Oxide
LV	Low Voltage
MV	Medium Voltage
N_2O	Nitrous Oxide
NCA	Nickel Cobalt Alumina
NiMH	Nickel Metal Hydride
NMC	Nickel Manganese Cobalt
NO_x	Nitrogen Oxides
OMB	Office of Management and Budget
PM	Permanent Magnet
PWM	Pulse-Width Modulation

RCS	Rapid Charging System
SOH	State of Charge
SOLAS	Safety of Life at Sea
STEP	Sustainable Transportation and Energy Program
USCG	United States Coast Guard
USDA	United States Department of Agriculture

Definitions	
EJ SREEN	Environmental Justice Screening and Mapping Tool
Electric or Low-Emitting Ferry	A ferry that reduces emissions by utilizing alternative fuels or onboard energy storage systems and related charging infrastructure to reduce emissions or produce zero onboard emissions under normal operation.
Hotel Loads	Energy demands onboard a vessel unrelated to propulsion and control. This includes HVAC, food preparation, lighting, and other systems.
Justice40 Initiative or J40	has the meaning defined at Section 223 of Presidential Executive Order 14008, Tackling the Climate Crisis at Home and Abroad. The Justice40 Initiative is a government effort to deliver at least 40 percent of the overall benefits from certain federal investments to disadvantaged communities.

EXECUTIVE SUMMARY

The United States and the world face a profound climate crisis; Alaska is at the forefront of its impacts, experiencing change at twice the national rate. Federal infrastructure investment through the Infrastructure Investment and Jobs Act (IIJA) provides an opportunity to reflect and rebuild in ways that support our communities by mitigating the worst damages of climate change while advancing environmental justice. Funds from the FTA's Low-No Ferry Program will be leveraged by the Alaska Department of Transportation & Public Facilities (DOT&PF) to modernize the Alaska Marine Highway System (AMHS) with the purchase and deployment of an electric ferry and associated charging infrastructure.

The Alaska Marine Highway System provides essential transportation to 34 of Alaska's coastal communities, stretching from Metlakatla north to Prince William Sound and the Kenai Peninsula and west to the Aleutian chain. With only five of these communities connected to Alaska's road system, AMHS provides a critical transportation link for Alaska residents and businesses and nonresidents visiting our state. A strong ferry system is essential to regional economic development, quality of life, and community well-being. The AMHS provides access to health care, shuttles workers to their jobs, carries visitors, connects markets and customers, and allows fishermen to move seafood to markets. It moves freight, building materials, and machinery to support local development. It supports social and cultural connections and is relied upon for food security. Transportation connectivity for Alaska's marine highway connected communities has long been identified as the most vulnerable element of the regional economy. The age and condition of AMHS' fleet has required extensive overhaul and maintenance, even as lack of available resources has resulted in deferred and reduced maintenance, which has led to ships being removed from service.

The current number of vessels serving proposed routes are inadequate to meet the ridership demands of these communities, if maintenance needs are taken into account. It is worth noting that each time a vessel enters a maintenance or overhaul period, whether drydocked for intensive capital expenditures or tied up pier-side for smaller scopes of work, there is a high risk of delay, change orders, and increased work scope due to the discovery of additional structural or mechanical issues during planned maintenance. Delays due to discovery work can keep a vessel in the shipyard or tied up at the pier for longer than expected, especially if the discovered issues are severe enough to trigger a USCG no-sail order until they are remediated. This, in turn, reduces the level of service each can provide to the communities they serve. A new vessel added to the inventory will better support ridership by being positioned to augment current capacity and fill holes when current vessels are under repair.

This collaborative and extensive research analysis arrives with a suggested pilot vessel construction project that lowers carbon emissions and is scalable to reducing emissions entirely on some routes. Five of six route locations utilize hydropower for the majority of their electric needs, and low/no emission shoreside power will complement the overall mitigation efforts of the State.

1. INTRODUCTION AND RESEARCH APPROACH

The DOT&PF|Alaska Marine Highway System (AMHS) serves 34 Alaska ports by transporting passengers and vehicles between coastal communities. This service helps meet Alaskans' social, educational, health and economic needs. AMHS provides year-round scheduled ferry service throughout Southeast and Southwest Alaska, extending south to Prince Rupert, British Columbia and Bellingham, Washington. The system connects communities with each other, regional centers, and the continental road system. It is an integral part of Alaska's highway system, reaching many communities that would otherwise be cut off from the rest of the state and nation. AMHS also provides a coastal transportation alternative between Anchorage and the "Lower 48" states versus driving the Alaska Highway.

AMHS is designed to provide essential transportation services to communities: transportation that allows community access to health services, commodities, legal services, government services, and social services; transportation that meets the social needs of isolated communities; and transportation that provides a base for economic development. AMHS service is divided into two major systems: the Southeast System (from Bellingham north to Yakutat) and the Southwest System (from Cordova west to Unalaska). The Alaska Marine Highway fleet consists of nine vessels; six operate in the Southeast System and three operate in the Southwest System. All nine vessels are designed to carry passengers and vehicles ranging in size from motorcycles to large freight container vans. Trips on AMHS can last several hours or several days, so passenger services are an important aspect of the State's transportation service. Most vessels provide food service, shower facilities, observation lounges, and recliner lounges. The larger vessels provide additional amenities, including play areas for children. Four vessels have stateroom accommodations for overnight travel.

One regular use of AMHS is the year-round transportation of container vans. These vans transport time-sensitive cargo such as fresh vegetables, meat, and dairy products from Bellingham and regional Alaska centers to communities served by the system. Local restaurants, grocery stores, individuals, and food distribution businesses have established delivery schedules with AMHS to ensure regular and continuous delivery of perishable goods. Shipping perishable supplies on AMHS is more cost-effective than air freight, and in many cases ensures delivery to communities on a more frequent basis than commercial barge and freight lines. Vans are also used to move fresh Alaska fish and seafood to markets, and to transport US mail and household goods.

The Southwest system serves Prince William Sound, the Kenai Peninsula, Kodiak Island, and the Aleutians. The MV TUSTUMENA provides regular service between Kodiak, Port Lions, Seldovia and Homer. The Southwest routes connect to the continental road system at Valdez, Whittier, and Homer, Alaska. The MV KENNICOTT provides regular cross-gulf sailings. These sailings connect Southeast Alaska with the Southcentral and Southwest regions of the state. The Southeast route is divided into two subsystems: the "mainline" routes, which typically take more than one day for the ship to travel and shorter routes, where vessels depart their home port in the morning, travel to destination ports and then return to their home port on the same day. The mainline routes carry a high percentage of tourists and vehicles in the summer, and provide service between Bellingham, Washington or Prince Rupert, BC, and Skagway or Haines, Alaska. Along the way, the ships stop in Ketchikan, Wrangell, Petersburg, Sitka, Juneau, and Haines. Although Kake and Hoonah are smaller communities, they are also served by certain mainline sailings. The day boat routes connect the smaller communities to regional hub communities for commerce, government, health services, and connections to other transportation systems.

1.1 CURRENT FLEET SUMMARY

AMHS' fleet is composed of nine vessels with an average age nearing 34 years. Typical commercial vessels are designed for a lifetime of about 25 years, but public ferries are often designed to operate closer to 50 years. The propulsion arrangements for all vessels in the fleet are similar: two prime movers (diesel engines) each powering a propeller through a reduction gear. Table 1 shows the characteristics for all current vessels in the fleet.

Table 1: AMHS Fleet Summary

	AURORA	COLUMBIA	KENNICOTT	LECONTE	LITUYA	MATANUSKA	TAZLINA	TUSTUMENA	HUBBARD
Build Date	1977	1974	1998	1974	2004	1963	2019	1964	2019
Length (ft)	235	418	382	235	181	408	280	296	280
Beam (ft)	57	85	85	57	50	74	67	59	67
Dispalcement (LT)	2132	7684	7504	2132	647	5569	3016	3081	3016
Gross Tonnage (ITC)	3124	13009	12635	3124	758	9214	5304	4529	5304
Gross Tonnage (Domestic)	1280	3946	9978	1328	97	3029	3217	2174	3217
Installed Horsepower	4300	10800	13200	4300	2000	7200	6000	5100	6000
Service Speed (kt)	14.5	17.3	16.8	14.5	11.5	16.5	16.5	13.3	16.5
Fuel Use (gal/hr)	190	397	354	188	55	234	250	151	250
Normal Crew Count	24	63	55	24	5	48	14	38	14
Passenger Capacity	250	499	450	225	125	450	290	160	290
Vehicle Capacity (lane ft)	660	2660	1560	660	300	1675	1060	680	1060

Figure 1: AMHS ferry TAZLINA[1], an EBDG design built at Vigor Alaska in 2018.

[1] MV Tazlina - Wikipedia

1.2 PROBLEM STATEMENT AND RESEARCH OBJECTIVE

AMHS has worked diligently to keep its fleet operational as its structure, machinery, and outfitting have aged, up to and including multimillion-dollar refurbishments of vessels. Nevertheless, especially for older vessels, structural and mechanical issues in this period of the vessel's life are widespread. These issues affect the vessel's capabilities as well as its reliability; due to structural issues, each vessel's service has been limited, and the vessel's planned maintenance periods frequently reveal structural and mechanical issues that require longer stays in the shipyard and higher costs than expected. The vessels that new low-emissions ferries could potentially replace - but are planned to augment - include the LITUYA (2004), KENNICOTT (1998), or AURORA (1977). The latter is currently out of service due to age and condition. What's more, the AMHS has no low/no-emissions vessels. The confluence of an aging ferry fleet, and the contemporary call for conversion to low/no-emissions transportation infrastructure supports AMHS' efforts to take steps to continue the mission to serve communities using a new generation of vessels. **To that end, the research objective is to determine how a new battery electric vessel can sustainably serve certain AMHS ports given varied Alaska weather, sea states, routes, shoreside charging, and other supporting infrastructure. This report also discusses the considerations for the use of alternative fuels to extend range beyond the limits of battery-only operation.**

1.3 SCOPE OF STUDY

The scope of this study is to evaluate a decarbonized solution for AMHS-operated ferries. The scope includes use of a new battery electric ferry to shuttle passengers and vehicles between rural communities, rotating through low mileage (16 miles) routes, and replacing/augmenting less efficient vessels that serve: 1) Ketchikan/Saxman to Annette Bay/Metlakatla, 2) Haines/Klukwan to Skagway, and 3) Homer to Seldovia. If successfully implemented, this project would contribute to establishing and sustaining zero carbon-emitting ferry service to help meet social, educational, health, and economic needs of certain Alaska communities.

1.4 RESEARCH APPROACH

The research approach includes the following tasks:

Task One: Concept Vessel Design and Operational Analysis. This task shall include the following:

- Service area and route screening analysis;
- Route and service schedule analysis;
- Vessel size/capacity needs assessment;
- Propulsion systems analysis;
- Vessel construction cost analysis;
- Crew requirements and cost analysis; and,
- Operational cost analysis.

Task Two: Shoreside Infrastructure Analysis. This task shall include the following:

- Assessment of generation capacity in candidate AMHS port communities.
- Assessment of electrical grid capacity for transmission and distribution in port communities.
- Assessment of port infrastructure needs for the interface between vessel and grid.

Task Three: Financial and Economic Analysis. This task shall include the following:

- 10-year pro forma financial analysis (operating revenue and expenses).
- Assessment of port community economic benefits (including potential benefits to electric energy rate payers).

Task Four: Reports and Recommendations. This report is the embodiment of this task.

1.5 METHODOLOGY

Elliott Bay Design Group (EBDG) prepared a detailed description of the state of current technology and proposed the notional routes based on currently available sustainable electricity sources. In conjunction with McKinley Research, EBDG sized a notional vessel that would meet the transportation needs of the selected routes based on historical data. Utilizing the characteristics of the notional vessel, EBDG calculated the notional energy consumption and battery sizing; the vessel's capital cost; and simplified operational costs. McKinley Research prepared economic analyses and conducted community engagement. Respec prepared existing utility details and prepared summaries of the additional infrastructure needed at each port to support all-electric ferries.

2. STRATEGIC FRAMEWORK: DOT&PF SUSTAINABLE TRANSPORTATION

Like many agencies in Alaska and the nation, DOT&PF is facing unprecedented challenges such as workforce shortages, aging fleet, and supply chain issues. DOT&PF has been working to adapt to these dynamic challenges and continues to work toward reliable and predictable service, while also reducing carbon emissions from operations.

Well-prepared and updated planning documents are essential to sustainable transportation. In support of sustainable transportation, Alaska DOT&PF takes a "Family of Plans" approach, integrating long-term and short-term goals. Among the agency’s Family of Plans, are the AMHS Long-Range Plan and the AMHS Short-Range Plan. From these, regional multi-modal plans will follow to guide service delivery to AMHS customers and the development of the Statewide Transportation Improvement Program.

Efforts to implement low-emission and no-emission vessel power systems will feature prominently in the AMHS planning process. Much of the maritime industry has adopted decarbonization efforts and set emission reduction goals for vessels and port facilities. Public and private sector marine entities target funding available through the IIJA to finance conversion of existing and construction of new low carbon emitting and zero carbon emitting propulsion systems.

The planning documents will play a critical role for the AMHS: Five of its nine ships are more than 45 years old, and only two are less than five years old. Sustaining the AMHS depends in large part on replacing all of its costly-to-operate older vessels. Given this need, and the movement of the maritime sector toward carbon reduction, sustaining AMHS ferry service necessitates planning for and putting into service vessels that are both new and largely decarbonized. This effort will require careful planning given the remote nature of Alaska communities, the lack of infrastructure at some AMHS ports, and in some locations a lack of low and no carbon energy sources needed to refuel vessels.

Consistent with the long-term view of working toward a fleet of low-emitting and lower operating cost vessels, the AMHS recently applied for funding from the Rural Ferry and Low/No Emission Ferry programs in the IIJA. Those applications include:

1. Electric Ferry Pilot Program - $46,214,008
2. TUSTUMENA Replacement Vessel Propulsion System - $85,610,480
3. Planning & Design for Replacement Mainline Vessel - $8,591,616
4. Mooring dock upgrades at Auke Bay, Pelican, and Prince William Sound - $48,164,658
5. M/Vs COLUMBIA, TAZLINA, MATANUSKA, and KENNECOTT Vessel Upgrades - $72,065,545

Each of these projects works to perpetuate the AMHS by lowering carbon emissions while simultaneously reducing vessel operating costs. Both outcomes are essential to achieve service longevity to AMHS communities.

2.1 CLIMATE CHANGE

Local/regional climate action plans call for efficient transportation, and the State is developing a Sustainable Transportation and Energy Program (STEP) and drafting a transportation equity plan.

There has been growing interest in Alaska in pursuing energy policies and innovations that increase use of renewable energy sources. In 2010, the Alaska Legislature enacted a state energy policy[2] that included a nonbinding goal of generating 50% of Alaska's electricity from renewable sources by 2025. Potential benefits include reduced costs, increased energy resilience, reduced carbon emissions, and economic diversification.

3. STRATEGIES AND ACTIONS

3.1 POLICY AND REGULATION REVIEW

AMHS' vessels, their operation, design, and funding are regulated by a variety of entities as detailed herein.

3.1.1 FLAG STATE (USCG)

The United States of America is the flag state for vessels in the AMHS fleet. There exists a large body of regulations under 33 and 46 Codes of Federal Regulations that define the safe design and operation of vessels. New technologies like batteries, fuel cells, reformers, and low flashpoint fuels are evolving faster than new regulations can be written to define their safe use, so USCG relies on developing guidance from classification societies and IMO for design guidance. Where new technology is applied, the design firm and USCG will work together to prepare a design basis agreement that outlines all the

[2] Alaska State Legislature House Bill HB 306, 2010

design considerations proposed by IMO and class as a list of regulations that will apply to the novel design.

USCG has two regulation sets for small passenger vessels. 46 CFR Subchapter T regulates small passenger vessels limited to 150 passengers or less, and 46 CFR Subchapter K regulates small vessels with more than 150 passengers. Subchapter T generally has lesser requirements that would decrease the capital cost of getting a new vessel in service. However, it would be permanently limited to not more than 150 passengers and much of the capital cost savings would likely be offset by enhanced regulatory requirements related to the hybrid / electric propulsion system and an enclosed vehicle deck, should this be desired. Subchapter T vessels are typically smaller day-boats or open deck ferries. The Seldovia Bay Ferry is an example of a Subchapter T ferry. Subchapter K invokes structural fire protection requirements and other features but maintains similar manning requirements to Subchapter T. Passenger capacity for Subchapter K vessels is generally limited to 600 or fewer, though there are provisions for higher passenger counts. The LITUYA is an example of a Subchapter K ferry. Subchapter T and K vessels are both required to admeasure at less than 100 GRT which imposes design restrictions, most especially in the use of below-deck spaces.

USCG regulations also have a set for large passenger vessels, 46 CFR Subchapter H. These vessels are not limited in passengers or GRT admeasurement. They have significantly higher manning and equipment requirements meaning higher operating and capital costs.

3.1.2 CLASSIFICATION SOCIETIES

Classification societies (e.g., American Bureau of Shipping) are non-governmental regulatory bodies that provide surveyance of the design, construction, and lifecycle maintenance of a vessel. Typically, a vessel is classed for insurance reasons. As many governmental agencies are self-insured, vessel classification is often by Owner preference. Classification societies maintain and enforce a detailed set of design and maintenance rules on classed vessels. USCG will invoke a class ruleset for new inspected vessels. As US law lags technology, classification societies can be expected to have more developed design guidelines for novel technologies than USCG. Vessels in the AMHS fleet are classed with the American Bureau of Shipping, except for the LITUYA which is not Classed.

3.1.3 INTERNATIONAL MARITIME ORGANIZATION (IMO)

While not legally enforced on domestic voyages, IMO regulations will apply to vessels operating on international voyages, like MATANUSKA and KENNICOTT. Additionally, IMO has prepared interim guidelines for classification societies and flag states to build from. Regulations that IMO has prepared that may be new to new vessel design include design guidance for alternative fuels, batteries, and emissions reductions[3].

[3] Appendix D includes calculations showing AMHS compliance with the IMO Guidelines on 2021 Operational Carbon Intensity Indications (CII) and the Calculation Methods Annex 10. These calculations are intended for cargo vessels, not ferry operations.

In addition to design guidance, IMO has implemented CO_2 emissions targets that should be considered in the design of all new vessels. These targets are referred to as IMO 2030 and IMO 2050. IMO 2030 sets an aim for the industry "to reduce CO_2 emissions per transport work, as an average across international shipping, by at least 20% by 2030, pursuing efforts towards 70% by 2050, compared to 2008." These targets are measured by carbon intensity per volume of cargo moved, rather than a total industry cap. There are no provisions for electric vessels operating on shore power, but the source of the electricity used onboard should be considered for these vessels.

The International Maritime Organization (IMO) is implementing new air emission and efficiency requirements for existing ships. These regulations, called the Energy Efficiency Existing Ship Index (EEXI), enter into force on January 1, 2023, and will apply retroactively to all SOLAS ships. These regulations involve calculating an "attained" EEXI number for the existing vessel that scores efficiency improvements instituted on a vessel against a baseline for that vessel. The regulations mandate a minimum factor of improvement over the baseline, varying by vessel type. These minimum factors increase over a series of phases, culminating in a final phase from January 1, 2025, onwards. The AMHS fleet is being rehabilitated with SOLAS in mind, with existing ships needing extensive work to comply.

3.2 BUY AMERICA AND OTHER FUNDING DEPENDENT REGULATIONS

Funding dependent regulations tied to programs included in the IIJA are the focus of much attention and will likely remain so over the life of the Act, given that billions of dollars are available through the IIJA for transportation projects. The statute and subsequent regulations, particularly those addressing Buy America mandates, deserve close consideration[4].

Buy America refers to a series of statutes and regulations related to domestic procurement of materials in infrastructure projects. The statutes and regulations contain differing domestic purchase requirements across agencies within Federal DOT. While Buy American requirements predate the IIJA, the Act expanded the scope of the requirements. Buy America standards in the Act are further bolstered by provisions included in Presidential Executive Order 14005, which articulates enforcement provisions to better ensure compliance with domestic preference statutes, including the IIJA. The Act centralizes decision-making authority on all Build America waiver requests in the Office of Management and Budget, through the EO-established Made in America Office within OMB.

Section 70914 of the IIJA sets criteria for meeting the Buy America standard. To be considered produced in the United States under the IIJA standard, a manufactured good must contain greater than 55% domestic content, and be manufactured in the US. As to construction materials, the entirety of the manufacturing process of these materials must take place domestically. On April 18, 2022, the Office of Management & Budget released guidance on how federal agencies are to implement the Buy America requirement. The guidance aims to instruct agencies on how to implement "(1) a "Buy America" preference to Federal financial assistance programs for infrastructure; and (2) a transparent process to waive such a preference, when necessary." As a point of initial clarification, the guidance defines a

[4] Holland & Knight White Paper dated April 25, 2022; Congressional Research Service In Focus edition dated December 7, 2021.

Federal financial assistance program for infrastructure as "any program under which an award may be issued for an infrastructure project, regardless of whether infrastructure is the primary purpose of the award. The term "project" means any activity related to the construction, alteration, maintenance, or repair of infrastructure in the United States."

The IIJA Buy America requirement does not apply uniformly to programs funded in the Act. The requirement does not apply:

1. If another domestic procurement already applies to funding, so long as the other requirement is at least as stringent to those in the Act.

2. If an agency determines that funds are not spent on infrastructure.

3. If tools and supplies purchased for the infrastructure work but removed from the project site upon completion. The mandate does not apply to furnishings, or equipment not an integral part of or affixed to the infrastructure.

The application of the first bullet point is material. It is not clear if FHWA's longstanding (circa 1994) nationwide waiver from Buy American requirements for eight "certain ferryboat equipment and machinery items" meets or exceeds that found in the Act. Based on input from industry representatives, and the prevalence of Europe-based manufacturers and suppliers at ferry and maritime conferences, there remains a lack of domestic production of electrical control and integration systems, and energy storage and management systems. The extent to which Federal DOT agencies can continue to implement their Buy America programs in the wake of IIJA remains to be seen. Given the variation between the existing agency programs and the Act, some reconciliation between preexisting DOT agency domestic procurement programs and the IIJA is likely through the regulatory process. Additional changes to domestic procurement programs, especially as to program waivers, are likely as U.S. firms enter segments of the electric ferry component market to compete with both foreign and other domestic producers.

Oversight of expanded Buy America requirements mandated in the IIJA is likely to prove complicated due to other provisions in the Act. Some small jurisdictions, or those unfamiliar with Buy America provisions but that are eligible to apply for funding from the Act, may find it difficult to comply with the requirements without outside staff or legal expertise.

Any acquisition projects involving Buy America (or comparable) requirements must consider the following:

a. Include explicit Buy America text in bid documents.

b. Ensure Buy America considerations are a priority in the design stages.

c. Require design firms demonstrate Buy America experience and expertise.

d. Train a Buy America specialist on the DOT&PF project staff.

3.3 GREEN HOUSE GAS EMISSIONS REDUCTIONS OPPORTUNITIES

During financial year 2016, AMHS fleet-wide consumed some 9.2 million gallons of diesel fuel [1]. Representing a total CO_2 emission of 93,000 Mt. Fleet-wide, there are several options for reducing vessel emissions.

3.3.1 SLOW OPERATION

Appendix D contains calculations of the notional vessel's trip energy at a cruise speed of 13.2kt and at a slower speed of 9.7kt (at roughly 50% of the installed power). Just slowing down the vessels results in a 23% energy savings at the cost of a roughly 30% increase in transit time. The energy savings and transit time are highly route dependent, but the concept of "slow-steaming" may be applied across the fleet to reduce fuel consumption and CO_2 emissions.

3.3.2 COLD IRONING

Emissions in port are a relatively large part of total emissions. Cold ironing, a term that describes shutting down engines and letting them cool, is used to describe the practice of turning off the vessel's power plant at the dock and allowing any shipside electrical demands to be provided by connection to shore power. This practice avoids the harmful emissions that the vessel would otherwise produce at the dock, typically near inhabited areas, and allows the loads to be supplied by sustainably produced electricity, if available.

3.3.3 CONVERTING TO CARBON-NEUTRAL FUELS

Converting to many of the alternative fuels may be very difficult for existing vessels for the reasons discussed in 5.2.1, but fueling existing vessels with bio- or renewable diesel may be a simpler approach. Both of these fuels may be considered "drop-in" replacements for conventional diesel and may offer a CO_2 emissions reduction.

3.3.4 UTILIZING ALL-ELECTRIC SYSTEMS ON SHORT ROUTES

Battery-powered ferries have zero emissions at the vessel. While the operator must consider the emissions generated to provide the shore power, battery-powered ferries may be powered by sustainable energy yielding zero emissions. Batteries are much less energy dense than diesel, so battery-powered ferries are typically limited to shorter runs. New vessels may easily be designed for operation as all-electric, but existing vessels can also often be considered for conversion.

3.3.5 UTILIZING SHUTTLE FERRIES ON SHORT ROUTES

The notional vessel on the pilot routes could replace the trips otherwise performed by main line ferries such as COLUMBIA, KENNICOTT, MATANUSKA, and TUSTUMENA on these routes. Using the 2016 route schedule, replacing the trips performed by these vessels of higher fuel consumption with the same trips performed by the notional vessel running on sustainable electricity could reduce the main line annual CO_2 emissions by 1,091 tonnes, as detailed in Table 2. This estimate accounts only for transit emissions and not those produced to support hotel loads at the dock.

Table 2: GHG Savings by Replacing Main Line Ferry Trips with the Notional Vessel

2016 Route Data	COLUMBIA	KENNICOTT	LECONTE	LITUYA	MALASPINA	MATANUSKA	TUSTUMENA
Service Speed (kts)	17.3	16.75	14.5	11.5	16.5	16.5	13.3
Fuel Consumption (gal/hr)	397	354	188	55	270	234	151
Trips HNS-SKG	64		44		84	84	
Trips ANB-KTN				84			
Trips HOM-SLD		56					56
Operation (hr/yr)	57	61	46	65	78	78	75
Fuel Consumption (gal)	22740	21767	8567	3582	21099	18286	11328
CO_2 Production (Mt)*	231	221	87	36	214	186	115
Total (Mt)	1091						

** CO_2 production of $22.4lb_{CO2}$ / gal_{diesel}*

Figure 2 below lists some equivalencies of avoided 1,091 tonnes of carbon emissions estimated in Table 2.

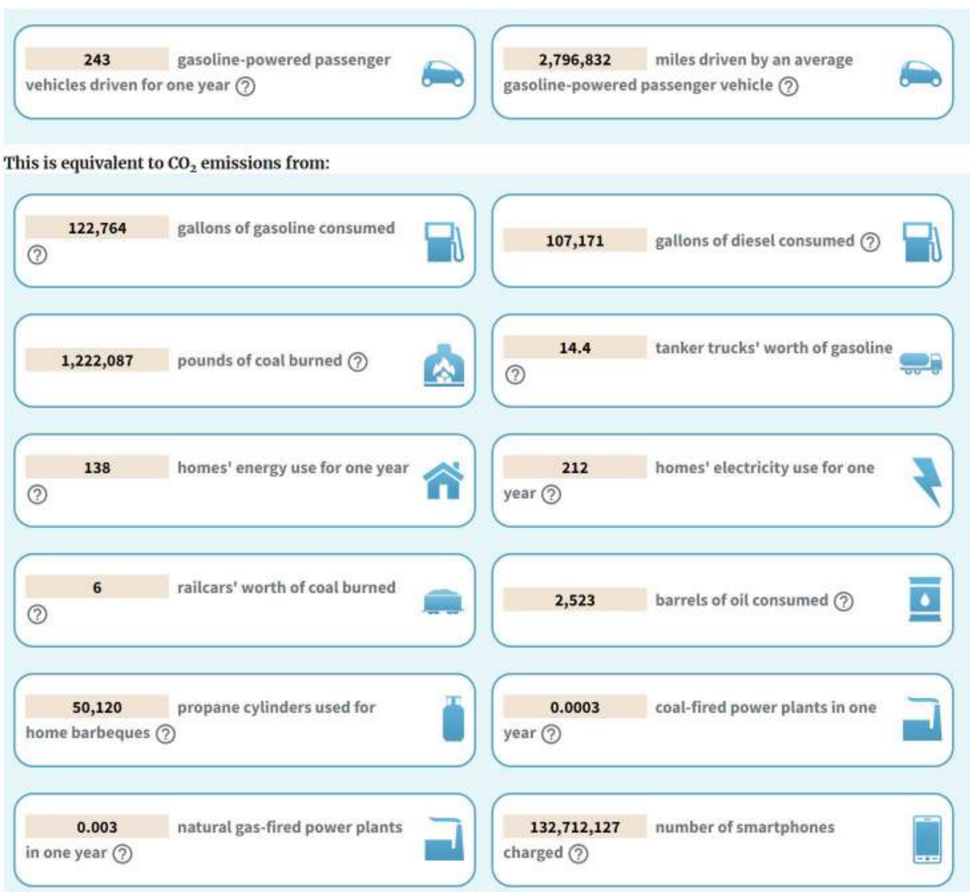

Figure 2: Estimated carbon equivalencies [5]

[5] Greenhouse Gas Equivalencies Calculator | US EPA

In context 1,091 tonnes of avoided CO_2 emissions amounts to about 1.2 percent of total AMHS emissions compared to the baseline year of 2016. While not a significant percentage reduction, the change is measurable. In absolute terms, the reduction in CO_2 emissions still nets avoidance of some 107,000 gallons of diesel fuel annually. Given the energy efficiencies and emission reductions to be gained by the M/V Tustumena and mainline replacement vessel projects, the AMHS is positioned to significantly reduce its volume of CO_2 emissions as the new ferries come online.

The mix of energy sources of electricity is noteworthy here. Homer Electric Association relies on renewable hydroelectric for about 18% of its electricity production, and natural gas combustion for most of the balance. Conversely, Alaska Power & Telephone (Haines & Skagway), Metlakatla Power & Light (Metlakatla), and Ketchikan Public Utilities (Ketchikan) derive the vast majority of their electricity from hydro generation. Given that the data in Table 2 is built on the premise that all electricity used to power the notional vessel is generated renewably, the full avoided tonnage of CO_2 is dependent upon full renewable production of electricity. That goal is achievable along the Ketchikan-Metlakatla and Haines-Skagway routes, given the presence of hydroelectric infrastructure and use of battery electric storage systems to charge during low load times. While efforts by Homer Electric Association are underway to increase zero emission production of electricity, the Homer-Seldovia route will be dependent in part on fossil fuel-derived electricity for the foreseeable future.

4. LOW-NO EMISSIONS VESSELS: A PILOT PROJECT

4.1 PILOT PROJECT PURPOSE

DOT&PF is committed to the long-term sustainability of the AMHS. Unique in the nation, Alaska’s ferry system is a critical link in Alaska's transportation landscape. Alaska’s ferries knit together ports, towns, and cities from southcentral to southwestern Alaska, and their service affects the lives and livelihoods of many Alaskans. After decades of reliable service, DOT&PF acknowledges the need to plan for the future and ensure future vessels are up to the job.

A pilot project allows the DOT and passengers to evaluate new technologies and determine their applicability to broader fleet application. The pilot project showcases emerging technologies which may provide opportunities for emissions reductions but is not intended to demonstrate a solution for all of Alaska's ferry needs.

Low-No Emission vessels will be a critical infrastructure component for rural, disadvantaged communities in Alaska that are not connected to the road system and for whom sustainable transportation is a key feature of community sustainability.

4.2 LOCAL, REGIONAL, AND STATE PLANNING

This pilot project is supported by regional Comprehensive Economic Development Strategies (CEDS) and local Comprehensive Plans. Numerous support letters have been provided by impacted communities. This pilot project is consistent with State plans.

Consistent with Regional and Community Plans

Southeast Conference's CEDS stresses that a strong ferry system is essential to regional economic development, quality of life and community wellbeing in Southeast Alaska. Their priority transportation objective is to minimize impact of budget cuts to AMHS and develop sustainable operational model. This objective includes: design a new strategic operating plan for AMHS, lower State's general fund subsidy percentage, fleet renewal plan, and AMHS value outreach. Skagway is the northern terminus of Southeast Alaska's part of the AMHS, and has a long tradition of advocating for consistent ferry service. Their Comprehensive Plan notes that the ease and cost of resident travel are negatively affected when ferry service is down, especially in the winter. Haines Borough's Comprehensive Plan calls for ongoing advocacy for daily summer and frequent winter AMHS ferry port calls as they are essential for tourism and residents.

Kenai Peninsula Economic Development District's CEDS highlights disruptions to marine travel as being a key challenge for the region. The ferry service provides critical passenger connections and transporting goods between the Kenai Peninsula and southwest and southeast Alaska. Seldovia depends on the AMHS for scheduled trips to accommodate freight, vehicles, and passenger travel to and from Homer and the Sterling Highway. Seldovia's Comprehensive Plan's goal is to retain, safe, well-timed, water-based transportation options, namely by cooperating with the state of Alaska to improve AMHS service for all users.

Consistent with DOT&PF Strategic Planning and AMHS Prioritization

Focus areas impacting AMHS are identified to make progress toward the long-term strategies, including sustainability. DOT&PF Strategic Themes (and the respective AMHS Focus areas) include: Safety (Vessel Repair); State of Good Repair (Preservation and Maintenance of Terminals and Vessels); Economic Vitality (New Service Vessels, New Terminals); Resiliency (Fleet Modernization, Vessel Replacement, Terminal Upgrades); Sustainability (Vessel Hybrid Conversion, terminal Electronification, Electric Shuttle Ferry Construction, Energy Efficient Operations Strategies); Mobility/Access (Increased Service, ADA accessibility). Developing sustainable transportation infrastructure involves a multi-modal lifecycle approach that considers environmental quality, economic development, and social equity.

4.3 ENVIRONMENTAL JUSTICE

Ketchikan/Saxman has high exposure rates to diesel particulate matter, ranking in the 79th percentile for Alaska, 98th for the EPA region, and 62nd for the county. Metlakatla's Environmental Justice (EJ) indices show it is in the 76th percentile for exposure to diesel particulate matter and air toxins cancer risk. Metlakatla has socioeconomic indicators associated with high potential susceptibility to environmental factors that lead to negative health outcomes, including high percentages of people of color (87%), low income (38%), and unemployment (38%). Klukwan, served through Haines, and Saxman served through Ketchikan, are Tribal and considered disadvantaged under Justice40 (J40). Seldovia is considered disadvantaged by J40, and the City of Homer ranks relatively low in the Environmental Justice Indicators compared with other communities in the state, EPA region, and nation. All communities served by the project are considered rural, and difficult to develop by HUD.

4.4 EQUITY

This project promotes racial equity and removes barriers to opportunity. The AMHS is at the heart of Alaska's equitable approach to ensuring the benefits of affordable transportation. This publicly subsidized system ensures that coastal communities (the majority of which are considered disadvantaged) have high costs and limited service mitigated. Coastal communities' land use policies and housing take into account distance from the ferry terminal and dock access. The State's sustainable transportation program and future transportation equity plan include maritime transportation. The proposed pilot project proactively advances racial equity and addresses a barrier to opportunity by ensuring reliable service, which might be reduced otherwise. All project costs are considered investments in addressing racial equity or removing barriers to opportunity, especially to the extent they contribute to improving the socio-economic and health status of the disadvantaged communities served.

4.5 JUSTICE40

The project will support the J40 Initiative by strengthening the resiliency of a vital transportation system in the face of extreme impacts from climate change and by connecting disadvantaged rural communities to commerce, health and social services, and providing an affordable, climate-conscious way to bring food and other goods and services in. Communities served by the lower emission ferry are without reliable and affordable transportation otherwise, given harsh climate and remoteness, which speaks to environmental justice. Transportation planning in Alaska accounts for both environmental justice and climate change, and this project includes design components that result in greater efficiency and contribute to climate change mitigation. Resilience to climate change in the transportation network is particularly important in Alaska, where climate change puts much of the state at increased risk. The AMHS has also been integrated into the state's emergency response system.

Many of the datasets in the J40 screening tool are not complete for Alaska or use data that is not always applicable. The Climate and Economic Justice Screening Tool lists a number of communities in high percentiles. Every community is listed as a Medically Underserved area by the EJSCREEN[6] tool. Fifteen of the 35 served communities on the AMHS route are considered Tribal or Disadvantaged, though other datasets (e.g., USDA or HUD) would consider all communities served as Tribal and additional communities as Difficult Development Areas or climate impacted. Climate Action Plans at the local and regional level have identified emission reduction as a goal. The EJSCREEN does not report information for the Haines and Skagway region, nor Seldovia, stating that the area exceeds the size or is too complex for reporting.

[6] www.epa.gov/ejscreen

5. FINDINGS OF STATE OF CURRENT TECHNOLOGY

5.1 PROPULSION SYSTEM ARRANGEMENTS

There is a broad spectrum of propulsion arrangements to select from when designing a vessel. Each of these arrangements, from a high level considers the path that power takes from an "engine", such as an internal combustion engine (ICE) or fuel cell, to the propeller.

5.1.1 MECHANICAL

The mechanical system, which a traditional diesel engine arrangement may be described as, takes an internal combustion engine that produces rotational energy and connects it to the propeller, either directly or through a gear box. This arrangement tends to be more compact and cheaper than the other arrangements under consideration. Converting to utilize alternative fuels in an existing design may be quite difficult, but in a new design may be feasible depending on the arrangement concerns and equipment availability discussed herein.

5.1.2 DIESEL-ELECTRIC

Diesel-electric is a common configuration wherein the diesel engine drives a generator which in turn provides power to an electric motor. This can be advantageous where there are large house loads present and where the demand fluctuates between propulsion and house loads. As with the mechanical solution the diesel engine could instead utilize alternate fuels.

5.1.3 ALL-ELECTRIC

In the all-electric arrangement, there may be just a small generator onboard for emergency, but all operational power is generally provided by shore power when the vessel docks. Batteries take up a large amount of space on the vessel, so the vessel is limited to relatively short distances on the order of 4 hours or less. Battery-powered boats will typically operate at lower speeds to conserve energy and may require robust shore-side infrastructure to charge at one or both ends of the route.

5.1.4 HYBRID

The hybrid arrangement can take many forms, but essentially includes an engine and batteries. The propeller may be driven by a shaft connected to the engine with battery assist through a motor connected in parallel. Alternatively, the engine may drive a generator end sharing a common bus with batteries, with electricity supplied to the motor via the common bus. In the hybrid system, battery banks may be relatively small. The engines are sized for the average load rather than the peak load, and batteries supply additional peak-shaving power. Hybrid arrangements are also sometimes used to allow the vessel to operate on battery power at the dock (saving the engines from operating for long periods at low power) or for a short period of all-electric operation.

The hybrid system contains all the components of the mechanical system and the all-electric system, so may be more easily modified to accommodate alternative fuels. The batteries may be charged from shore to reduce fuel consumption or just from the onboard generators, depending on the route needs or infrastructure. Increased fuel economy and/or emissions reductions may be achieved by operating the engines at their most efficient power point rather than at the propeller demand, using the batteries to charge or discharge the difference.

Vessels may also be built as hybrids intended for all-electric operation. In this case, batteries of a capacity sufficient to support normal operation on the typical route may be installed, along with diesel (or other) generating capacity to support the vessel in a diesel-electric mode of operation. The generators may then be brought online to provide continuity of service in case of an interruption to shore power, to support alternate longer routes, to support surges in schedule demands for peak traffic, or for transit to and from the shipyard. This type of installation may also allow a new vessel to enter service ahead of upgrades to shore infrastructure, operating in a diesel-electric-hybrid mode until such upgrades are brought online.

5.2 ALTERNATIVE FUELS

Diesel has proven a reliable and dependable fuel for decades. Its high-temperature flash point prevents it from needing much special consideration regarding flammability, and its chemical stability has made it simple to transport. Given these benefits, diesel is readily available almost anywhere and has a robust and reliable distribution system. The largest drawbacks of all alternative fuels are their availability, given a lower utilization by local markets, and their impacts on vessel design. This section discusses these impacts for the most popular alternative fuels under consideration.

The alternative fuels under consideration are methanol, ammonia, methane, and hydrogen.

5.2.1 ARRANGEMENT CONSIDERATIONS

All of the alternative fuels under consideration, other than biodiesel, are low flash-point fuels and have both lower energy density (chemical energy per unit volume) and higher fire and explosion risks compared to diesel. These characteristics yield the following considerations for applications on vessels.

- Increased fuel tank volumes or decreased endurance
- Increased parasitic loads from added ventilation
- Additional alarms and monitoring systems
- More extensive fixed gas firefighting systems
- The addition of a tall mast for the safe remote release of any gas leaks
- Requirement for substantial automation
- Extensive crew training requirements
- Double-walled piping requirements (increased cost, space, maintenance, active ventilation requirements)
- Explosion-proof motors, electronics, and lighting
- Additional structural fire protection insulation
- Arrangement complications
    - Ventilated cofferdams around all fuel tanks or external fuel tanks
    - Restricted crew access to hazardous spaces
    - Air locks on hull spaces that do not open to an exterior deck
    - Careful consideration of location of compartment openings (ventilation, doors, etc.) with regards to hazardous zones
    - Bunkering station location

- Balancing the vessel considering the fuel arrangement and hazardous zones issues
- If using alternative fuels in an ICE, will need to mitigate NOx (adding a selective catalytic reducer, DEF tanks, etc.)

- Stability issues for external tanks

5.2.2 FUEL PROPERTIES

Table 3 shows a comparison of the common alternative fuels under consideration. Note that diesel has the highest specific energy of any fuel on the list, indicating for the same endurance other fuels will take much more volume than diesel. Note also the alternative fuels given the most consideration by the industry, methanol and ammonia, have roughly half the energy density and specific energy of diesel, indicating that for the same endurance the vessel will have to carry twice as much fuel weight and volume. The last column shows the inherent CO_2 produced during combustion per unit energy. This column indicates that any alternative fuel will have a slightly lower CO_2 production for the same energy from combustion (not including any additional auxiliary loads required to safely utilize alternative fuels). Ammonia and hydrogen have no carbon in their molecular makeup, so no CO_2 is produced during combustion. Battery storage is provided in the last two rows to illustrate how much heavier and more voluminous battery banks are compared to any fuel.

Table 3: Various Fuel Properties

Fuel Comparison	Density	Specific Energy	Energy Density	CO_2 Production *
	kg/m³	MJ/kg	MJ/L	$kgCO_2$/kW (LHV)
Diesel	846	42.6	36.0	0.27
Ethanol	788	27	21.3	0.25
LNG	428	48.6	20.8	0.20
Methanol	791	19.9	15.8	0.25
Ammonia	707	22.5	15.9	0
Liquid Hydrogen	71	120.2	8.5	0
Hydrogen@350bar	23.4	120.2	2.8	0
Batteries	1128	0.27	0.31	N/A
Batteries (incl. access)	1022	0.27	0.28	N/A

*Fuel from a demonstrably renewable resource may have a lesser or 0 net CO_2 production

5.2.3 FUEL PRICES

For financial years 2018 through 2021, AMHS has experienced low diesel prices averaging $2.30 for that period. In 2022 the price of fuel rose significantly. While the 2022 fuel prices may be attributable to international politics, the cost of fuel is expected to rise in the future. For comparison, the fuel price of the previous four years will be used. Because alternative fuels have varied fuel densities (energy per unit volume) fuel prices are shown for the various alternative fuels in dollars per unit energy in Table 4. Note that other than diesel these prices do not include the logistical costs of delivering the fuels to AMHS ports, so final fuel prices may be significantly higher.

Table 4: Alternative Fuel Prices

Fuel	$/kWh*
Conventional diesel	0.061
Renewable diesel	0.140
Grey methane	0.037
Green methane	0.132
Methanol	0.128
Ammonia	0.216
Hydrogen	0.179
*Heat of combustion (lower heating value)	

5.2.4 ENGINE TYPES

Ethanol, methanol, ammonia, and hydrogen are all candidates for fueling an internal combustion engine. However, there are few engines available currently that utilize these fuels. This section will detail the engine availability by fuel type. Thermal efficiency describes the ratio of useful work produced by a system to the theoretical input energy. For ICEs, the thermal efficiencies denominator is the heat of combustion of the fuel. There are two values for heat of combustion, but ICEs and similar systems utilize the lower heating value of combustion. Lower heating value describes the useful heat produced by combustion leaving out the latent heat of water vapor as it not typically recoverable. Thermal efficiencies by lower heating value for ICEs vary from 30% to 45% depending on engine size and type. Very large engines have exceeded 50%, but the engines that would be appropriate for the notional vessel design are in the 38-40% range. Diesel engines produce rotational energy, so are optimal for providing energy directly to a propeller. Turning the rotational energy into electrical energy results in additional system losses approximately on the order of 8% to 10%.

Fuel cells are an alternative to internal combustion engines. There are many types of fuel cells, but most of them operate on pure hydrogen. Some fuel cells can reform hydrogen from high hydrogen fuels like methane, methanol, and ammonia. There are also independent reformers which can convert fuels to pure hydrogen. Depending on the fuel cell type, thermal efficiencies range from approximately 37% upwards to 60%[7]. EBDG's experience with reformers indicates a compounding efficiency of approximately 83%. For example, if starting with a methanol fuel and an efficient fuel cell, the compound efficiency may be 50%*83%=41.5%. Fuel cells, depending on type, degrade with time and may need the stack replaced as often as every two to three years. Some types of fuel cells degrade quickly when exposed to CO_2. Fuel cells directly create electricity without the need of a generator, so may provide an efficient alternative to an ICE when connected to a hybrid electric system. Fuel cells react slowly to changes in load, so highly variable loads need to be compensated for with a large battery

[7] https://www.energy.gov/eere/fuelcells/types-fuel-cells 9/16/2022

bank. Given the quantity of precious metals required in their cathodes, fuel cells are both expensive and may have a significant environmental impact from mining.

5.2.5 ENGINE AVAILABILITY

Internal combustion engines are often placed into three categories: low-, medium-, and high-speed. These speed categories are related to power density, weight, torque, and efficiency. Medium- and high-speed engines are typically used on passenger ferries where there is limited space or weight margin for the larger, slower-speed engines.

At this time there are no high-speed (>1500 RPM) engines available in the marine market that can operate on alternative fuel. There are medium-speed (200 RPM – 1500 RPM) engines currently available that can operate on a few of the alternative fuels with the availability and options expected to increase greatly in the next few years. There are also a number of low speed (<200 RPM) engines available that can burn methanol and methane.

5.2.6 METHANE

Methane is commonly referred to as liquified natural gas (LNG) or compressed natural gas (CNG). Natural gas is a gas mixture predominately composed of methane. LNG has been cooled to below its vaporization temperature of approximately -260 °F. Cooling the gas to, and keeping it at this temperature, requires high energy loads. CNG is compressed gas at the environmental condition and does not need active cooling. CNG does not have the energy density needed for most marine applications, so only LNG is considered herein.

Natural gas is mostly produced from oil wells and is not normally considered a green or renewable fuel. Methane can be created organically from sustainable feedstocks like municipal waste and livestock manure and work is being done to synthesize methane from solar energy, water, and CO_2, but these sources are currently insufficient to supply the marine market. Methane is a greenhouse gas with a global warming potential approximately 28 to 36 times that of CO_2.

LNG must be stored in cryogenic tanks which can be two to three times larger than traditional diesel tanks. Cryogenic tanks are expensive and require high-tech insulation. With the specific energy of LNG (48.6 MJ/kg) being similar to diesel (42.6 MJ/kg), the density difference between LNG (428 kg/m^3) and diesel (846 kg/m^3) helps offset the additional LNG tank weight. Since the vessel would use the boil off gas as fuel, reliquification equipment likely would not be required. LNG tanks require a higher level of safety compared to diesel tanks, so their location and construction will require special consideration by USCG, especially if they are located below Main Deck or any passenger spaces. LNG is used by Seaspan Ferries and by BC Ferries in some of their vessels.

There are currently medium and low-speed engines available that can burn LNG. The technology for burning and storing LNG is mature and readily available. Methane has the lowest CO_2 production per unit energy production of the carbon-based fuels, but the methane released from incomplete combustion may negate any benefits, as it is a recognized greenhouse much more powerful than CO_2. Internal combustion emissions using LNG as a fuel typically have low particulate matter.

LNG has limited availability in ports on the west coast of the United States but is becoming more available. An LNG plant has received permitting for construction in Tacoma, WA to support the Tote vessels that are currently being converted to LNG. Long Beach, CA has started offering LNG at one of their terminals. ITB is currently setting up a station for bunkering in Canada that expects to be operational in 2023. There are a number of LNG bunkering barges operating on the east coast of the US supporting the cruise and shipping industries. As the demand for LNG grows, EBDG expects the availability of LNG and the infrastructure needed to support it will grow on the west coast.

Currently, LNG is not available in large quantities in any of the AMHS ports. To support LNG vessels, AMHS would have to work with a supplier to charter LNG bunkering barges.

5.2.7 METHANOL

Multiple manufacturers are working to produce methanol medium speed engines with some expecting to enter the market in the next year. These engines will likely still require a small amount of diesel fuel to use as a pilot fuel. Many smaller engine manufacturers are putting more research into methanol than ammonia.

Methanol is a low flash point, grade A fuel. It is possible that methanol engines will not need exhaust aftertreatment to comply with the most stringent NOx emission regulations. Methanol combustion typically produces low particulate matter. Methanol has similar storage requirements as gasoline and only requires minor modifications to existing gasoline storage, distribution and bunkering infrastructure.

Methanol is a liquid that mainly comes from natural gas, but it possible to produce it from a variety of renewable feedstocks or as an electro-fuel. Methanol has roughly the same density (791 kg/m^3) as diesel (846 kg/m^3), but the specific energy of methanol (19.9 MJ/kg) is less than half the specific energy of diesel (42.6 MJ/kg). Therefore, methanol-fueled vessels will either fuel more frequently or will need to have more than double the fuel storage volume of a conventional diesel vessel. Doubling the fuel storage area will also increase the weight of the vessel especially when the fuel tanks are full.

Currently, methanol is not readily available in Alaska, but there is one methanol farm owned by Delta Western in the Anchorage area. While not recommended in this report, were AMHS to move to a methanol fueled fleet consideration may be given to building methanol farms at strategic ports that could be serviced by a supplier using a methanol bunkering barge.

Methanol is very toxic to human and environmental health. Storing methanol is challenging due to the hazardous zones and risk-reduction measures that must be considered in case of a methanol leak. As a low-flashpoint fuel, methanol tanks must be secured with an inert gas blanket (e.g. nitrogen).

5.2.8 AMMONIA

Multiple manufacturers are working to produce ammonia medium speed engines and expect to have them on the market in approximately two years. The engines will likely still require a small amount of diesel fuel to act as a pilot fuel. Ammonia is gaining the interest of many international cargo companies, so larger engines are expected to be available sooner.

Most ammonia is currently produced from natural gas but can be made renewably using electrolysis and the Haber-Bosch process with renewable electricity. Ammonia has similar density and specific energy as methanol, or less than half the specific energy of diesel. Like methanol, ammonia-fueled vessels will either fuel more frequently or will need to have more than double the fuel storage volume of a conventional diesel vessel.

While ammonia is carbon-free, it still contains a lot of nitrogen and burning ammonia produces nitrogen oxides (NO_x) and nitrous oxide (N_2O). Nitrous oxide is a greenhouse gas that is significantly stronger than carbon dioxide. However, these emissions can be controlled by the combustion process and removed with aftertreatment.

Ammonia is mostly being explored for use in the ocean shipping industry. While ammonia is currently used on some vessels as a refrigerant, it may be challenging for ammonia to be accepted for use as fuel on passenger vessels. Ammonia is toxic and has a powerfully unpleasant odor. Storing ammonia is also challenging due to the hazardous zones and risk-reduction measures that must be considered in case of an ammonia leak. As a low-flashpoint fuel, ammonia tanks must be secured with an inert gas blanket (e.g. nitrogen).

EBDG was unable to determine the availability of ammonia for bunkering vessels, however, AMHS would likely need to build ammonia farms at strategic ports that could be serviced by a supplier using an ammonia bunkering barge.

5.2.9 HYDROGEN

Green hydrogen is typically produced through electrolysis using renewable electricity such as wind, hydro, or solar. Hydrogen may also be produced from reforming hydrogen-containing fuels like methanol, which may be produced renewably. The biggest downside of hydrogen is the monetary and energy cost of compression and distribution. Producing hydrogen from electrolysis may be 60 to 80 percent efficient, while liquefaction may only be 35% efficient. The combination of electrolysis and liquefaction results in the vessel receiving only roughly 25% of the starting quantity of sustainable energy. Combine that with the 40% thermal efficiency of the fuel cell or engine, and the vessel's propeller only receives 10% of that sustainable energy. This is prior to the costs of shipping hydrogen to the vessel. For comparison, the propeller in a battery system gets likely better than 80% of the starting energy.

Multiple manufacturers are developing hydrogen dual fuel engines. BeH_2ydro [2] is currently building two hydrogen dual fuel engines (85% H_2 and 15% diesel) for the first ever hydrogen powered tugboat that is expected to be operational in 2023. It is also possible to combine the engines with aftertreatment systems to reduce NO_x and diesel particulate matter. Furthermore, the dual fuel engines may operate on 100% diesel if hydrogen is not available.

BeH_2ydro recently announced a spark ignited 100% hydrogen engine that will be available with 6, 8, 12 or 16 cylinders and will deliver power from 1000 to 2670 kW. The 100% hydrogen engines are expected to be available in 2024.

Hydrogen can be stored as a gas or a liquid. Even liquid hydrogen has an energy density less than one quarter of diesel. Given the high pressure and low temperature properties of the fuel, hydrogen cannot be stored like diesel in ship-shaped tanks low in the hull. Hydrogen is lighter than air, so tanks should be installed high on the vessel to prevent hydrogen gases from accumulating in the superstructure. In a liquid form, 3.5 times more hydrogen can be stored per volume than as a compressed gas, but liquid hydrogen requires cryogenic tanks that are kept extremely cold by a refrigeration plant. Compressed hydrogen must be stored high pressure (up to 700 bar) requiring heavy cylindrical tanks. In general, hydrogen storage requires roughly 14 times more volume than diesel for the same energy. BeH_2ydro has created a modular hydrogen storage system that stores the hydrogen at 250 bar and allows for easy maintenance, access, and removal of the hydrogen storage system.

The cost of a hydrogen engine is similar to a diesel engine however the supply and storage of the hydrogen is significantly more than diesel since hydrogen components (valves, pipes, sensors, etc.) are currently very expensive, but as demand and production increases these costs may decrease. Construction of hydrogen piping systems is complicated by additional ventilation requirements and double-walled piping.

Hydrogen can also be converted to electricity via fuel cells. The fuel cells generate DC power that is compatible with modern ship electric and hybrid architectures and maybe deployed in parallel, dispatchable configurations to meet variable power requirements of vessels. The only emissions from a fuel cell are water vapor and heat [3].

Fuel cells can be powered by liquid hydrogen or compressed hydrogen gas and are currently commercially available. Fuel cells are modular and scalable for various requirements.

Fuel cells require redundant systems to allow for optimizing fuel consumption to the load demand and offer resiliency in case of failure of the power system.

Currently, hydrogen is not available in any of the AMHS ports. To support hydrogen vessels, AMHS would have to work with a supplier to charter hydrogen bunkering barges that could then be placed in strategic ports to fuel the vessels.

5.2.10 BIODIESEL

Biodiesel is a domestic, sustainable, renewable fuel that is produced from a variety of renewable resources such as plant oils, animal fats, and recycled grease. There are many marine engines currently on the market that can run on biodiesel mixes. In fact, there are several ferries in Norway that operate on hydrotreated vegetable oil (HVO).

Biodiesel is biodegradable, non-toxic and produces lower, but not cleaner emissions than regular diesel. Biodiesel does have a reduced fuel efficiency of 1-2% and can reduce power on an average of approximately 10%, however biodiesel is usually cheaper than regular diesel and the price difference overcomes these inefficiencies.

The cost associated with installing a biodiesel system is approximately the same as a conventional diesel engine. Fuel storage and safety is similar to conventional diesel, as is its energy density and other properties.

Currently, biodiesel is not available in any of the AMHS ports, however it may be available in the future. Through research completed in 2021 by Pacific Northwest National Laboratory, it was determined that kelp and fish waste could be used to create biodiesel. The kelp industry is expected to be thriving in Alaska within five to 10 years which could lead to greater availability of biodiesel.

Some operators have experienced difficulties with increased maintenance when using biodiesel.

5.3 DIESEL ELECTRIC HYBRID AND ALL-ELECTRIC PROPULSION COMPONENTS AND CONSIDERATIONS

5.3.1 ELECTRICAL DISTRIBUTION

A direct current (DC) grid with direct battery connections has been assumed in this study.

The first diesel-electric vessels employed DC-DC (DC-input power from generators to DC motors propelling the vessel) distribution without any solid-state power conversion equipment. These DC propulsion motors had higher efficiency losses, their brushed commutators had high maintenance requirements and more frequent failures than AC machinery, and voltage control could only be achieved through rudimentary resistors and/or pilot exciters.

The development of power switching devices like diodes and thyristors allowed a shift to supplying power with alternating current (AC) generators in the 1970s that improved the efficiency and voltage control of the power generation and distribution, but still utilized DC motors for propulsion power. Further advances in AC motor drives allowed AC-AC to take over marine in the 1990s. Initially, this was done with thyristor-based cycloconverter or load-commutated inverter (LCI) drives. Propulsion power is provided in this system with synchronous motors, AC motors with rotor field windings like that of the standard AC generator.

The increase in the current and voltage ratings of power transistors has allowed the use of pulse-width modulation (PWM) drives to control higher-powered induction motors. PWM drives allow for power factor control and significant reductions in harmonics. Meanwhile, real-time processing speeds in computer technology have also advanced in motor drives allowing implementation of the difficult control schemes necessary for an induction motor. As a result, induction motors driven by PWM became the preferred solution in the 2000s over the more expensive synchronous AC motors.

The earlier AC distribution required propulsion generators to operate at constant speed. Given that diesel engines do not operate efficiently at low load, vessels with variable load cycles or long periods at low load suffered an efficiency loss with AC distribution. Integrating DC power sources such as batteries, solar panels, and fuel cells with an AC distribution system would also yield an efficiency penalty. The approach that avoids these issues in current hybrid propulsion system design is reverting to the DC grid.

A DC grid uses a DC propulsion bus, but all machinery is AC. AC generators pass AC voltage through a rectifier to the DC grid. Since the rectifier negates any issues with differences between the frequency of power generation and power distribution, the frequency of the connected AC generator becomes irrelevant. Connected AC generators may operate in variable speed mode and drop their speed to match a drop in load. Variable speed generators typically have a higher efficiency across their load profile. Without the need for synchronization, standby generators can also be brought online more quickly.

AC motors and hotel loads are supplied power through DC-AC inverters. The DC grid also protects sensitive and vital loads from the dangerous harmonics that challenged older AC-AC systems. The large, heavy phase-shifting transformers used in 12, 18 or 24-pulse AC diesel-electric systems are eliminated.

DC sources such as batteries can be easily connected to the DC grid. This can be done through single-phase DC-DC converters that are simpler, lower cost, and lighter than three-phase AC-DC rectifiers or

DC-AC inverters. DC-DC converters have been utilized by systems integrators like Danfoss/Vacon, NES and AKA. In some systems, batteries may even be directly connected to the DC grid, eliminating the DC-DC converters. This arrangement is how Siemens and ABB have typically connected their battery systems.

5.3.2 PROPULSION MOTORS

Induction motors controlled by PWM drives have become the preferred propulsion arrangement, but permanent magnet (PM) motors are gaining in popularity. While induction motors are significantly smaller, simpler, and lower cost than the synchronous motors they replaced, they are never employed with the high pole-count and therefore low speed range of the synchronous motors and, therefore, require a reduction gear. The reduction gear adds system cost, volume, and weight while incurring efficiency losses from the gear and the slightly lower efficiency of the induction motor itself.

Permanent magnets are expensive, and the overall cost of PM motors is significantly higher than that for induction motors. However, PM motors have higher efficiency, even compared to a synchronous motor. They can be employed with the same high pole-count and low speed of the synchronous motor. As a result, they eliminate the reduction gear and reduce the overall volume and weight.

Selection of a PM or induction motor depends upon many factors of vessel design and operation.

5.3.3 BATTERY CHEMISTRIES

Lithium-ion batteries are a family utilizing a spectrum of proprietary chemistries. The three marine battery makers, Corvus Energy, Spear Power Systems and Siemens, with the most market presence use the same cell chemistry: lithium nickel manganese cobalt oxide (NMC). The NMC chemistry is preferred because of its wide use in the vehicle segment and the rapid decline in prices achieved with such manufacturing volume. The leading marine cell manufacturer, LG Chem, uses NMC in the Nissan Leaf, Chevy Volt and Bolt, Ford Focus and other vehicles. Other manufacturers such as Leclanché, EST-Floattech, Shift, Xalt and Super-B have also all had their installations based on NMC type.

The lithium iron phosphate (LFP) chemistry is used in limited fashion by Corvus Energy in their Blue Whale offering but is aimed at very large vessels such as cruise ships. Saft's marine offerings have typically used their LFP-based Seanergy modules. Despite initial successes some years ago, their reference list has grown little more recently. Other battery makers like Super-B, Valence Technology or Lithium Werks have a smaller marine market presence. While cost competitive, LFP typically cannot achieve the cycle life of NMC nor the same charge or discharge rates.

Lithium titanate (or lithium titanium oxide, LTO) has a unique set of advantages over NMC. LTO can charge and discharge at about twice the rate of NMC with triple NMC's cycle life. Unfortunately, LTO's energy density of just half that of NMC translates to roughly double the price. Manufacturers of LTO batteries, such as Eschandia and Toshiba SCiB/Forsee, have achieved only a smattering of small marine installations.

One possible pathway for LFP or LTO to gain advantage over NMC is that they do not utilize cobalt. Given that cobalt, with roughly 70% of the world's supply coming from the Democratic Republic of Congo, has both availability and human rights problems, NMC blends are evolving to utilize smaller concentrations of cobalt. The original lithium-ion chemistry still used in laptops and cell phones, lithium cobalt oxide (LCO), has nickel, manganese, and cobalt in equal 33.3% shares. The latest "NMC 811" blend being introduced should drop cobalt usage to a 10% share versus the now dominant NMC blends with 20%.

Panasonic's lithium nickel cobalt alumina (NCA) cells as used by Tesla have not found a marine niche. Nilar attempted to introduce to the marine market a non-lithium battery chemistry with nickel metal hydride (NiMH) as found in a Toyota Prius. However, it never found a market segment, likely due to inferior energy density and cycle life. For the same reasons, lead acid (which for decades was utilized in diesel-electric submarines, amongst other applications) has been overtaken by other options in hybrid systems.

Selection of the best battery chemistry for a given project is dependent on many variables. There is no single correct answer.

5.3.4 BATTERY REPLACEMENTS

Lithium-ion batteries degrade over time from two main mechanisms: cyclical and calendar aging. Cyclical aging is impacted by the rate of charge or discharge, as compared to the total capacity; the temperature rise during charge and discharge; and the total depth of discharge (DoD, the average energy discharged during one cycle as a percent of the total capacity). Normally, calendar aging has less impact than cyclical, but given the low annual cycle count of the subject routes, calendar aging will likely have a higher impact than in other marine applications.

The point at which a battery degrades to 80% of original capacity or state of health (SOH) is often termed its end of life (EOL). A rough guideline of a two percent calendar aging decrease from original capacity each year translates to a roughly 10-year life. In reality, lithium-ion does not precipitously degrade past this 80% threshold like lead acid may. Some vessels might operate lithium-ion to a lower SOH such as 70%. Unfortunately, there is not a track record with lithium-ion to suggest an EOL beyond 10-years, so a life span of 10 years has been assumed for this report.

At EOL, removal, replacement options and disposal of spent batteries must be considered. Battery replacement may have several significant cost savings over the original installation. First, the battery manufacturer may still sell the same module replacement frame which may save cost on replacement. At the 10-year point, advances in battery technology may also drop the cost of replacement batteries or improve the performance to require fewer batteries.

Spent batteries may have a resale value either for recycle or for continued use for an application with a lesser depth of discharge. Fortunately, the looming future volume of spent electric vehicle batteries has caused large investment and progress in lithium-ion battery recycling. Further, the marine rack-based form factor, in stark contrast to the "skateboard" profile of vehicle batteries, allows the marine type to be more readily repurposed for shoreside electrical grid peak-shaving. Grid energy storage applications can usually operate at even lower SOH for EOL than vehicle batteries. Various studies have shown that repurposed lithium-ion batteries would have a positive rather than negative value when removed from a vessel [4]. For the purpose of this analysis and for conservatism, old battery disposal is assumed to be zero cost, and battery replacement is assumed to be similar to initial purchase.

5.3.5 BATTERY SAFETY SYSTEMS

Lithium-ion batteries' Achilles' heel has been the danger of thermal runaway and the extra safeguards necessary to prevent it. A cell in thermal runaway can release a significant amount of energy which can overheat neighboring cells and start a chain reaction. USCG, ABS, and other agencies have prepared guidance and best practices to reduce the hazards and risks associated with thermal runaway.

A good battery management system (BMS) is the first line of defense for lithium-ion batteries. The BMS monitors voltage, current, and temperature of each individual cell or subgroup inside each module to balance the load and degradation of all cells. The BMS will also disconnect the cells electrically and generate alarms should a dangerous condition begin to develop.

There has been a variety of fire suppression systems used for past systems. Fixed gas systems such as 3M NOVEC 1230 or FM200 were initially used in some systems. However, subsequent events and large-scale testing have shown fixed gas may not be enough. Class societies have moved towards a strong recommendation for water-based systems. While water deluge such as sprinkler systems have been used, water mist is rapidly becoming the clear-cut favorite. Foam fire suppression systems that inject directly into the modules have been used in limited cases. However, they have only been known to be used with battery systems that do not meet cell-to-cell propagation testing and require this more direct approach.

Most vessel systems cut off ventilation and the flow of oxygen to aid firefighting. However, lithium-ion thermal runaway produces oxygen inside each cell. Consequently, these events actually benefit from continued ventilation flow to keep the build-up of flammable gases to a minimum. The dedicated off-gas piping systems usually contain a small fan, either continuously running or set up to start during an event. In some cases, such as where the off-gas system is not used, the battery room space has been fitted with a higher-flow emergency ventilation fan.

Gas detection systems are also employed. Various sensors have been employed to detect carbon monoxide or hydrogen gas as well as monitor oxygen levels. The Nexceris Li-Ion Tamer systems were originally designed with support of the US Navy to improve the safety of lithium-ion battery installations onboard ships. Their sensors monitor multiple gases to identify a specific signature given off by lithium-ion cells beginning to enter thermal runaway. Not only are these sensors dedicated to the specific application and danger it poses, but the approach also provides a significantly earlier warning of thermal runaway than standard gas detection systems.

5.4 EXAMPLE HYBRID AND ALL-ELECTRIC VESSELS UNDER CONTRUCTION AND IN SERVICE

5.4.1 DOMESTIC VESSELS

Following are examples of some recent projects incorporating electric or hybrid propulsion systems.

Casco Bay

In 2018 EBDG was selected by Casco Bay Lines to design a new car ferry for service between Portland, ME and Peaks Island, a 2.2 nm route. The hybrid-electric ferry has capacity for 15 vehicles and 599 passengers, spread across three decks including a sun deck with unobstructed views. The new Subchapter K ferry is currently under construction and slated for delivery in 2024.

The ferry features ABB Marine & Ports' hybrid propulsion system supporting diesel-electric and zero-emissions battery-powered modes, as well as a combination of both. With the ferry operating in zero-emission mode, the passengers will benefit from a smoother, quieter and cleaner ride. A Stemmann Technik FerryCHARGER shore charging system is also provided by ABB for rapid vessel charging during the 12-minute stop in Portland.

New Governors Island Ferry

In 2022 EBDG designed a hybrid-electric passenger-vehicle ferry for Governors Island to provide transportation between the Battery Maritime Building in Lower Manhattan and Soissons Landing. The ferry has an overall length of 190', a beam of 62', a depth of 13' and a draft of 8.5'. The vessel has capacity for 600 passengers and 220 LT of vehicle weight and meets USCG Subchapter K regulations. The vessel is designed to operate fully electric once shore charging is available, recharging the batteries during the ten minutes spent at the Soissons Landing end of the route. The new ferry is currently under construction and slated for delivery in 2024.

Cameron Parish Ferry

In 2021, EBDG was awarded the contract to complete the contract design of the Cameron Parish Ferry. The ferry has an overall length of 190', a beam of 50', and a depth of 13'. The vessel will have the capacity for up to 34 automobiles and passengers and meets USCG Subchapter H regulations.

The ferry has been designed to be the first US new-build ferry vessel equipped with the Vard Electro SeaQ® hybrid propulsion system and is intended to operate in a hybrid mode. In this mode the diesel engines will share load with the propulsion batteries whereby the propulsion system will maximize the usage of the battery energy capabilities, resulting in lower exhaust emissions. It will have enhanced maneuvering capabilities provided by the Schottel SRP azimuthing thrusters.

The ferry is planned to enter the construction phase in late 2022 and EBDG will continue to provide technical support services to the Louisiana Department of Transportation and Development as the ferry progresses through construction. The ferry is expected to enter operating service in 2024.

Niagara Falls Tour Ferries

Maid of the Mist is now operating their new battery-powered Niagara Falls tour ferries. These vessels were designed to carry 520 passengers on the sustainable energy produced by the falls. ABB provided systems integration for this project.

5.4.2 INTERNATIONAL VESSELS

Following is a selection of the vessels currently in service outside the US.

AMPERE[8]

Ampere, operating a 3.1nm route in Norway since 2015, is the world's first battery-electric car ferry. The 260' Ampere carries up to 360 passengers and 120 cars at a maximum speed of 10 kt. Siemens was the propulsion integrator, with Corvis batteries.

COLOR HYBRID[9]

The 525 ft-long Color Hybrid is a combination diesel-mechanical/diesel-electric hybrid that is designed to operate normally in full electric mode and entered service in 2019. The vessel carries up to 2000 passengers and 500 cars and has a top speed of 12 kt. The vessel can operate in all electric mode for up to 60 minutes before needing charge from shore or the onboard power plant. All-electric operation is typically conducted near shore to minimize impacts on populations. The vessel utilizes a medium voltage charging system from NG3. Siemens was the propulsion integrator.

ELEKTRA[10]

The 322' Elektra operates on a 0.86 nm route in Finland carrying 90 cars and 375 passengers at a top speed of 11 kt. Elektra is designed to operate on batteries only but utilizes three diesel generators to cope with heavy ice in winter. The vessel entered service in 2015 and is equipped with Siemens BlueDrive PlusC propulsion system. A Cavotec charging system was installed.

BASTØ ELECTRIC[11]

At the time of construction, Bastø Electric was the largest all-electric ferry in operation. This ferry began operating in 2021 on a 5.7 nm route in Norway. Bastø Electric is 457' in length, carries 200 cars and 600 passengers and has a top speed of 13 kt. Siemens Energy served as propulsion integrator. Charging is at medium voltage using a Stemmann-Technik tower.

5.5 SHORESIDE INFRASTRUCTURE

5.5.1 COMMUNITY PORT-SIDE INFRASTRUCTURE OPTIONS

Rapid charging systems (RCS) transmit high volumes of electrical power from the shore to the vessel and make the connection quickly for ferry or other short-docking operations. Such charging systems are a rapidly evolving technology and there are many design solutions available and in development to overcome various challenges. The leading standard for such systems is IEC/ISO/IEEE 80005-1, first published in 2012. ABS and DNV also have published standards for electrical shore connections.

The most significant challenge to overcome with an RCS is the ship's motion and position relative to the pier. The system needs to span a gap to connect to the vessel without interfering with vessel operations while maintaining a safe electrical connection. Most existing systems utilize positive restraint, typically

[8] https://en.wikipedia.org/wiki/MV_Ampere
[9] https://en.wikipedia.org/wiki/MS_Color_Hybrid
[10] https://www.ship-technology.com/features/elektra-finlands-first-hybrid-electric-ferry/
[11] https://www.dailyscandinavian.com/worlds-largest-electric-ferry-now-operational-in-norway/

an automated mooring device near midship, to minimize vessel motions while at the dock. Bow charging may either be mounted on a stationary structure or on the vehicle ramp and may not require a positive restraint.

The various RCS solutions developed can be loosely categorized as follows:

- Mounted on Auxiliary Side Dock/Pier vs. Loading Ramp vs Vessel
- Vertical (Hook) vs. Horizontal (Extension) vs Davit (Crane)
- Automated vs. Manual

While almost all concepts install the RCS active component on shore, an alternative concept is to install the active component onboard the vessel such as the NG3 system (below).

Another significant variation in design solutions is whether systems are automated or manual. While the many benefits offered by autonomous charging systems come at significant capital cost, automated charging may reduce the requirement for additional crew and is especially advantageous when there is limited time or crew to charge the vessel.

Several aspects of charging systems are important to consider:

1. Charge power. This determines how much energy can be loaded aboard the vessel in a given time, or conversely, how much time is required to transfer a given amount of energy.

2. Operating voltage. The decision is essentially between low- and medium-voltage systems.

    a. Medium-voltage requires thicker cable and transformer insulation, more careful grounding and ground fault protection measures, insulated busbars and additional design, construction and testing safeguards.

    b. Low-voltage systems will require higher amperage to pass the same amount of power, larger copper conductors, busbars, and transformer windings, leading to added weight.

3. Time to connect and disconnect. As charge duration has a significant effect on performance and costs, connecting quickly upon arrival and disconnecting immediately before departure maximizes charge duration.

4. Automation and Autonomy. Given the speed required to make the medium-voltage connection, robotics will likely be necessary including sensors, infrared, laser or other optical sensors for connection targeting and telemetry to prepare a charging system for an approaching vessel.

5. Range of motion. A careful analysis of motions will be necessary to ensure the system is designed to accommodate freedom of vessel movement along all three axes.

6. Dependability. The ability to connect despite potentially challenging weather and lighting conditions, vessel motions, and hull conditions (fouling) will be a key driver in the long-term success of vessel electrification.

7. Structural and mechanical robustness. The system will require excellent corrosion resistance, galvanic protection, and minor impact resistance to improve performance and increase service life. RCSs consist of a variety of mechanical elements, and stout construction will enable long life.

8. Serviceability. Accessibility to wearing parts, quick trouble shooting and repair, and intuitive operation are advantageous.

9. Infrastructure. RCS may require substantial land-based equipment, which could necessitate improvements or upgrades to the existing dock infrastructure to deploy the desired RCS.

10. Safety. Proximity of the public and crew to medium voltage without sufficient barriers and protections in place is simply unacceptable. Circuit protection must include not just short circuit and overload trip settings but also quick acting and sensitive ground fault trips.

Some notable characteristics of RCS described in the following sections are summarized in Table 5 below.

Table 5: Selection of Available Shoreside Technologies

Company	RCS Description	Autonomous vs Manual	Land vs Vessel Mounted	Vertical vs Horizontal vs Davit	Voltage
Stemmann- Technik	Pantograph Robotic Arm Crane/Davit	Semi- Autonomous Autonomous Autonomous	Land Land Land	Horizontal Horizontal Davit	LV LV/MV LV
Cavotec	Vertical APS (Hook) Horizontal APS RL2C Ramp APS Crane/Davit Cable Reel	Semi- Autonomous Autonomous Manual Autonomous Manual Manual	Land Land Land Land Land Land	Vertical Horizontal Davit Horizontal Davit Horizontal	LV LV/MV LV LV/MV MV LV
Mobimar	NECTOR	Autonomous	Land	Horizontal	LV/MV
NG3	PLUG	Semi- Autonomous	Vessel	Vertical	LV/MV
ABB	Robotic Plug System	Autonomous	Land	Davit	MV
LOS Gruppen Zinus	Telescopic Compact ZPP215	Manual Autonomous Semi- Autonomous	Land Land Land	Vertical Vertical Horizontal	LV LV LV
BlueDay	BluEco	Manual	Land	Horizontal	LV/MV

5.5.2 STEMMANN-TECHNIK

Stemmann-Technik first developed a horizontal pantograph charging system, Figure 3. A pantograph is the typical arrangement for rail applications where a vertically extending control arm makes contact with an overhead cable. In this case, however, a row of horizontally extending carbon brushes on shore makes contact with vertical busbars mounted in the side of the vessel. Both sides have automatic doors that cover up when the connection is not made. The vessel-side vertical busbars are sized to accommodate the tidal fluctuation. This system requires access to the side of the vessel with a pier running some part of the length of the berth. Since the pantograph pushes against the vessel to maintain contact between the brushes and busbars, it requires positive restraint mooring.

Figure 3: Stemmann-Technik First Generation Horizontal Pantograph RCS

Stemmann-Technik developed another system, Figure 4, which placed a horizontally extending robotic arm on a vertically traveling platform that moved up and down inside a tower. An electric eye allows it to autonomously target a fixed receptacle on the vessel. The system does not push against the vessel but makes an interlocking connection with plug and receptacle. Nevertheless, the system has been mounted on a significant auxiliary dock with a vacuum mooring system at the side of the vessel. There are at least 26 of these systems from Stemmann-Technik that have now been installed in Norway.

Figure 4: Stemmann-Technik Second Generation Tower RCS

Stemmann-Technik is deploying a crane-based system. Four of these units will be used in Ontario, Canada at the Wolfe and Amherst Island routes for the Ontario Ministry of Transportation. Each will be mounted at a location just to the side of the vehicle loading ramps and would be considered a bow charging solution; these systems will utilize an integrated mooring system developed by Stemmann-Technik. An additional unit will be used in Skagit County, WA for the Guemes Island ferry.

Figure 5: Stemmann-Technik Third Generation Crane Based RCS

5.5.3 CAVOTEC

Cavotec offers both manual and automatic e-charging technologies and automated positive restraint, vacuum mooring systems. The automated plug-in system (APS) requires no human intervention and requires minimum modifications to vessels. Figure 6 below shows the APS Towers that establish connections in under 30 seconds when combined with an automated mooring system.

The Cavotec APS Tower is mounted on a pier alongside the vessel. It is an enclosed tower which features a plug assembly that lowers into a receptacle installed in the side of the vessel. The APS-vertical system is a proven technology with two active installations in Europe. The existing APS vertical installations are mounted near the midship point of the ferry with a pier extending out a substantial portion of the vessel length. Both systems use a Cavotec MoorMaster automated vacuum mooring system to provide positive restraint for the connection, Figure 7.

Figure 6: Cavotec APS Tower RCS

Figure 7: Cavotec MoorMaster Automated Vacuum Mooring System

Cavotec has also developed a horizontal APS system, Figure 8, as a bow charging solution. Initial concepts show this system mounted to an auxiliary side dock adjacent to the vehicle loading ramp. This system would require a much shorter auxiliary dock (or pier), extending no further than the ramp itself. In this configuration, the APS box moves vertically, and the arm extends horizontally to connect with the ship. There are or will soon be over 20 installations of the bow charging APS in Norway.

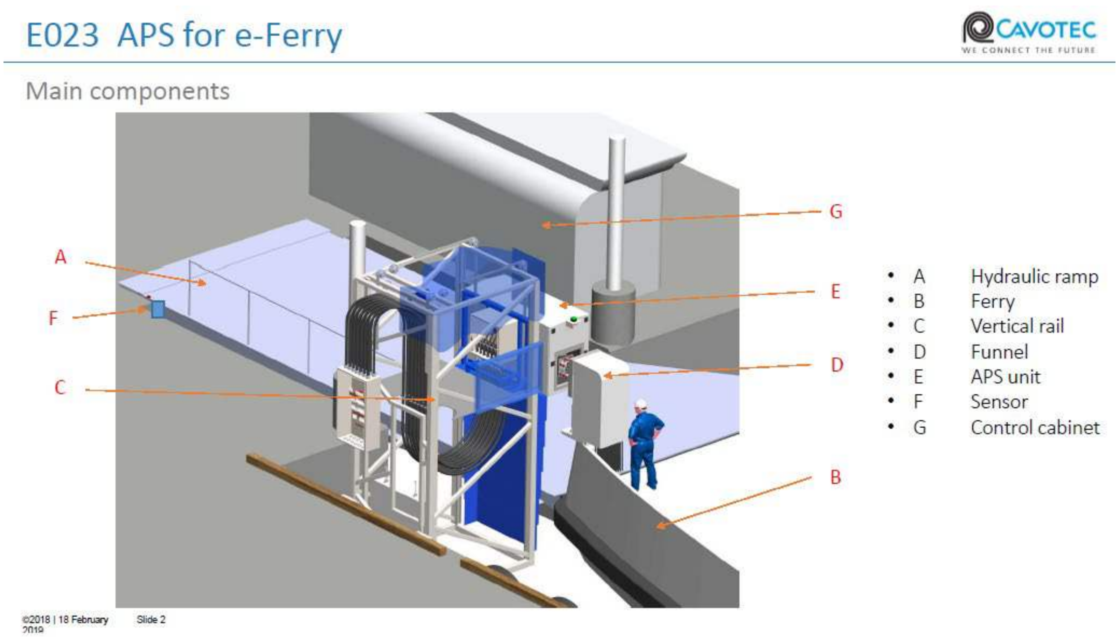

Figure 8: Cavotec Horizontal APS RCS

An additional Cavotec RCS is the PowerRampNxG, which utilizes the APS box. In this design, the APS box rotates and extends horizontally from the car ramp to connect with the vessel. Like the other autonomous systems offered by Cavotec, the PowerRampNxG is compatible with the MoorMaster mooring system.

Cavotec has developed manually controlled davit systems for both MV and LV vessel systems, Figure 9. The davit arm can rotate as well as adjust in height and horizontal length.

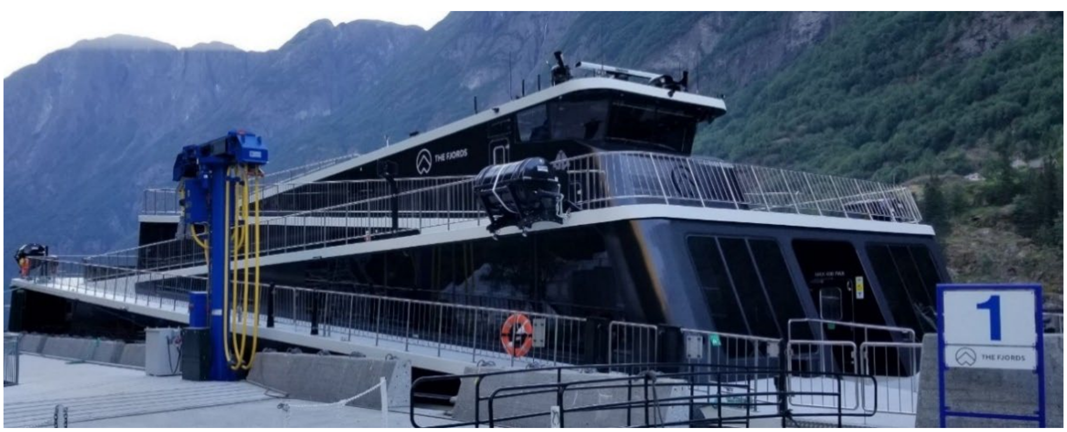

Figure 9: Cavotec Manual Davit (blue, with yellow cables)

Another manual charging system from Cavotec is a cable reel for LV electrification. The cabling extending from the reel is placed onboard the ship to establish electrical connection.

5.5.4 MOBIMAR

Mobimar offers a ramp-mounted bow charging system called NECTOR that can establish a rapid autonomous connection to the vessel, Figure 10 and Figure 11. The system can be easily activated with a push button from the bridge.

Figure 10: Mobimar NECTOR RCS

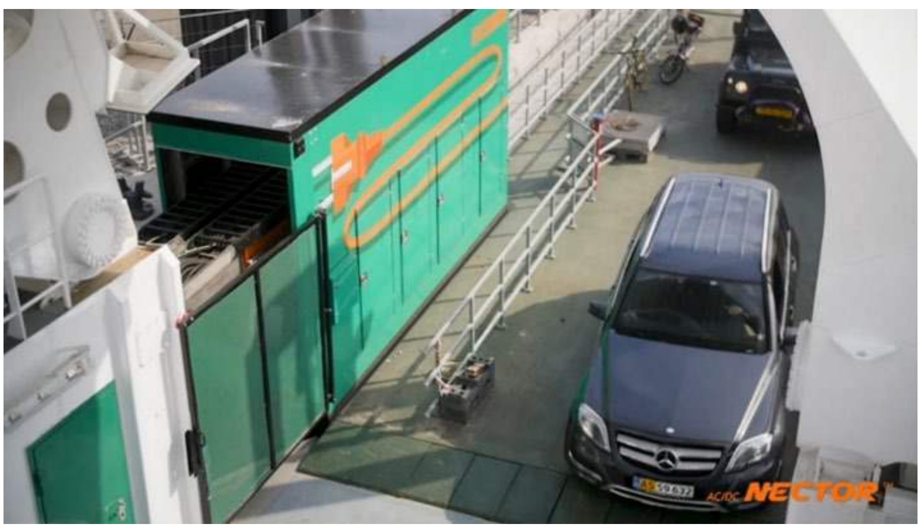

Figure 11: Mobimar NECTOR RCS

5.5.5 NG3

NG3 has supplied systems for large passenger ships operating in Scandinavia. The PLUG system has a vessel mounted arm that extends from the vessel, Figure 12. From this arm, it pays out a chain and hook that grabs a shoreside cable and pulls it up and into a receiving receptacle mounted to the extended arm. The system supports an 11kV and 4.5MVA connection and can connect in roughly one minute.

Since 2011, the system has been operating onboard five large ColorLine passenger vessels and at four terminals at which they operate.

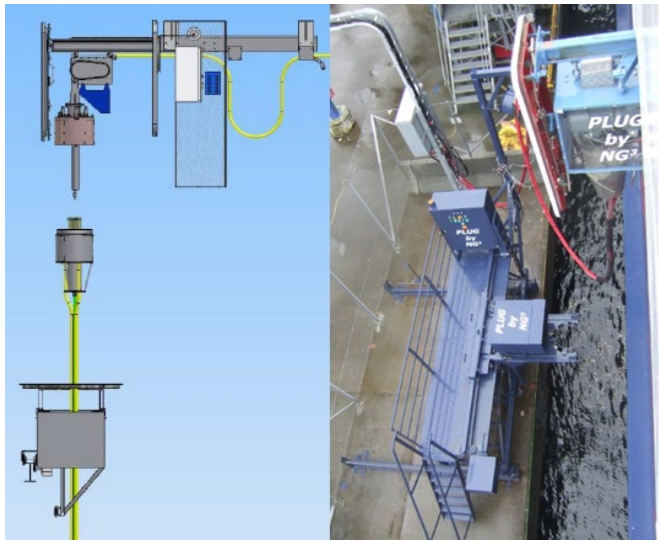

Figure 12: NG3 Plug RCS (left, engineering diagram; right, photo of installation)

5.5.6 ABB

ABB's ForSea Ferries (previously HH Ferries) retrofit project employs charging at a medium-voltage level of 10kV and 10MW, charging 4.2MWh battery packs in as little as five minutes.

The key RCS components were charging towers housing ABB factory robots, Figure 13, which are substantial in size and weight. Despite initial challenges in making connections quickly enough, the vessels now consistently make zero emissions crossings.

ABB made significant investments in this equipment and gained valuable know-how and insight while recognizing that this system was applied to an operator with unique existing infrastructure and operations.

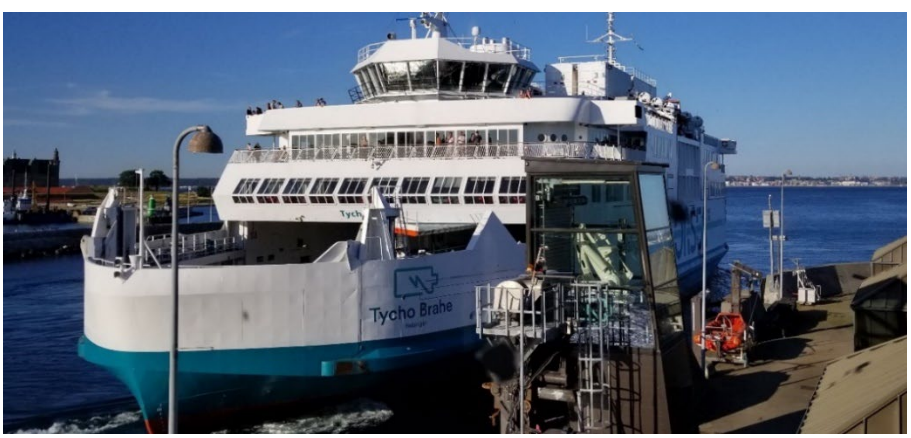

Figure 13: ABB Tower RCS

5.5.7 LOS GRUPPEN ZINUS

The LOS Gruppen Zinus RCS offers a manual or autonomous system, consisting of four vertical plugs hanging from an extendible overhead arm, Figure 14. It is rated to supply 230-690VAC and up to 1400A for a power transfer of up to 1.6MW.

Figure 14: LOS Gruppen Zinus RCS

Another charging system offered by Zinus is the semi-autonomous Compact ZPP215. The system can supply 230-690VAC through a maximum of four 45-meter spooled cables, each capable of carrying 350A.

Figure 15: Zinus Compact

5.5.8 BLUEDAY

Blueday has developed manually controlled cable reel RCS for LV vessel systems, Figure 16. The design can accommodate a varying number of cables and plugs to provide the required level of power.

The lightweight Wärtsilä charging system for the MEDSTRAUM uses a similar concept, employing six vehicle CCS-2 charging plugs to achieve up to 2.4MW of power.

Figure 16: Blueday BluEco RCS

6. PILOT PROJECT NOTIONAL VESSEL DESIGN

6.1 PILOT ROUTES

Routes selected for this analysis must be applicable to a pilot project to reliably prove the concept and meet the budget considerations for future implementation phases. In consultation with SEC, the routes selected for focus cover relatively short distances (less than four-hr transit) and have access (or potential access) to renewable energy sources.

6.1.1 PASSENGER / CAR LOADING

Annual AMHS passenger and vehicle traffic was examined for the four-year period between 2016 and 2019 to provide insights regarding demand prior to the pandemic. These years were selected as they represent passenger loading pre-Covid limitations. Vehicle and passenger counts are given as "Link Volume" and "On/Off Volume". Link volume provides the total number of passengers onboard for that leg of their journey from the departing port to any other port. On/Off Volume is the total count of passengers coming onboard at the first port and leaving at the second port. Because these ports are visited by larger ferries travelling longer distances, the link volume is typically a fair bit higher as the passengers may stay onboard for more than just one leg.

Note that peak passenger volumes may be limited by vessel availability rather than actual passenger demand. That is, if more trips are scheduled more traffic may be expected.

Haines-Skagway

- Haines-Skagway has the highest maximum vehicle count of up to 44 vehicles in one trip. This route makes one trip per day or less. All routes have an average vehicle count of less than thirteen. All routes indicate a maximum passenger count of 140 or less.

- AMHS traffic between Skagway and Haines peaked in 2017, with 21,007 passengers and 7,407 vehicles in link volume and 7,549 passengers and 3,508 vehicles in on/off volume.
- The number of voyages ranged from 212 in 2016 to 304 in 2017.

Table 6: Skagway-Haines Passenger and Vehicle Volume, 2016 – 2019

	2016	2017	2018	2019
Link Volume				
Passengers	16,826	21,007	18,439	16,155
Vehicles	5,741	7,407	6,896	6,313
On/Off Volume				
Passengers	5,809	7,549	6,756	6,156
Vehicles	2,752	3,508	3,130	2,944
Total Voyages	212	304	254	243

Source: AMHS Annual Traffic Volume Reports, 2016 – 2019.

- Passenger volume between Haines and Skagway was similar in 2017 and 2018, with a peak of 22,595 passengers and 8,449 vehicles in link volume in 2018. When examining on/off volume, passenger movement was highest in 2018 at 9,170 people and vehicle traffic was highest in 2017 at 4,396.
- The number of voyages ranged from 204 in 2016 to 305 in 2017.

Table 7: Haines-Skagway Passenger and Vehicle Volume, 2016 – 2019

	2016	2017	2018	2019
Link Volume				
Passengers	15,743	22,522	22,595	17,806
Vehicles	5,712	8,152	8,449	7,006
On/Off Volume				
Passengers	6,634	9,162	9,170	7,399
Vehicles	3,223	4,396	4,386	3,663
Total Voyages	204	305	265	244

Source: AMHS Annual Traffic Volume Reports, 2016 – 2019.

Ketchikan-Metlakatla

- AMHS traffic between Annette Bay and Ketchikan peaked in 2017, with 18,129 passengers and 5,026 vehicles.
- The number of voyages ranged from 479 in 2018 to 516 in 2017.

Table 8: Annette Bay-Ketchikan Passenger and Vehicle Volume, 2016 – 2019

	2016	2017	2018	2019
Link Volume				
Passengers	16,176	18,129	16,666	15,008
Vehicles	4,880	5,026	4,351	3,579
On/Off Volume				
Passengers	16,176	18,129	16,666	15,008
Vehicles	4,880	5,026	4,351	3,579
Total Voyages	485	516	479	496

Source: AMHS Annual Traffic Volume Reports, 2016 - 2019.

- AMHS traffic between Ketchikan and Annette Bay peaked in 2017, with 17,794 passengers and 5,182 vehicles.
- The number of voyages ranged from 478 in 2018 to 516 in 2017.

Table 9: Ketchikan-Annette Bay Passenger and Vehicle Volume, 2016 – 2019

	2016	2017	2018	2019
Link Volume				
Passengers	16,956	17,794	16,115	14,267
Vehicles	4,992	5,182	4,460	3,660
On/Off Volume				
Passengers	16,954	17,794	16,115	14,267
Vehicles	4,991	5,182	4,460	3,659
Total Voyages	485	516	478	497

Source: AMHS Annual Traffic Volume Reports, 2016 - 2019.

Homer Seldovia

- AMHS traffic between Homer and Seldovia peaked in 2016, with 2,988 passengers and 1,857 vehicles in link volume and 2,467 passengers and 1,494 vehicles in on/off volume.
- The number of voyages ranged from 92 in 2019 to 116 in 2016.

Table 10: Homer-Seldovia Passenger and Vehicle Volume, 2016 – 2019

	2016	2017	2018	2019
Link Volume				
Passengers	2,988	1,438	2,296	2,005
Vehicles	1,857	1,042	1,318	1,329
On/Off Volume				
Passengers	2,467	1,434	2,292	1,657
Vehicles	1,494	1,040	1,313	1,103
Total Voyages	116	94	112	92

Source: AMHS Annual Traffic Volume Reports, 2016 - 2019.

- AMHS traffic between Seldovia and Homer peaked in 2016, with 2,577 passengers and 1,555 vehicles in link volume and 2,247 passengers and 1,371 vehicles in on/off volume.
- The number of voyages ranged from 93 in 2019 to 114 in 2016.

Table 11: Seldovia-Homer Passenger and Vehicle Volume, 2016 – 2019

	2016	2017	2018	2019
Link Volume				
Passengers	2,577	1,490	2,146	1,993
Vehicles	1,555	1,014	1,266	1,355
On/Off Volume				
Passengers	2,247	1,481	2,137	1,538
Vehicles	1,371	1,011	1,262	1,076
Total Voyages	114	95	112	93

Source: AMHS Annual Traffic Volume Reports, 2016 - 2019.

Notional Vessel Loading

The notional vessel should be considered capable of supporting all traffic (link volume) as a shuttle ferry between ports. Passenger loading is not expected to be limiting for the notional vessel as cars consume more deck space than passengers. For all three routes analyzed the average link volume of cars is less than 20. During peak days more than one round trip per day may be required.

6.1.2 ENCLOSED VS. OPEN VEHICLE DECK

The selected routes are exposed to varying weather and sea conditions. An open vehicle deck operating in exposed waters may subject the vehicular cargo to excessive water spray, ice accumulation, and even green water.

The totally enclosed vehicle deck has a structural cover over the car deck that adds steel weight and requires large ventilation fans to remove vehicle exhaust, a sprinkler system, and structural fire protection. These additional requirements yield a bigger vessel that is capable of supporting the added elevated weight of the vehicular enclosure.

A partially enclosed vehicle deck is utilized on some vessels. The partially enclosed vehicle deck still utilizes a full structural cover over the vehicle deck but has the back open so that it does not require a ventilation system. The partially enclosed vehicle deck still requires structural fire protection under any passenger spaces above and a sprinkler system under the entire enclosure. Given the openings required for ventilation, portions of the deck may still be susceptible to icing.

To have route and seasonal flexibility EBDG recommends an either partially or totally enclosed vehicle deck on the notional vessel.

6.1.3 LOADING

All ports of selected routes are capable of side loading, so the notional vessel is expected to utilize side loading. Stern loading is also an option, but bow loading would not be considered due to the high cost, complexity and weight, as well as the current lack of compatible infrastructure.

6.2 PORT ELECTRICAL INFRASTRUCTURE

6.2.1 SKAGWAY-HAINES

Haines and Skagway receive their electrical power/energy from Alaska Power & Telephone (AP&T). Their main office is in Skagway. Most of the electricity for both communities is generated from their hydroelectric powerplants in or near Skagway and Haines. Both communities are supported with backup diesel-driven powerplants that are used for peaking power needs and hydroelectric powerplant outages. The use of diesel generated electricity is minimal.

The two communities are interconnected by a 35kV-rated submarine cable allowing optimal loading of the plants and better water reservoir management. The distribution system in Skagway is powered at 2.4kV, delta configured. The distribution system in Haines is powered at 12.47kV, wye configured. The higher voltage system allows higher power delivery.

The existing ferry terminals at both Haines and Skagway are provided with three phase power. Both facilities have dedicated utility transformers for providing low voltage power to the terminals. Based on the application of a Battery Energy Storage System (BESS) AP&T has capacity to power EV ferries with their present facilities.

At the time of the writing of this report, the cost of electricity for this route is:

- $0.205163 per kWh with the present COPA and regulatory charge
- $6.71 per kW of load sustained for more than a 15-minute window of time
- $172.27 per month customer charge

For this analysis, it is assumed that the homeport will be Skagway.

6.2.2 METLAKATLA-KETCHIKAN

The electrical power/energy is provided in Metlakatla by their municipally owned utility, Metlakatla Power & Light (MP&L), headquartered in Metlakatla. The bulk of the electricity generated in Metlakatla is from the Purple Lake and Chester Lake hydroelectric power plants. MP&L utilize a diesel generator power plant for peaking requirements and during hydroelectric plant outages. Like Skagway and Haines, production of electricity using the diesel power plant in Metlakatla is minimal.

Like Metlakatla, the electrical power/energy for Ketchikan and its surrounding areas is provided by its municipally owned utility headquartered in Ketchikan. Ketchikan Public Utilities (KPU) receives much of its electricity from local hydroelectric power plants, and is supplemented with energy purchased from Southeast Alaska Power Agency, SEAPA. SEAPA generates and wholesales energy from its Tyee and Swan Lake hydroelectric powerplants to Petersburg, Wrangell, and Ketchikan. KPU also has a diesel generator powerplant for supplying peak loads and for hydroelectric power plant outages.

The distribution system in Metlakatla is powered at 12.47kV. They have a distribution line extending approximately 12 miles from the community to Waldon Point where the ferry terminal is located. MP&L recently signed an agreement to install a submarine transmission line between their two utilities. It is anticipated that the line voltage will be 34.5kV which will require a new substation in Metlakatla with a transmission line constructed to Waldon Point.

The cost of electricity at the Metlakatla terminal is:

- $0.1469 per kWh
- $12.00 per kW of load sustained for more than a 15-minute window of time
- $17.50 per month customer charge

KPU distributes electricity to its customers at 12.47kV. They also transmit 34.5kV power along their community's corridor from north of Ward Cove to south of Mountain Point. The present ferry terminal is powered from the 12.47kV distribution system with a utility transformer at the terminal providing user voltage power. KPU has the ability and capacity to power the EV ferry from either the transmission line or distribution system.

With the application of a BESS at the ferry terminal on Waldon Point, MP&L has ability to provide a fast charge to the EV ferry. It might be possible to provide charging power without a BESS at the Ketchikan ferry terminal, depending on the required charge time.

The cost of electricity at the Ketchikan terminal is:

- $0.1039per kWh
- $3.37 per kW of load sustained for more than a 15-minute window of time
- $42.00 per month customer charge

For this analysis, it is anticipated that the homeport will be in Metlakatla.

6.2.3 HOMER-SELDOVIA

Homer Electric Association (HEA) provides electricity for both Homer and Seldovia and is headquartered in Homer. The bulk of the electricity for the HEA grid is generated at power plants using Liquid Petroleum Gas, LPG, engine/generators with support from hydroelectric powerplants. The system is currently supported by a BESS with capacity to receive or discharge up to 46.5MW. This allows HEA to optimally load its generators to achieve good performance and best energy consumption.

The distribution systems in both communities are powered at 14.4/24.9 kV. The electrical power for Seldovia is routed from the feeder on Homer Spit. HEA is beginning to evaluate upgrading their feeder on Homer Spit to provide greater capacity for cruise ship and ferry electrification, and for Seldovia. It is anticipated that BESS equipment will be provided at Seldovia to allow for a fast charge if charging at each port is required. If only one trip per day is anticipated and if the charge rate to the EV ferry is controlled to occur over a longer period of time, a BESS may not be required at the Homer ferry terminal.

The cost of electricity for the ports serving this route is:

- $0.183553 per kWh with the present COPA and regulatory charge
- $21.63 per KW of load sustained for more than a 15-minute window of time (minimum of $432.60)
- $50.00 per month customer charge

It is anticipated that Homer will be the homeport for this analysis.

6.2.4 COMPARATIVE COST OF ENERGY

As noted above, the utilities providing electrical power to the communities along the three identified AMHS routes have sufficient capacity to recharge the notional vessel. Table 12 summarizes the projected cost of diesel fuel versus electricity to operate each of the three routes. Monthly fees (including the peak demand rate and per user fees) are divided by the assumed number of charges (round trips) per month.

Table 12: Projected Cost of Diesel Fuel vs Electricity

	Battery-Only/Hybrid, Chargin at One Port - Electrical Cost[1]							Diesel Mechanical - Diesel Cost		
Route[5]	$/kW	Charge Demand[2,4] kW	Monthly Fee	Charges per Month	$/kWh	Crossing Energy[4] kWh	**$/Round Trip**	$/gal[3]	Fuel Cons. gal	**$/Round Trip**
Skagway - Haines	$ 6.71	190	$ 172.72	12	$ 0.2052	4562	$ 1,057	$ 2.31	298	$ 688
Ketch. - Met.	$ 3.37	215	$ 42.00	40	$ 0.1039	2585	$ 288	$ 2.31	170	$ 392
Homer - Seldovia	$ 21.63	234	$ 50.00	12	$ 0.1836	5621	$ 1,458	$ 2.31	367	$ 846

1. Includes only power and energy rates. Does not include monthly account charges, etc.
2. Assumes ESS such that the charge demand is spread over 24hr (12hr for Ketch-Met).
3. Average of fuel prices from FY18 through FY21
4. Includes 2hr of full hotel load at the dock at 150kW
5. Charging assumed at one end, underlined port.

Based on the existing electric rates and cost of diesel, the cost of electrical energy per run is greater than the cost of diesel in two of the three identified routes. A portion of the cost differential between electric and diesel is due to the referenced four-year average price of diesel between FY18-FY21 (the current spot price is approximately 50% greater) and the demand charge component of the utilities' rate structures, set by utility tariff. Adjustments to utility tariffs to lower the cost of electricity could make energy costs of electric-powered ferries closely cost competitive with diesel-mechanical propulsion.

The utility tariffs currently accepted by the Regulatory Commission of Alaska (RCA) are identified in the previous section for the communities anticipated to provide shore power to the ferries. The question regarding the utility tariffs has been posed to representatives of all the utilities for the anticipated ports with respect to their interest in forming special agreements with ADOT/PF for shore power. The objective is to remove the demand charges as a minimum, and perhaps reduce the energy charges as well.

The responses received from the utility representatives are as follows:

Skagway – Haines: A special agreement might be possible if a BESS is included. The significance of the agreement could be based on how the BESS is utilized. If it remains on-line for utility use to aid their effort to stabilize frequency and voltage responses on their system, they are quite interested. There are numerous elements to the agreement that must be addressed including: rating of the BESS, how the BESS if funded, location of the BESS, the ability to accept power interruption, etc.

Metlakatla: The utility's representative states that they will support a special agreement. They are presently working to install a new BESS within the community. How the BESS is utilized and connected to the ferry terminal will be a factor considering the distance between the BESS and the ferry terminal. However, the use of their BESS was not addressed as a criteria for the special agreement.

Ketchikan: KPU will support a special agreement. They are also quite interested in incorporating a BESS. The significance of a special agreement with them has similar desires as those by AP&T for Skagway & Haines.

Homer-Seldovia: Presently, HEA is less committal toward a special agreement, although they are open to discussion. They have a large BESS on their system and the advantage small BESS's at the ports was not determined considering that they are amid planning and defining their feeder upgrades to the Homer ferry terminal and to Seldovia.

The conclusion is that the utilities are favorably open to agreements with special considerations to demand and energy charges. This is particularly true where the installation of a BESS is included.

6.3 NOTIONAL VESSEL DETAILS BASED ON ROUTES

To meet the needs of the selected routes, the notional design should carry 20-25 vehicles in an enclosed vehicle deck and a minimum of 150 passengers. This makes the notional vessel most similar to the MV PRINCE OF WALES. The notional vessel may be designed as a hybrid such that it may operate on battery or on diesel/alternative fuel generators to provide service in the scenario that shore charging becomes unavailable.

6.3.1 LOAD ASSUMPTIONS

Outside of propulsion, the next energy consumer on the vessel is the hotel loads. These loads include heating and ventilation loads, lights, and other support systems. In this analysis this load also includes the various service system loads like cooling pumps. The notional vessel is assumed in this analysis to have a constant hotel load of 150kW. In reality, the hotel load will vary to a great extent by the level of heating or cooling is needed in the passenger and machinery spaces.

The 150kW load assumes electric resistance heat. During contract design, the designer should consider options to minimize the hotel load such as increased insulation, heat pumps, and LED lighting.

In the trip analyses, the hotel load is assumed to be provided by shore power at all ports.

6.3.2 BATTERY SIZING FOR ALL-ELECTRIC OPERATION

Battery sizing for all-electric operation is primarily dependent on the trip energy and the charge rate.

The trip lengths are long enough that these vessels will need to fully recharge at minimum every round trip or the volume required for the batteries could start displacing passengers or cargo. Appendix D contains battery sizing calculations for charging at both ends of each route and for charging only at one dock.

Trip energy is largely impacted by vessel transit speed. As discussed in Section 3.3.1, decreasing the transit speed will significantly reduce the transit energy. Appendix D evaluates the battery sizing with the vessels operating at the design speed and at a reduced speed. The minimum battery capacity needed to operate on any of the selected routes (Section 6.1) is provided below in Table 13.

Table 13: Battery Sizing (kWh)

Transit Speed \ Charging at:	One End (kWh)	Both Ends (kWh)
Cruise Speed = 13.2kt	7200	3600
Cruise Speed = 9.7kt	5500	2800

7. FINANCIAL AND ECONOMIC ANALYSIS

7.1 CAPITAL COSTS

7.1.1 NOTIONAL VESSEL CAPITAL COST

The notional vessel capital cost is estimated in Appendix D. To estimate the vessel capital cost, the vessel dimensions, installed power, and weight are compared to the shipyard costs for similar vessels. These costs are broken out by ship work breakdown system (SWBS) groups that help identify and scale for differences in reference vessels. There are large gains in efficiency and reductions in cost when more than one vessel is constructed in a class. This cost estimate has assumed that each vessel after the first costs 18% less than the first. The notional vessel is estimated to cost approximately $53 million for the first vessel and $140 million for three vessels.

7.1.2 SHORESIDE INFRASTRUCTURE

For a 3MW manual charging system (PowerReach) with two connectors from Cavotec, the rough estimated cost for a complete system in December of 2022 is $2.5 million to $3 million. A complete system includes charging connectors, cabling, cable cooling, system integration, and other electrical/mechanical equipment. Pier modifications associated with landside infrastructure for the charging system may generate additional costs.

An automatic charging system supplying similar power may cost considerably more. Cavotec's PowerAdapt may cost an additional $500-750k more than the manual PowerReach. Given that the vessel is assumed to be at the dock for a minimum of one hour between trips, manual is likely to be a preferred option both for capital cost and for flexibility with other vessels.

Energy storage systems for rapid charging may vary greatly by the cost of building the facilities, permitting, and connections to utilities, but the essential components (batteries and electrical systems) can be roughly estimated. Batteries for energy storage systems may be estimated to be $700/kWh. Seldovia is estimated to need a roughly 4000kWh energy storage system. The other electrical equipment and systems integration is roughly equal in cost to the batteries. Outside of the permitting, utility, and facility costs, the Seldovia energy storage system may cost roughly $5.6 million. While the shoreside battery bank could be of a lower energy density or cheaper chemistry, there are expected to be distinct benefits in retaining commonality of manufacturer and integrator between vessel and shore. These include potentially swappable battery modules and spare parts and common service technicians and lead times.

7.2 LOW-EMISSION FERRY PRO FORMA FINANCIAL ANALYSIS

This analysis provides estimates of the annual operating revenue and expenses associated with operating an electric ferry in each of the three routes considered in this study. Key assumptions framing the analysis are described below, followed by the results of the pro forma cash flow analysis.

7.2.1 OPERATING COSTS ASSUMPTIONS

- Non-fuel operating costs are assumed to be $125 per nautical mile (nm) for all routes, which is the LITUYA’s actual operating cost per mile. For comparison, the IFA vessel per mile operating cost (excluding fuel) is $106/nm (including vessel operations and engineering/maintenance).
- Annual total route mileage assumptions are: 8,000 nm for Annette Bay/Ketchikan (equivalent to current service); 14,040 nm for Haines/Skagway (based on two RT/day for six months and one RT/day for six months, 360 days total); 9,180 nm for Seldovia/Homer (based on one RT daily for six months, and one RT every other day for six months, 360 days total).
- Haines/Skagway electric power cost is $36.12/nm, plus monthly demand and customer charges. Annette Bay/Ketchikan energy costs are $22.64/nm (plus monthly demand and customer

charges) assuming the vessel is homeported on Annette Bay. If homeported in Ketchikan, energy costs would be $16.01/nm. Seldovia/Homer energy costs are $30.83/nm.[12]

- All operating costs are held constant over the 10-year period of analysis.

7.2.2 REVENUE ASSUMPTIONS

- Annual revenue estimates are based on actual 2018 and 2019 AMHS revenues generated by on/off traffic for each port pair. Where there is additional through traffic (principally in the Haines/Skagway route), average revenue per vehicle from on/off traffic was applied to total through traffic to estimate potential revenue from that market.
- A vessel with capacity of 20-25 ASV would easily meet demand in the Annette Bay/Ketchikan and Seldovia routes, and therefore would at least capture revenues at past levels. Such a vessel could substantially increase service to meet future needs with an increased number of scheduled trips.
- Haines/Skagway revenue estimates are divided into on/off and through-traffic. This provides the lower and upper bounds of annual revenue, based on 2019 actual revenue for on/off traffic and estimated revenue for through traffic, based on rates paid by on/off travelers.
    - For the Haines/Skagway route, a vessel with capacity of 20-25 ASV making two round trips daily would meet on/off average daily summer demand but would not meet all potential summer demand including through traffic. On peak days, the vessel could complete three round trips in under 12 hours, at the higher speed provided by hybrid operation or with a battery bank sized for this operation. The volume of through traffic is approximately equal to the volume of on/off traffic.
    - Haines/Skagway on/off traffic is projected to increase 3% annually. All other traffic and revenues are held constant through the 10-year period of analysis.

[12] These costs differ slightly from the more recently obtained data presented in Table 12. Energy costs are estimates, highly subject to change, and sensitive to operational assumptions.

7.2.3 PRO FORMA FINANCIAL ANALYSIS RESULTS

Table 14 shows a summary of the annual operating cashflow for the three analyzed routes.

Table 14: Annual Operating Cashflow by Route for Electric Ferry

	Annette Bay/Ketchikan	Haines/ Skagway	Seldovia/ Homer
Annual Revenue	$1,174,000	$922,000	$490,000
Energy Costs	$222,000	$553,000	$374,000
All Other Vessel Operating Costs	$999,000	$1,754,000	$1,147,000
Total Annual Operating Costs	$1,221,000	$2,307,000	$1,521,000
Net Annual Cashflow	-$48,000	-$153,000	-$1,031,000

Annette Bay/Ketchikan

Analysis of estimated operating revenues and expenses for the Annette Bay/Ketchikan route indicates electric ferry service would operate on roughly break-even basis, assuming service frequency is about the same as currently offered. (The LITUYA, which now provides daily Annette Bay/Ketchikan service, generally operates on a break-even basis.) Additional ferry service, such as extending service to seven days a week, or adding another daily round-trip, would increase expenditures on energy proportionally. How labor costs would be affected has not been assessed, though those would likely increase at a greater rate. Traffic and revenue would also increase, though the magnitude of the increase is not possible to predict without further, detailed market research.

Seldovia/Homer

The Seldovia/Homer route has the lowest historical traffic volume and revenue among the three routes considered in this analysis. Implementation of daily summer service and every-other-day service in winter would represent a substantial increase in total annual voyages (there were 92 voyages between Homer and Seldovia in 2019 and 93 between Seldovia and Homer). The degree to which traffic might increase with such a significant improvement in service is unknown, but with a hypothetical 50% increase, the route would generate approximately $490,000 in annual revenues (absent that 50% increase, annual revenues would total $327,000, the amount historically generated by that route). At that level of annual revenue, operating expenditures would exceed revenues by about $1 million. [13]

Haines/Skagway

Revenue generated by ferry service on the Haines/Skagway route depends on how AMHS manages Lynn Canal service. At a minimum, revenue from on/off traffic would initially total approximately $922,000 annually. At that level of revenue, electric-ferry operating costs would exceed revenues by approximately $1.4 million. If AMHS were to configure Lynn Canal service so that a portion of through

[13] Seldovia Bay Ferry provides daily passenger-only service on the Homer/Seldovia route with a 150-passenger catamaran. It is unclear how an increase in AMHS service would affect ridership on the privately-operated Seldovia Bay Ferry.

traffic would be served on dayboat service by terminating northbound mainline in Haines, for example, or call on Skagway without a Haines stop, electric ferry revenues would increase accordingly. If all through traffic was served on the electric ferry, annual revenues would total approximately $2.15 million, and total expenses would exceed total revenue by approximately $153,000.

Haines/Skagway dayboat service does have the potential to generate increasing revenues as the market responds to more frequent and consistent service. The following table illustrates the effect of 3% annual revenue growth within the on/off market. At that rate of growth, by year 10, potential revenues would exceed expenses by $128,000, assuming operating costs have not increased.[14]

Table 15: Annual Operating Cashflow for Haines/Skagway Route

	Year 1	Year 5	Year 10
Annual Revenue			
On/Off Traffic	$922,000	$1,037,000	$1,202,000
Through Traffic	$1,232,000	$1,232,000	$1,232,000
Total Revenue	$2,154,000	$2,269,000	$2,434,000
Annual Expenditures			
Energy Costs	$553,000	$553,000	$553,000
All Other Vessel Operating Costs	$1,754,000	$1,754,000	$1,754,000
Total Annual Operating Costs	$2,307,000	$2,307,000	$2,307,000
Net Cash Flow All Potential Revenue	-$153,000	-$37,000	$128,000
Net Cash Flow On/off Revenue Only	-$1,385,000	-$1,269,000	-$1,104,000

7.3 COMMUNITY PROFILES AND POTENTIAL BENEFITS

Transportation is critical for the economic, cultural, and social well-being of communities and residents. AMHS provides important linkages between coastal communities and services in population centers. The homeport communities of the ferry will likely experience economic benefits associated with crew housing and expenditures on food and other personal expenses. The section below provides an overview of each community addressed in this study and potential benefits resulting from the electric ferry.

7.3.1 KETCHIKAN

Ketchikan's population was 13,948 in 2020, compared to 13,477 in 2010. In 2020, 19.4% of residents considered themselves Native Alaskan and 32.9% as minority. Municipal governance is provided by the City of Ketchikan, Ketchikan Gateway Borough, and the City of Saxman. Ketchikan Indian Community is the Federally recognized tribe. Ketchikan is designated as a partially disadvantaged community under the Justice40 criteria. Saxman, served through Ketchikan, is Tribal and considered disadvantaged under

[14] Increasing demand could be met in part or in whole with increased number of trips.

Justice40. Approximately 16% of Ketchikan's population is over 65. PeaceHealth hospital is the primary medical service provider. Ketchikan is connected to the road system only via AMHS.

Accessible by water and air from neighboring communities, Ketchikan is a retail, transportation, and medical hub for residents of Metlakatla and Prince of Wales Island (and to a lesser degree Hyder). The AMHS ferry terminal is located near the Ketchikan airport and hospital. Primary industries in Ketchikan are tourism, commercial fishing, and government services. The community attracts more than one million cruise passengers annually.

Ketchikan generates electricity primarily from lake hydropower sources, with diesel used to supplement hydropower during peak loads and in certain times of the year (such as in winter when water is locked in snowpack and lake levels decline).

Potential community benefits from a shore-based battery include:

- Power during peak load times in winter to reduce the use of diesel fuel.
- Auxiliary charging for tour and municipal buses, resulting in reduced emissions.
- Frequency stability when Ketchikan is isolated from power-sharing sources.
- Direct back-up power support for critical community assets, such as airport and hospital, during power outages or other crises.
- Support for future energy transition to new/green sources in the municipality or region, such as tidal or wind power.

7.3.2 METLAKATLA

Metlakatla is located approximately 16 miles south of Ketchikan on Annette Island. The population was 1,454 in 2020, up slightly from 1,405 residents in 2010. Municipal functions are administered by Metlakatla Indian Community. In 2020, the Metlakatla population was 85.7% Alaska Native and 90.2% minority. Metlakatla is classified as disadvantaged under Justice40. An estimated 16.4% of Metlakatla's population is over 65.

The island is connected to the road system only through AMHS. The ferry dock is located on the opposite side of Annette Island from the town, connected by a cross-island road. Metlakatla is the only Indian reservation in Alaska, and the reservation contains Annette Islands (marine) Reserve which supports commercial fishing. Other industries are tourism and seafood processing.

Metlakatla generates electrical hydropower from lakes and has excess power generation capability at certain times of the year. Metlakatla and Ketchikan are actively discussing a power intertie arrangement. A shore-based battery located at the ferry dock is not close enough to town for convenient auxiliary charging, however a potential community benefit is excess power storage.

7.3.3 HAINES

Haines population declined from 2,508 residents in 2010 to 2,080 in 2020. The Native Alaskan population in Haines is 15.3% of the total, and 20.3% identify at minority. Municipal services are provided by the Haines Borough. Chilkoot Indian Association provides services to tribal members in

Haines and Chilkat Indian Village serves tribal members in the nearby village of Klukwan. Haines is deemed a partially disadvantaged community according to Justice40 criteria. Klukwan, served through Haines, is Tribal and considered disadvantaged under Justice40. Approximately 16% of the population is over the age of 65. Southeast Alaska Regional Health Consortium operates the community health center.

Haines is connected to the continental road system via the Haines Highway. The ferry terminal is located 4.5 miles from downtown Haines. Primary industries are government, retail, tourism, and health care.

Haines accesses hydropower from Skagway and generates electricity from diesel locally. A shore-based battery located at the ferry terminal could be used for charging private or municipal vehicles. Additional benefits include storage of excess power generation and emergency or back-up power for the ferry terminal.

7.3.4 SKAGWAY

Skagway's population was 1,240 in 2020, up from 968 in 2010. Community services are provided by the Municipality of Skagway. Skagway Traditional Council provides services to tribal members. With an Alaska Native population of 7.8%, and minority population of 14.6%, the community is partially disadvantaged under Justice40 criteria. An estimated 13.3% of Skagway's population is over the age of 65. Limited health care is provided by municipally owned Dahl Memorial Clinic.

Skagway is connected to the continental road system via the Klondike Highway. The ferry terminal is located in downtown Skagway, adjacent to cruise ship docks and the White Pass railroad. Main industries in Skagway are government, retail, and transportation. The community attracts more than one million cruise passengers annually.

Skagway generates electricity primarily from lake hydropower sources. Depending on the sizing, control systems, and technology of the shore-based battery, additional uses of the battery include:

- Lowering the need for spinning reserve,
- Stabilizing the lake output,
- Providing peak power shifting from daytime to nighttime load, and
- Offering auxiliary vehicle quick charging to support bus electrification.

7.3.5 HOMER

Homer is located at the end of the Kenai Peninsula and is surrounded by Kachemak Bay. The population was 5,522 in 2020, up from 5,003 in 2010. The City of Homer provides municipal services. Alaska Natives are 11.6% of the population and 18.5% of residents identify as minority. Homer is not considered disadvantaged under the Justice40 criteria. Nearly 24% of residents are over 65. Primary healthcare is provided by South Peninsula Hospital.

Homer is about 220 miles south of Anchorage. Major industries include commercial fishing, charter fishing, and tourism. The ferry terminal is located approximately seven miles from town on the Homer

Spit and is co-located with the city's main harbor and other tourism infrastructure. The city intends to overhaul and expand the harbor in the next five to ten years.

Homer generates electricity from lake hydropower sources and also receives power from Chugach Electric. Community benefits from the shore-based battery include:

- Support the existing intermittent loads at the Port of Homer created by seven cranes and ice plant.
- Provide load buffering in the Port of Homer if future power demands create a need.
- Support the Homer harbor upgrade with another power source.
- Support the transition to EV vehicles if quick charging is possible.
- Support potential transition charter fishing vessels, bird tour vessels, and water taxis to electric or hybrid formats.
- Back-up power to the Homer Spit during power outages.

7.3.6 SELDOVIA

Seldovia is a community in Kachemak Bay that is tied to Homer for transportation, goods, services, and fuel. The population was 235 in 2020, down slightly from 255 in 2010. Seldovia's Native Alaskan population is about 18.3% of the population and 34.0% identify as minority. Seldovia is considered disadvantaged under the Justice40 criteria. An estimated 19.1% of Seldovia's population is over the age of 65. Basic healthcare is provided by Seldovia Village Tribe Health and Wellness.

The Seldovia Village Tribe operates a 100-passenger ferry during summer months. While small aircraft and charter boats also operate in the region, AMHS is able to transport vehicles and cargo. The ferry dock in Seldovia is fixed; only AMHS ferries with an elevator can service the community.

Seldovia receives power from Homer Electric Association and is intertied with Homer. Potential benefits of a shore-side battery include:

- Direct back-up power support for critical community assets during power outages.
- Support potential eventual conversion of the city fleet of heavy equipment.
- Back-up power for multiple community assets, such as water treatment plant, community center, the school, and the multipurpose center that houses volunteer fire and EMS services.

8. CASE STUDIES AND ADDITIONAL CONSIDERATIONS

Outside of Alaska, electric and hybrid vessels have been developed and deployed as both passenger and vehicle ferries. To inform this study, four examples are provided below with particular focus on the impacts and benefits of a low or no emission ferry or ferry system to the region or community where the ferry is located.

Case studies demonstrate the benefits of public transportation as a first or early adopter of new technology in a region. These benefits include the opportunity for synergistic development of alternative energy with local industry, utilities, and governments; the development of green infrastructure scaffolding for future adoption and expanded use by tourism, shipping, and other sectors; reduced local and global emissions; increased and quicker industry uptake of alternate fuel in the region and a ripple effect beyond the region[15]; and reduced risk from transporting fossil fuels and pollutant reduction.

Areas in **Norway** have shifted to electric ferries and with that shift came community and regional benefits that were both tangible and intangible. Electric passenger ferry service supported the Norwegian "green shift" in all transportation and maritime support sectors and drove long-term planning for electric and/or "green" maritime support (cranes, terminals, operations, shipping). A shift in public mindset accompanied the move to electric ferry service – away from "what if" to "what's next." Some practical benefits were reduced crew size on an electric ferry, increased crew competencies, increased remote technical services and monitoring, increased safety through redundancy, and reduced fuel costs and emissions[16]. The onshore battery for ferry charging buffered the power grid supply and fluctuation problems, supplied businesses and household with improved power security, and in one case stabilized the power grid for the fish processing industry on the island of Senja[17].

In **British Columbia, Canada**, hybrid-electric vessels had some clear environmental benefits, specifically reduced underwater radiated noise and vibration, protecting marine life and reduced environmental footprint and emissions. The hybrid ferries supported the broader environmental goals of the CleanBC provincial climate change plan and BCHydro 2040 Clean Power plan. The hybrid-electric ferries in British Columbia increased ferry reliability through redundancy using both a generator and battery bank. Constructing new but standardized low emission ferries created efficiencies in training, operations, and maintenance, enhanced safety through crew familiarization, offered consistent customer travel experience and ferry interchangeability.

In 2024, **Washington State** will begin to transition their ferry system to electric hybrid and eventually to all electric ferries with complete transition planned by 2040. Washington State Ferries has begun the process[18] to build up to five new ferry vessels, convert six vessels, and electrify terminals. Anticipated benefits include reduced GHG emissions of over 50% by 2040 and net zero by 2050 resulting in significantly improved air quality for local communities in the region[19]. Other anticipated benefits include reduced operating and maintenance costs and eliminating engine noise and vibration.

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[15] Seldovia Bay Ferry provides daily passenger-only service on the Homer/Seldovia route with a 150-passenger catamaran. It is unclear how an increase in AMHS service would affect ridership on the privately-operated ferry.
[16] MTU Solutions. 2021. Tomorrow's Power Grid in the Norwegian Sea. https://www.mtu-solutions.com/na/en/stories/power-generation/tomorrows-power-grid-in-the-norwegian-sea.html

[17] DNV. 2022. Maritime Forecast to 2050: Energy Transition Outlook 2022. Pg. 71
[18] Ferry system electrification | WSDOT (wa.gov)
[19] It is unknown by the author whether this could be captured as a deduction in operating costs by means of reduced / eliminated purchase of carbon offset credits.

9. CONCLUSIONS

This report concludes that there is an environmental and community benefit to adding new low/no-emissions vessels to the fleet. Utilizing a hybrid propulsion arrangement that is designed to operate entirely on battery power when servicing communities where sufficient shore power is available provides flexibility to the fleet so that the vessel may support other routes while deriving power either from low emissions diesel engines or from power systems running on sustainably produced alternative fuels. Designing for the safe application of alternative fuels adds strict design constraints and will increase cost and vessel complexity compared to a traditional diesel power plan.

The principal characteristics of a hybrid ferry supporting the identified routes as a shuttle ferry are determined to be:

Length	~198	ft
Passenger capacity	>150	
Car capacity	>20	
Installed propulsive power	3000	hp
Battery capacity	>4000	kWh
Gross registered tonnage	<100	tons
Cruise speed	10-14	kt

Most ports will need shore side battery energy storage systems to provide rapid charging to a ferry operating more than one round trip daily. If properly designed, these energy storage systems may have significant additional benefits to the community.

10. RECOMMENDATIONS

Recommended Actions:

- Move ahead with Low/No-Emission vessel and port designs.
  - Refine shoreside energy storage system sizing for expected future vessel schedules.
  - Verify notional vessel design meets AMHS' expected future demand requirements.
  - During contract design, consider performing computational fluid dynamics or tank testing of hull to decrease hull resistance and improve sea keeping capabilities specific to areas of operation.
  - Prepare site plans for each port where a shore-side charging ESS is beneficial to meet current and future charging demands. Consider:
    - Permitting difficulties;
    - Floating vs. Shoreside.
- Perform outreach to determine passenger/cargo sensitivity to transit speed to determine suitability as to whether reduced speed transit is an option for some routes.
- Investigate current practices with regards to cold ironing and research potential for procedural changes.
- Investigate the capacity of available hydro power and impacts to the community where it is expected to be the primary source for powering electric ferries. Evaluate the impact to local power costs from periods of constricted supply when diesel power plants must be utilized to supplement or replace hydro power.
- Develop benefit calculation for avoided greenhouse gas emissions due to use of electric ferry routes powered by greenhouse gas neutral-generation electricity.
- Consider increased weight of battery-electric vehicles versus internal combustion engine vehicles in design of ferry car deck and weight distribution of all new ferries
- During Low/No Emission port and BESS design, consider incorporating electric motor vehicle (National Electric Vehicle Infrastructure Program – NEVI) charging stations.
- Continue efforts to incorporate electric load sharing, also known as "peak shaving" technology with internal combustion engines on longer AMHS routes.

11. REFERENCES

[1] Elliott Bay Design Group, "AMHS Strategic Business and Operational Plan," 2017.

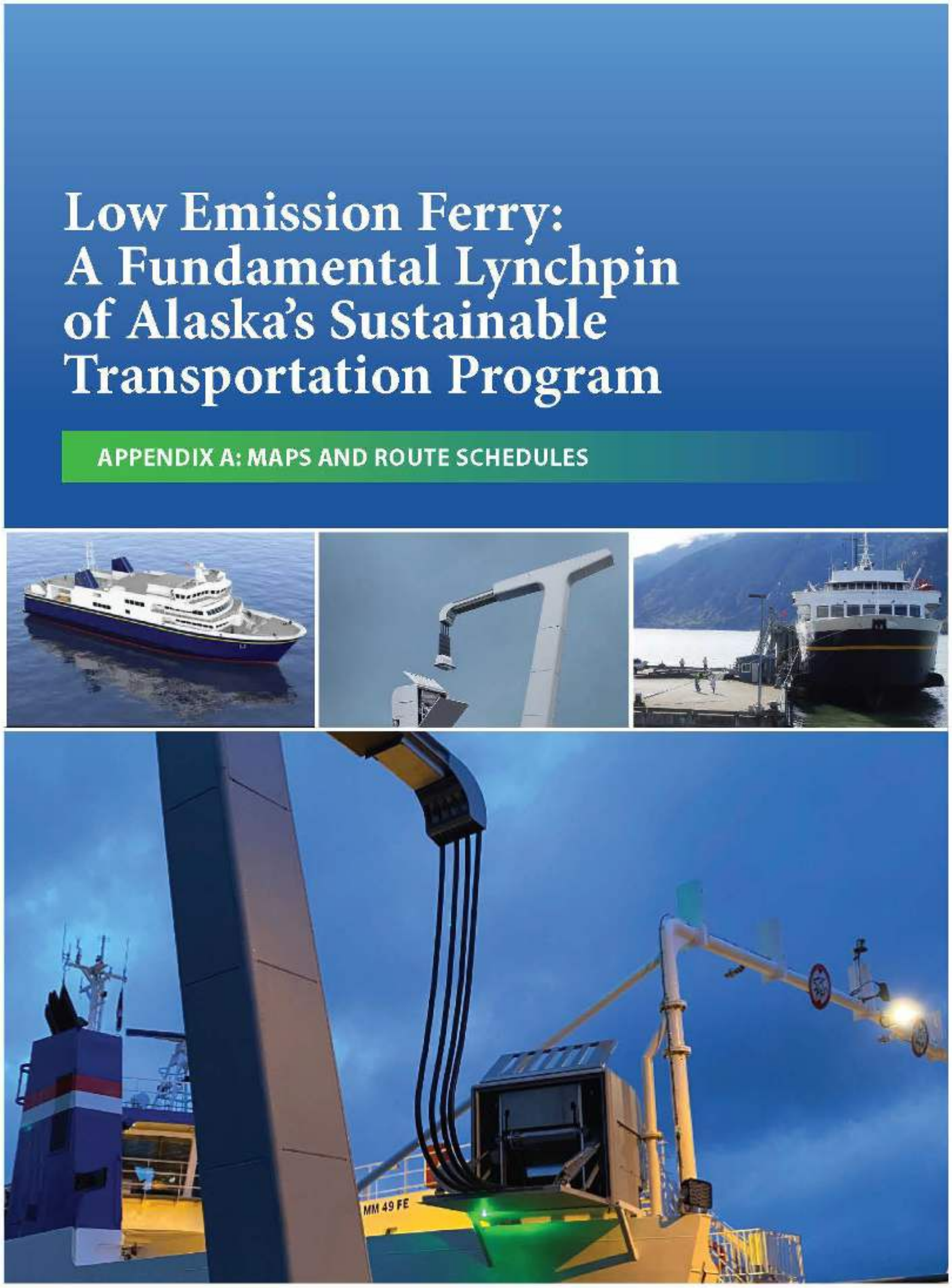
[2] "BeH2ydro," [Online]. Available: https://www.behydro.be/en/home.html. [Accessed September 2022].

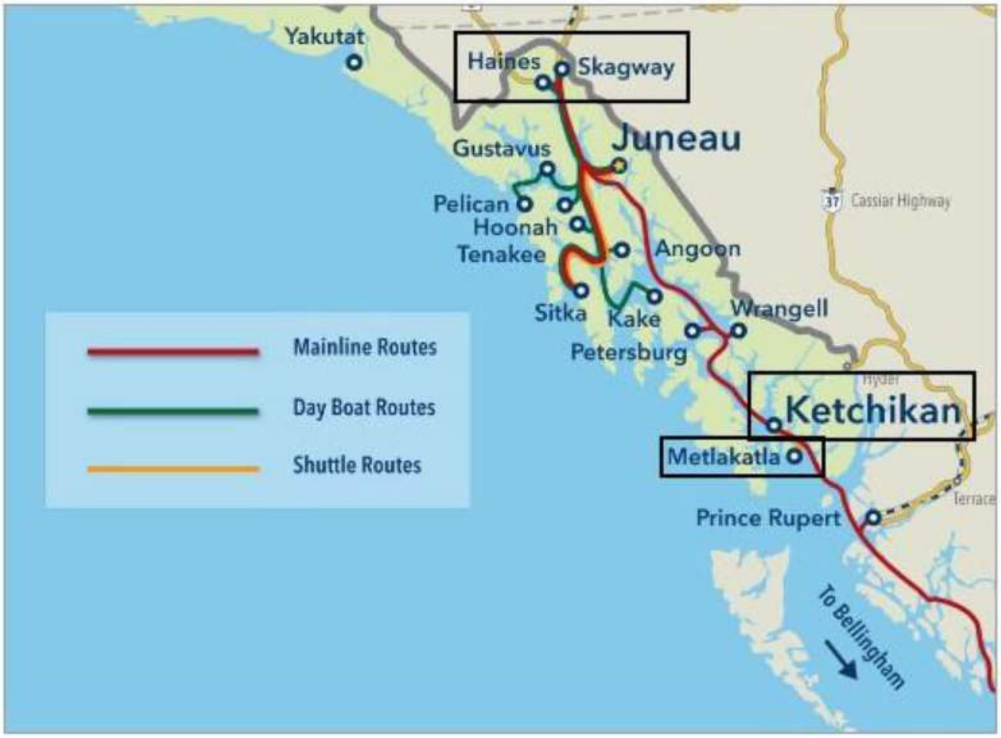
[3] Ballard, "Fuel Cell Applications for Marine Vessels," 2019.

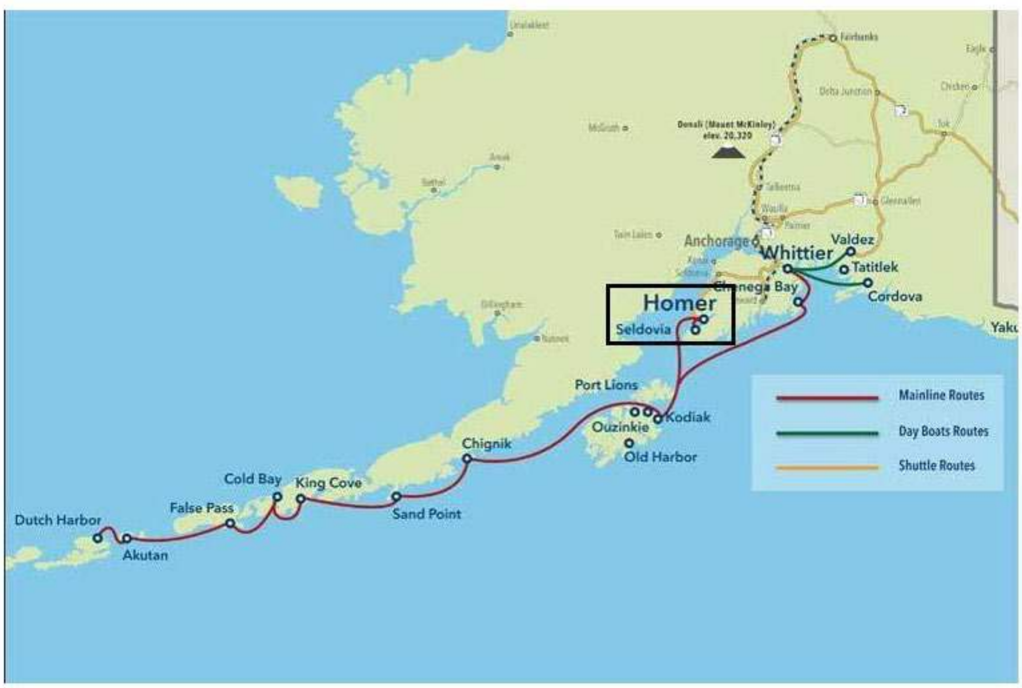
[4] W. Ayers, "Cradle to Grave Issues with Vessel Lithium-Ion Batteries," in *SNAME Maritime Conference (SMC), 2020*, Virtual Conference, September 29, 2020.

APPENDIX A

MAPS AND ROUTE SCHEDULES


Low Emission Ferry:
A Fundamental Lynchpin
of Alaska's Sustainable
Transportation Program
APPENDIX A: MAPS AND ROUTE SCHEDULES


Yakutat
Haines
Skagway
Juneau
Gustavus
Pelican
Hoonah
Tenakee
Angoon
Sitka
Kake
Wrangell
Petersburg
Cassiar Highway
Ketchikan
Metlakatla
Prince Rupert
Terrace
To Bellingham
Mainline Routes
Day Boat Routes
Shuttle Routes


Anchorage
Whittier
Valdez
Tatitlek
Chenega Bay
Cordova
Homer
Seldovia
Port Lions
Kodiak
Ouzinkie
Old Harbor
Chignik
Cold Bay
King Cove
False Pass
Sand Point
Dutch Harbor
Akutan
Mainline Routes
Day Boats Routes
Shuttle Routes


Regions
ALASKA
CANADA
Southwest
South Central
Southeast
Cross-Gulf

THE STATE of ALASKA
GOVERNOR MIKE DUNLEAVY

Department of Transportation and Public Facilities

ALASKA MARINE HIGHWAY SYSTEM
Office of the General Manager

7037 North Tongass Highway
Ketchikan, Alaska 99901-9101
Main: 907.228.7250
Fax: 907.228.6873

August 16, 2022

Dear Community Leaders and Members of the Public Interested in AMHS:

It is time to begin the public review process for the next Alaska Marine Highway System scheduling cycle. The proposed schedule patterns to be reviewed cover the winter schedule from October 01, 2022 through April 30, 2023.

The schedule patterns proposed are based on the funding levels for FY23. The operating plan has been designed to meet community service needs while staying within available funding levels, and maintaining regulatory and safety standards for the vessels.

Please take the time to review and comment on this proposed operating schedule and vessel deployment for winter 2022-2023.

AMHS is also interested in knowing about any need for special events scheduling and requests and that organizers or communities give the event name, dates, location, and arrival/departure times needed for each special event.

Please provide your written comments by August 26, 2022 to https://publicinput.com/G6532, by email at 71585@PublicInput.com, and by fax at 907-228-6873.

It is the policy of the Department of Transportation & Public Facilities (DOT & PF) that no person shall be excluded from participation in, or be denied benefits of any and all programs or activities we provide based on race, religion, color, gender, age, marital status, ability, or national origin, regardless of the funding source including Federal Transit Administration, Federal Aviation Administration, Federal Highway Administration and State of Alaska Funds.

The State of Alaska Department of Transportation & Public Facilities (DOT & PF) complies with Title II of the Americans with Disabilities Act of 1990. Individuals with disabilities who may need auxiliary aids, services, and/or special modifications to comment should contact AMHS Operations Manager, Captain Tony Karvelas at (907) 228-7252 or email at anthony.karvelas@alaska.gov no later than August 21, 2022 to make any necessary arrangements.

"Keep Alaska Moving through service and infrastructure."

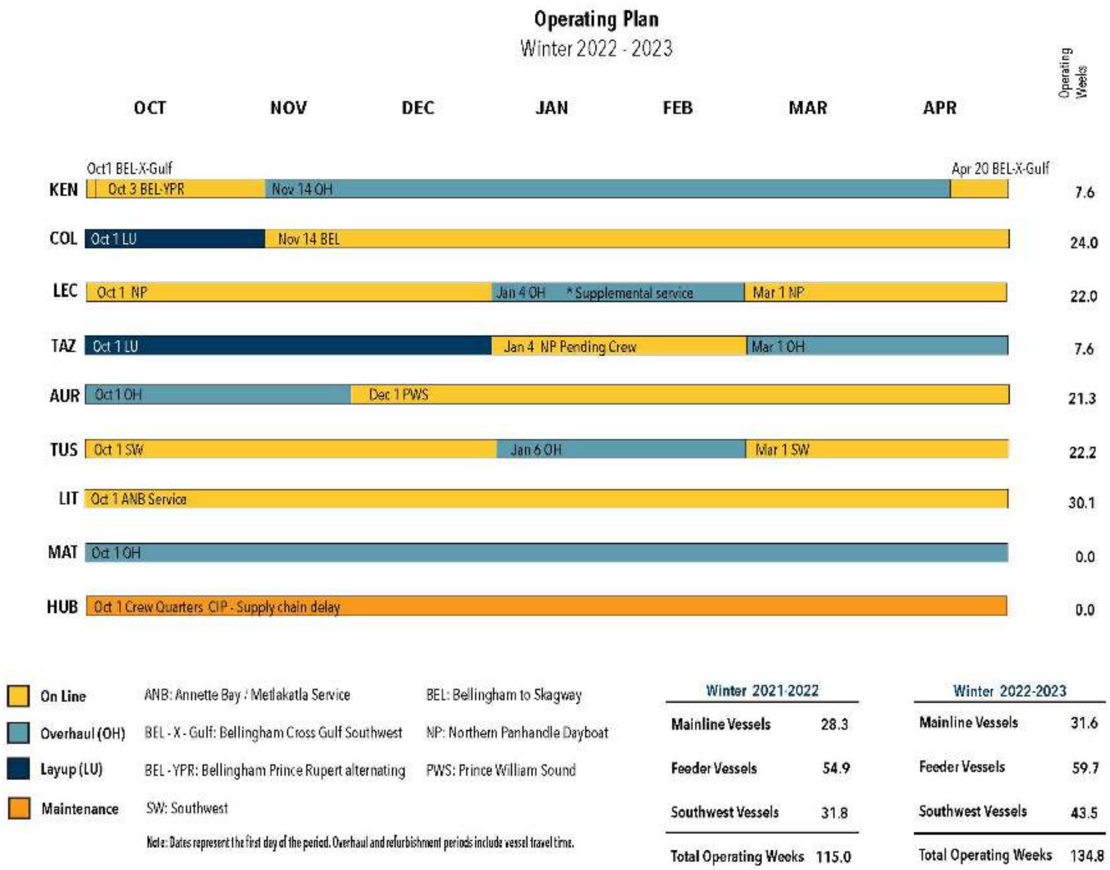
If you have any additional questions or need additional information, please contact the AMHS Business Development Manager, Matt McLaren, at (907) 228-7274.

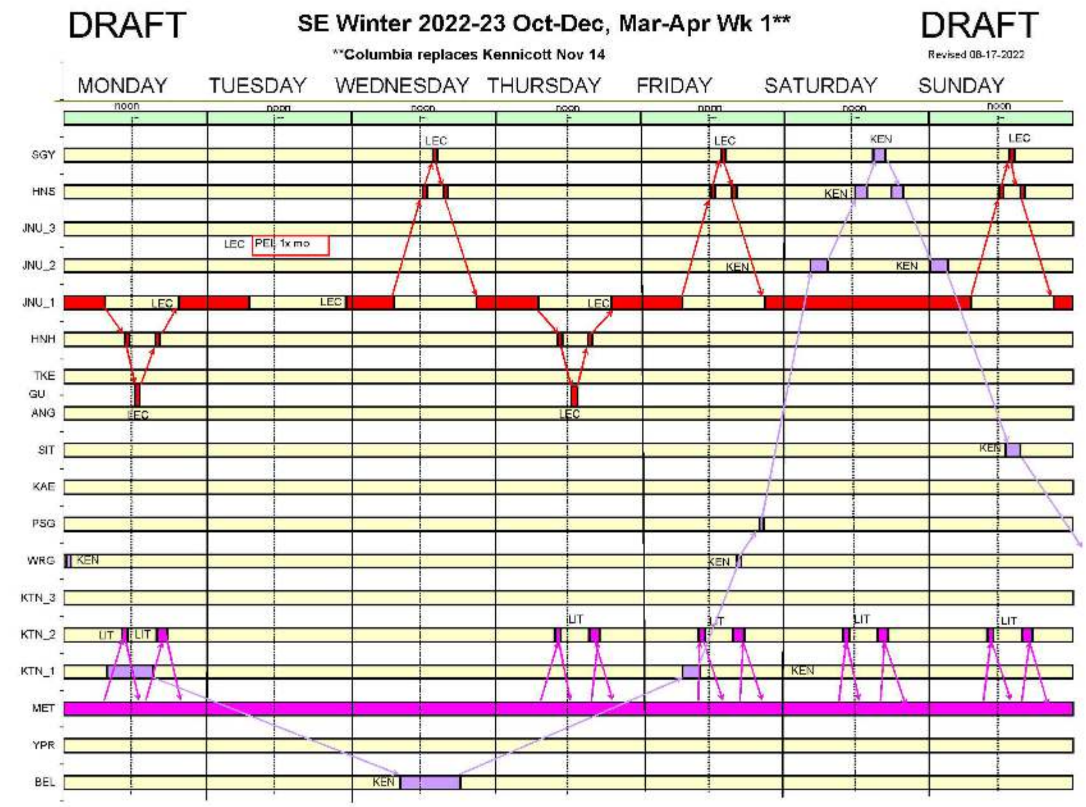
Sincerely,

Captain John F. Falvey, Jr.
General Manager Alaska Marine Highway

ENCLOSURES:
- FY 2022-2023 Winter Operating Plan
- Calendars of Events
- FY 2022-2023 Vessel Deployment Plan

DISTRIBUTION:
- All Southeast Alaska Mayors
- All Southcentral Alaska Mayors
- All Southwest Alaska Mayors
- Alaska Travel Industry Association
- ARDORS
- Commercial Shipping Companies
- CVBs
- DOT/PF Southeast Regional Director
- Marine Transportation Advisory Board
- Managers, AMHS Terminals
- Masters, AMHS Vessels
- Unions
  - IBU
  - MM&P
  - MEBA
- Tlingit & Haida Central Council
- S.E. Alaska Tribal Government Advisory Committee


Operating Plan
Winter 2022 - 2023
Operating Weeks
OCT
NOV
DEC
JAN
FEB
MAR
APR
Oct1 BEL-X-Gulf
KEN
Oct 3 BEL-YPR
Nov 14 OH
Apr 20 BEL-X-Gulf
7.6
COL
Oct 1 LU
Nov 14 BEL
24.0
LEC
Oct 1 NP
Jan 4 OH
* Supplemental service
Mar 1 NP
22.0
TAZ
Oct 1 LU
Jan 4 NP Pending Crew
Mar 1 OH
7.6
AUR
Oct 1 OH
Dec 1 PWS
21.3
TUS
Oct 1 SW
Jan 6 OH
Mar 1 SW
22.2
LIT
Oct 1 ANB Service
30.1
MAT
Oct 1 OH
0.0
HUB
Oct 1 Crew Quarters CIP - Supply chain delay
0.0
On Line
Overhaul (OH)
Layup (LU)
Maintenance
ANB: Annette Bay / Metlakatla Service
BEL - X - Gulf: Bellingham Cross Gulf Southwest
BEL - YPR: Bellingham Prince Rupert alternating
SW: Southwest
BEL: Bellingham to Skagway
NP: Northern Panhandle Dayboat
PWS: Prince William Sound
Note: Dates represent the first day of the period. Overhaul and refurbishment periods include vessel travel time.
Winter 2021-2022
Mainline Vessels 28.3
Feeder Vessels 54.9
Southwest Vessels 31.8
Total Operating Weeks 115.0
Winter 2022-2023
Mainline Vessels 31.6
Feeder Vessels 59.7
Southwest Vessels 43.5
Total Operating Weeks 134.8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**Columbia replaces Kennicott Nov 14
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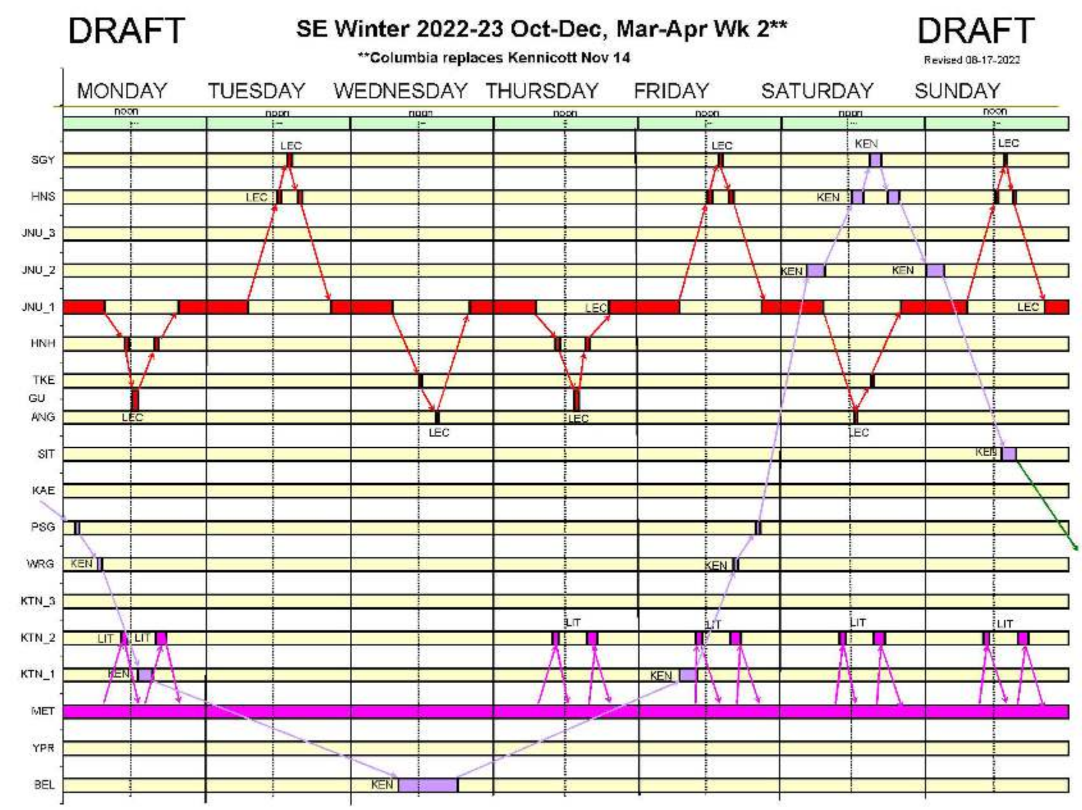
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**Columbia replaces Kennicott Nov 14
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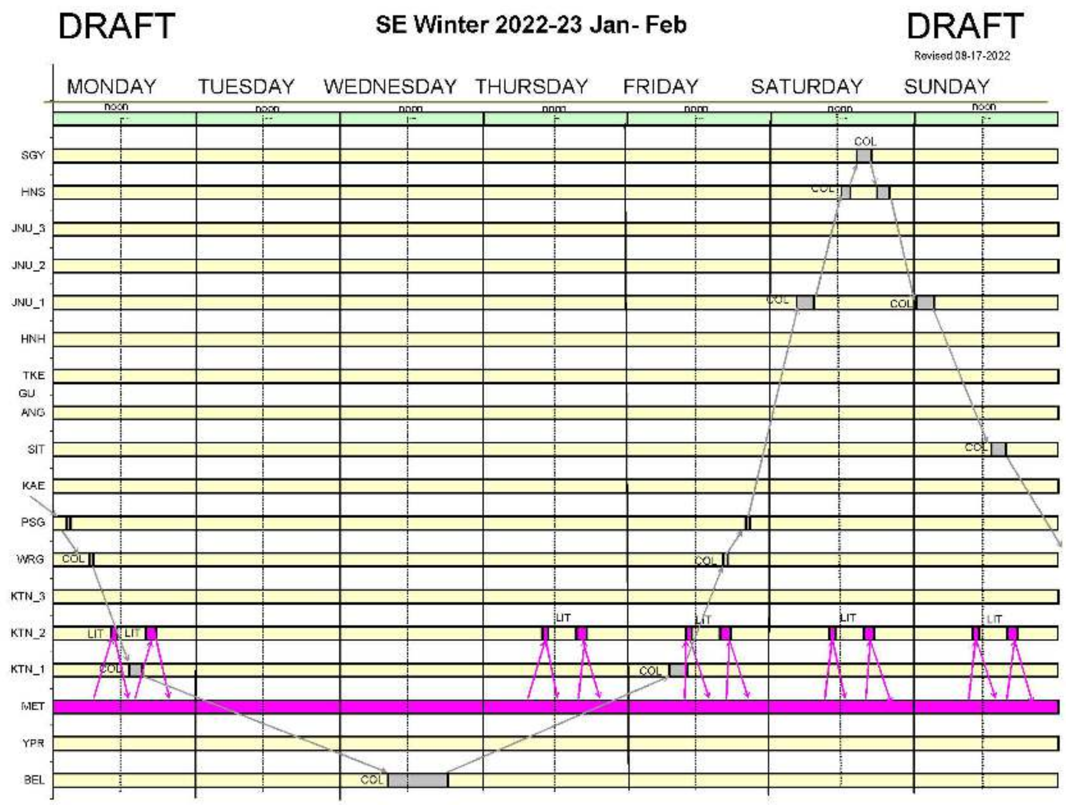
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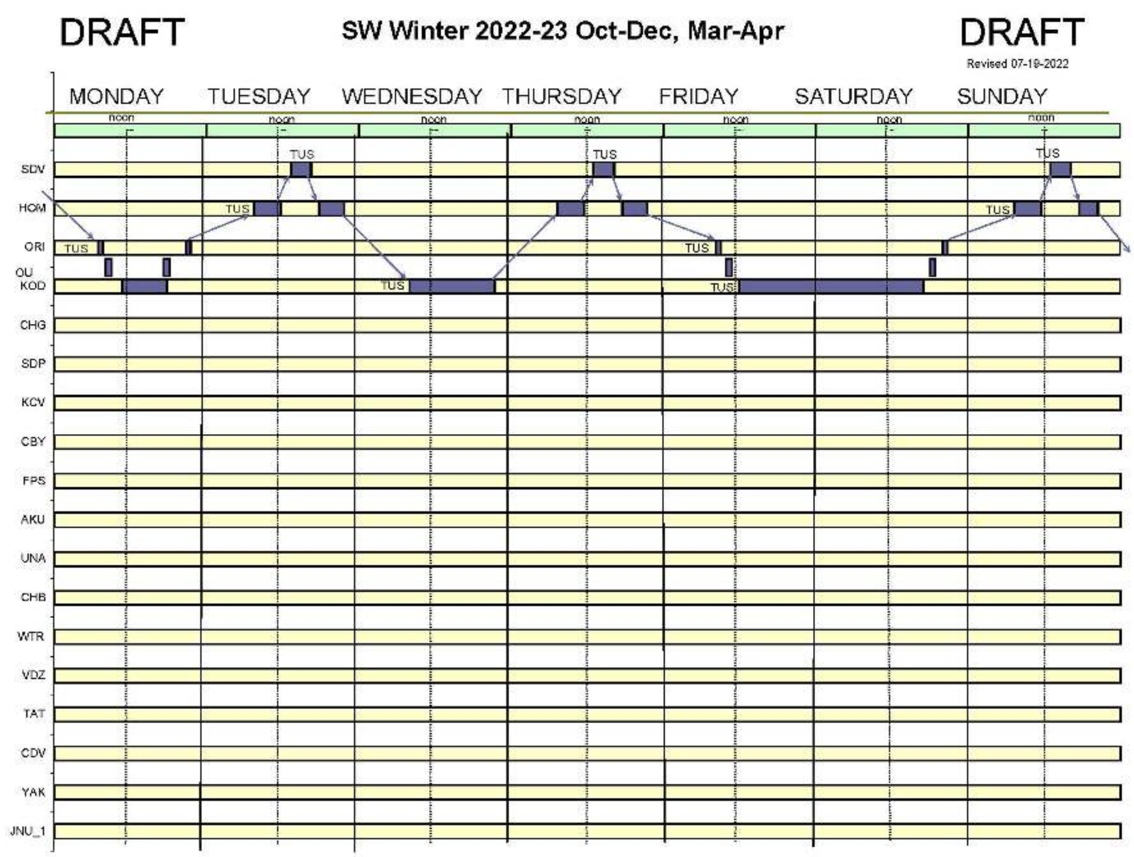
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SW Winter 2022-23 Oct-Dec, Mar-Apr
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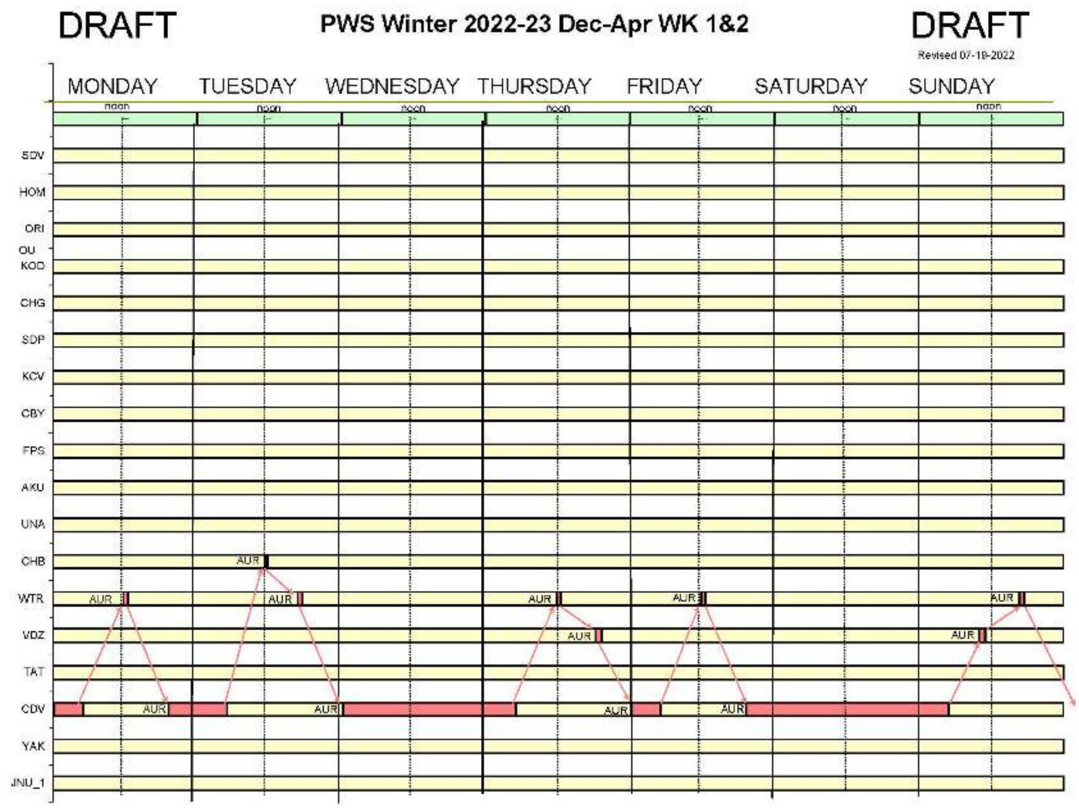
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PWS Winter 2022-23 Dec-Apr WK 1&2
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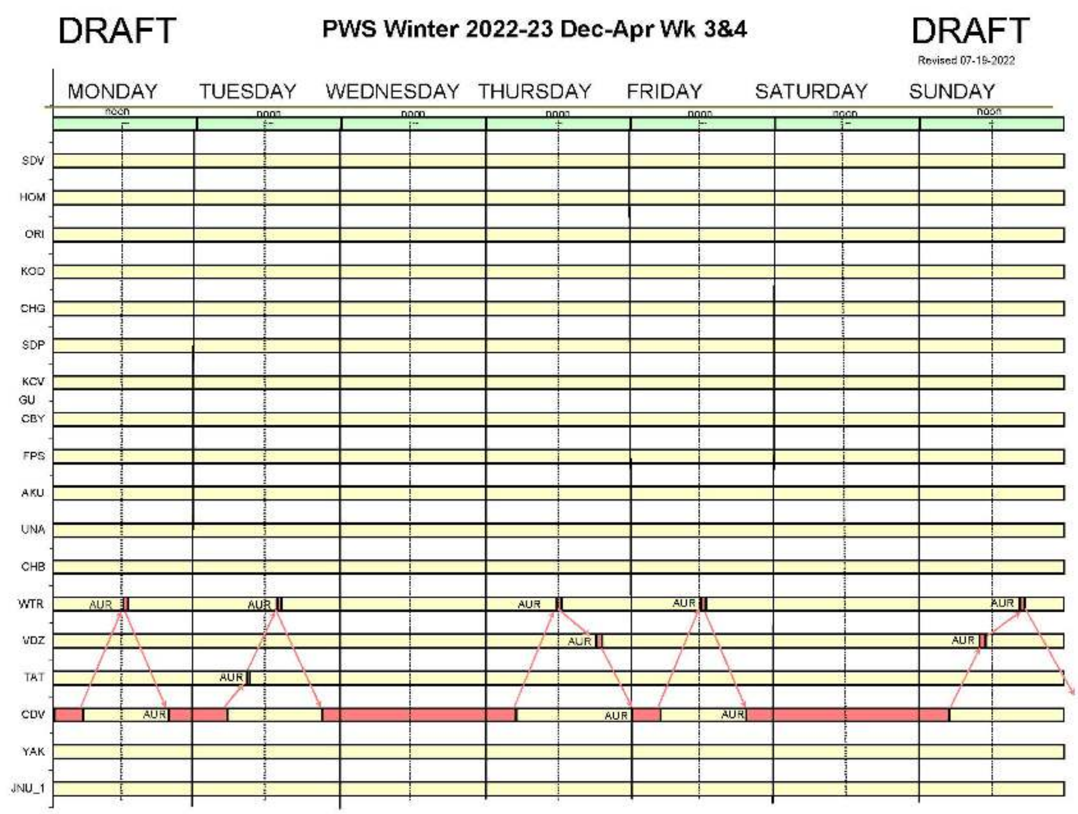
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2022-2023 F/W/S SOUTHEAST COMMUNITY EVENTS

rev 7-22-22

OCTOBER			
	ANB/ANS Grand Camp Convention		
	Octoberfest Celebration		
	Alaska Day Celebration	**SIT**	
	Annual Bridge Club Tournament		
	Region V Honor Festival		
	Region V Swim/Dive		
NOVEMBER			
	All Native BB		
	Bald Eagle Festival	**HNS**	Nov 11-14
	Whale Fest	**SIT**	Nov 3-6
	Volleyball 2A		
	Volleyball 3A/		
	Volleyball 4A		
DECEMBER			
	Victorian Yuletide Celebration	**SGY**	
	Wrestling 1A 2A/3A/4A		
	Clarke Cochrane Christmas Classic	**KTN**	
JANUARY			
	Legislature Reconvenes	**JNU**	
	Alcan 200 Snowmachine Race	**HNS**	
	Edgecumbe Invitational	**SIT**	
FEBRUARY			
	Dick Hotch Basketball Tourney	**HNS**	
	Sitka Jazz Fest	**SIT**	
	1A Basketball Tourney		
	All Native BB	**YPR**	
MARCH			
	2A/3A/4A Basketball Tourney	**JNU**	Mar 8-12
	Buckwheat Ski Classic	**SGY**	
	Gold Medal Basketball Tourney	**JNU**	
	Spring Break Smithers	**YPR**	
APRIL			
	Alaska State Folk Festival	**JNU**	Apr 10-16
	High School Music Festival	**KTN**	Apr-13-15
	Stikine River Birding Festival	**WRG**	
	Art Festival		
	Legislature session ends	**JNU**	

Please review the above Community Calendar of Events and comment on any events that are missed for your community. Schedule patterns may be changed if warranted to be able to provide service to/from the events.

2022-2023 F/W/S SOUTHWEST COMMUNITY EVENTS

rev7-22-22

OCTOBER

	Valdez Museum Road House Dinnner	**VDZ**
	Kachemak Heritage Land Trust Auction	**HOM**

NOVEMBER

	Sobriety Celebration	**CDV**

DECEMBER

	Nutcracker Faire	**HOM**

JANUARY

	Legislature Reconvenes	**JNU**
	Iceworm Festival	**CDV**

FEBRUARY

MARCH

APRIL

Please review the above Community Calendar of Events and comment on any events that are missed for your community. Schedule patterns may be changed if warranted to be able to provide service to/from the events.

Alaska Highway System
Winter 2022-23 Vessel Deployment Plan
August 10, 2022

Vessel Deployment – Winter 2022-2023

- Kennicott will sail Bellingham route October, enter overhaul November through April.
- Columbia will sail the Bellingham route November through April.
- Matanuska be in overhaul October to mid-April.
- Lituya will sail between Annette Bay and Ketchikan
- LeConte will sail Northern Panhandle October to early January, will enter overhaul and pick up the Northern Panhandle route in March.
- Tustumena will sail the Southwest route October to early January, entering overhaul until the end of February, resuming SW service in March.
- Aurora will be in overhaul October-November and will then sail PWS December to April.

Service Gaps

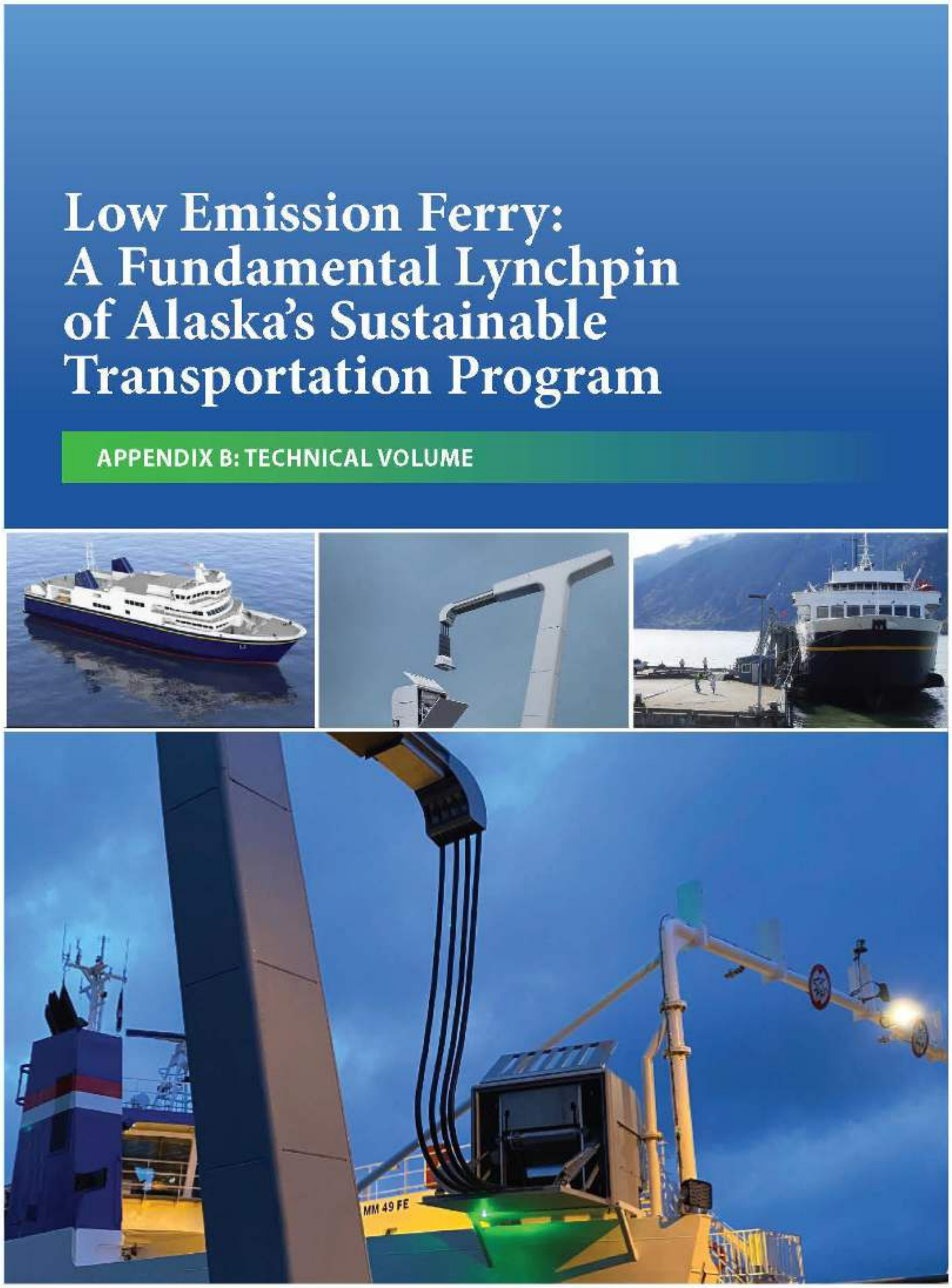
• Southwest	Jan 06 to Feb 28
• Northern Panhandle	Jan 04 to Mar 01
• PWS	Oct 01 to Nov 30

Alaska
in perspective

Alaska is the largest U.S. state consisting of 586,412 square miles of land and 6,604 miles of coastline. If you include Alaska's islands that brings the total to 33,904 miles of shoreline. The Alaska Marine Highway services an extensive 3,500-mile route. That's farther than the drive from Key West, Florida to Seattle, Washington!

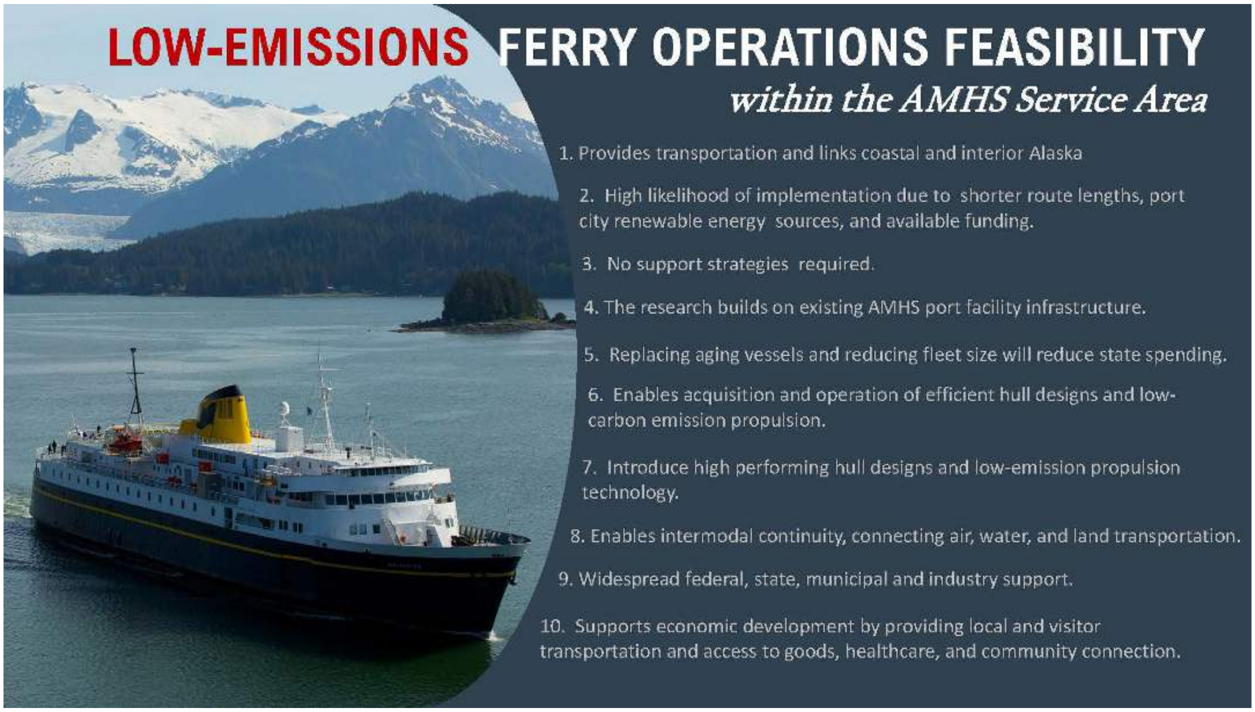
APPENDIX B

TECHNICAL VOLUME



Low Emission Ferry: A Fundamental Lynchpin of Alaska's Sustainable Transportation Program

APPENDIX B: TECHNICAL VOLUME


LOW-EMISSIONS FERRY OPERATIONS FEASIBILITY
within the AMHS Service Area
1. Provides transportation and links coastal and interior Alaska
2. High likelihood of implementation due to shorter route lengths, port city renewable energy sources, and available funding.
3. No support strategies required.
4. The research builds on existing AMHS port facility infrastructure.
5. Replacing aging vessels and reducing fleet size will reduce state spending.
6. Enables acquisition and operation of efficient hull designs and low-carbon emission propulsion.
7. Introduce high performing hull designs and low-emission propulsion technology.
8. Enables intermodal continuity, connecting air, water, and land transportation.
9. Widespread federal, state, municipal and industry support.
10. Supports economic development by providing local and visitor transportation and access to goods, healthcare, and community connection.

Department of Transportation and Public Facilities Alaska Marine Highway System 8/26/2022

AMHS Maritime Emission Regulation Risk Assessment Brief

A number of global and national policies, including IMO emissions regulations and the Bipartisan Infrastructure Bill (IIJA-BIL) guidance, have merged to create the need for increased vessel monitoring, data collection, and deployment of low-emission technologies in our public maritime sector. MARPOL[1] is the main international agreement covering all types of pollution from ships. MARPOL was developed through the International Maritime Organization (IMO), a United Nations agency that deals with maritime safety and security, as well as the prevention of marine pollution from ships which is specifically addressed in Annex VI of the MARPOL treaty which addresses air pollution from ocean-going ships. It was implemented in the US[2] and establishes limits on nitrogen oxides (NO_X) emissions and requires the use of fuel with lower sulfur content.

MARPOL requires that the maritime industry, including AMHS, track and report on greenhouse gas (GHG) related metrics such as the Carbon Intensity Indicator (CII) beginning January 1st, 2023. Some existing AMHS vessels are required to calculate an Energy Efficiency Existing Ship Index and seek improvements. New vessels also are required to reduce emissions where possible by establishing an Energy Efficiency Design Index (EEDI) and maintaining an annually updated Ship Energy Efficiency Management Plan (SEEMP).

Simultaneously, FY22-FY27 IIJA-BIL offers a major investment, over $1.25 billion, in our national maritime transportation sector. The USDOT/FTA ferry funds enable the modernization of AMHS through the implementation of its five-year capital program, which includes a number of retrofits, new vessels, and a low-no electric shuttle ferry. The Rural Ferry Program has clear investment strategies and is looking for projects that (1) renew our transit systems; (2) reduce greenhouse gas emissions from public transportation; (3) advance racial equity; (4) maintain and create good-paying jobs with a free and fair choice to join a union; and (5) connect communities. Additional considerations are given to projects that address (1) Climate Change; (2) Environmental Justice; (3) Racial Equity and Barriers to Opportunity; (4) Creating Good-Paying Jobs; and are (5) Low or Zero-Emission.

Recommendation: Due to current and pending regulations pertaining to emissions, the old way of constructing ships needs to be replaced with present-day technologies deployed in a way that serves Alaska. AMHS capital improvement projects need to include methods of reducing both the EEXI and CII, and new builds must meet 2030 EEDI requirements and be future-ready. Numerous actions must be taken by 1/1/23.

Summary Recommendations

Matanuska, Kennicott, Tazlina, Hubbard, and Columbia.

(1) Complete SEEMPs and calculate/track CII for Matanuska, Kennicott, Tazlina, Hubbard, and Columbia.
(2) Reduce vessel CIIs and track improvements.
(3) Calculate the baseline EEXI for all vessels*.
(4) Reduce EEXI through retrofitting clean technologies, such as batteries, waste heat recovery systems, air lubrication technology, and/or engine power limitation (reducing speed by 20%). *

*Not required by regulation for Tazlina and Hubbard

TRV, MRV, and Low-No Electric Shuttle

(1) Construct new vessels with clean technologies able to reduce the CII and EEDI.
(2) New builds need to meet 2030 EEDI requirements.

[1] the International Convention for the Prevention of Pollution from Ships
[22] through the Act to Prevent Pollution from Ships, 33 U.S.C. §§ 1901-1905 (APPS)

1

Draft and Deliberative Brief: Katherine.keith@alaska.gov

Department of Transportation and Public Facilities Alaska Marine Highway System 8/26/2022

Energy Efficiency Existing Ship Index (EEXI) & Energy Efficient Design Index (EEDI)

Who	>400 GT vessels engaged in international voyages (Matanuska, Kennicott, Columbia, Tustumena)
What	EEXI is a technical approach to emissions reduction on existing vessels. The EEXI is a one-time certification equivalent to the EEDI (Energy Efficiency Design Index).
Why	MARPOL Goal: GHG zero emissions at the earliest possible time in this century
When	The amendments to MARPOL ANNEX VI will take effect on 11/1/2022. EEXI requirements will start from 1/1/2023. Existing vessels: First annual, intermediate, or renewal survey of the International Air Pollution Certificate (IAPP Certificate) New Builds: Initial survey of the International Energy Efficiency Certificate (IEE Certificate).
Action	• AMHS needs to calculate EEXI for all vessels. • Reduce EEXI beginning with Matanuska, Kennicott, Columbia, Tustumena and extending fleet wide. Include retrofitting clean technologies, such as batteries, waste heat recovery systems, air lubrication technology, wind-assisted propulsion, or using low or zero-carbon fuels. The impact these solutions have on improving energy efficiency may not be enough on their own to comply with EEXI; therefore, some engine power limitation (reducing speed by 20%) is likely to be required in most cases. • New builds need to meet with EEDI requirements.

Concept formula

$$\text{EEXI [g/ton·mile]} = \frac{CO_2 \text{ Conversion factor} \times \text{SFC [g/kW·h]} \times \text{Engine Power [kW]}}{\text{Capacity [ton]} \times \text{EEXI Speed [knots]}}$$

CO_2 emissions (gram) from a ship when ship sail transport 1 (ton) cargo for 1 (nautical mile)

CO_2 Conversion factor (C_F)	C_F corresponds to the fuel used when determining SFC (DM grade: 3.206)
SFC	Fuel consumption at 75%MCR (M/E), at 50%MCR (A/E)
Engine Power	75% of the rated installed power (MCR) (In case of EPL, 83%MCR_{lim})
Capacity	Deadweight (For containerships, 70% of the deadweight)
EEXI Speed (V_{ref})	Ship speed at 75%MCR under the draught condition corresponding to the capacity

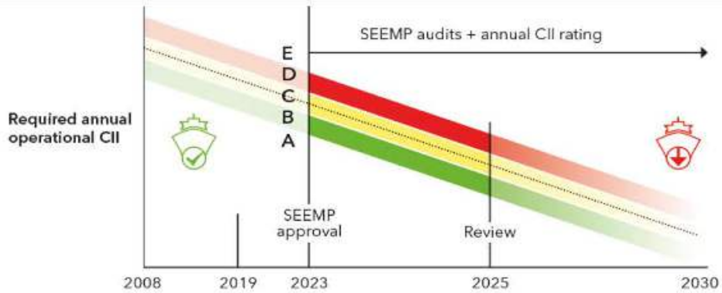
7

2

Draft and Deliberative Brief: Katherine.keith@alaska.gov

Department of Transportation and Public Facilities |Alaska Marine Highway System 8/26/2022

Carbon Intensity Indicator (CII)

Who	>5,000 GT of the following ship types: bulk carriers, gas carriers, tankers, container ships, general cargo ships, refrigerated cargo carriers, combination carriers, LNG carriers, vehicle carriers, Ro-Ro cargo vessels, Ro-Ro passenger vessels, and cruise ships. (Matanuska, Kennicott, Tazlina, Hubbard, Columbia, TRV, MRV)*
What	CII is an operational indicator measure of how efficiently a ship transports goods or passengers and is given in grams of CO2 emitted per cargo-carrying capacity and nautical mile. The ship is then given an annual rating ranging from A to E,  whereby the rating thresholds will become increasingly stringent towards 2030. For ships that achieve a D rating for three consecutive years or an E rating in a single year, a corrective action plan needs to be developed as part of the SEEMP and approved. **Calculation of annual CII:** 
Why	MARPOL Goal: GHG zero emissions at earliest in this century
When	Recording of data for Carbon Intensity Indicator (CII) will become mandatory starting the beginning of 2023 with reporting beginning on April 1, 2024. rating thresholds will become increasingly stringent towards 2030.
Actio n	Calculate and track CII For Matanuska, Kennicott, Tazlina, Hubbard, and Columbia. Construct new vessels with technologies able to reduce the CII. A vessel can reduce its carbon intensity by a combination of measures: Speed reduction, Optimization of operations and logistics, implementation of energy efficiency technologies, or use of alternative fuels
*Efforts are underway by regulators to reduce this to 400GT.	
The CII, which was developed for long-haul deep-sea operations, is unfair to ferry operators with a variable speed profile covering several port calls per day. An Interferry CII team is undertaking an extensive data analysis of the current regulations to provide the ferry industry's findings for an IMO review beginning immediately so revisions can be implemented in 2026.	

3

Draft and Deliberative Brief: Katherine.keith@alaska.gov

Department of Transportation and Public Facilities Alaska Marine Highway System 8/26/2022

Ship Energy Efficiency Management Plan (SEEMP)

Who	>5,000 GT - (Matanuska, Kennicott, Tazlina, Hubbard, Columbia, TRV, MRV)*
What	An enhanced SEEMP with an implementation plan for achieving the required CII needs to be approved and kept on board.
Why	The intention of the enhanced SEEMP is to ensure continuous improvement, and its implementation will be subject to company audits
When	On or before 1/1/2023, all ships above 5,000 GT need to have an approved enhanced Ship Energy Efficiency Management Plan (SEEMP), including an implementation plan on how to achieve the CII targets.
*Efforts underway by regulators to reduce this to 400GT.	
Action	Complete SEEMPs for all vessels staring with Matanuska, Kennicott, Tazlina, Hubbard, and Columbia by 1/1/23.

Cost Impact

$250 per ton of fuel. If CO_2 taxes become a reality for Alaska, this could cost AMHS $2.89m per year. The highlighted boxes in the below table indicate an item needed by 1/1/23 to remain in regulatory compliance.

	Domestic Tonnage: Gross	International Tonnage: Gross	EEXI	CII	SEEMP	Daily Fuel in Gal	Daily Fuenl in Tons	$ in fees	Cost of annual CO2 fees
			Energy Efficiency Existing Ship Index	Carbon Intensity Indicator	Efficiency Management Plan				
Columbia	3,946	13,009			n/a	8460	11.3	$ 2,827	$ 722,386
Kennicott	9,978	12,635			n/a	6752	9.0	$ 2,257	$ 576,543
Matanuska	3,029	9,214			n/a	4800	6.4	$ 1,604	$ 409,865
MRV					n/a	?		$ -	$ -
TRV	2,174	4,529				?		$ -	$ -
Tustumena	2,174	4,529		n/a		2700	3.6	$ 902	$ 230,549
Tazlina	3,217	5,304		n/a	n/a	2597	3.5	$ 868	$ 221,754
Hubbard	3,217	5,304				2597	3.5	$ 868	$ 221,754
Aurora	1,280	3,124		n/a	n/a	2220	3.0	$ 742	$ 189,562
LeConte	1,328	3,124		n/a	n/a	2395	3.2	$ 800	$ 204,505
Lituya	97	758	n/a	n/a	n/a	1325	1.8	$ 443	$ 113,140
Shuttle			n/a	n/a					
MARPOL Annex VI and the Act To Prevent Pollution From Ships (APPS)									
					TOTAL	33846			$ 2,890,058

4

Draft and Deliberative Brief: Katherine.keith@alaska.gov

15-VEHICLE ELECTRIC FERRY
ELLIOTT BAY DESIGN GROUP

VESSEL DESCRIPTION: This 120' monohull vessel is intended to provide vehicle and passenger transportation between Skagway and Haines. The vessel is intended to be all-electric. The vessel will utilize a lithium-ion battery bank charged by shore power. The estimated contract design cost is $400 - $500 thousand, with construction cost approximately $7 - $8 million, not including any shoreside infrastructure changes for charging.

PRINCIPLE DIMENSIONS:

Length (O.A.):	120'-0"
Beam (Max):	40'-0"
Draft (DWL):	7'-0"
Depth:	13'-0"
Lightship:	345 LT
Hull Type:	Monohull, drive-through deck arrangement

PERFORMANCE CHARACTERISTICS:

Design Speed:	10 kt
Certification:	USCG Subchapter T
Route:	Skagway to Haines
Route Length:	14.5 miles
Design Sea Conditions:	Approximately 25 kts and 6 ft seas
Passenger Capacity:	100
Vehicle Capacity:	15 (Alaska Standard Vehicle – 20 ft)
CO2 Savings:	1.1 mt / trip

PROPULSION MACHINERY:

Propulsion Motors:	(2) 700 kW, Permanent Magnet
Battery Bank Capacity:	2.7 MWh
Battery Bank Weight:	NMC
Expected Battery Life:	7.5 yr (approx. 2,700 cycles)
Propellers:	(2) 4-bladed, fixed pitch
Rudders:	(2) Balanced

SHORE POWER REQUIREMENTS:

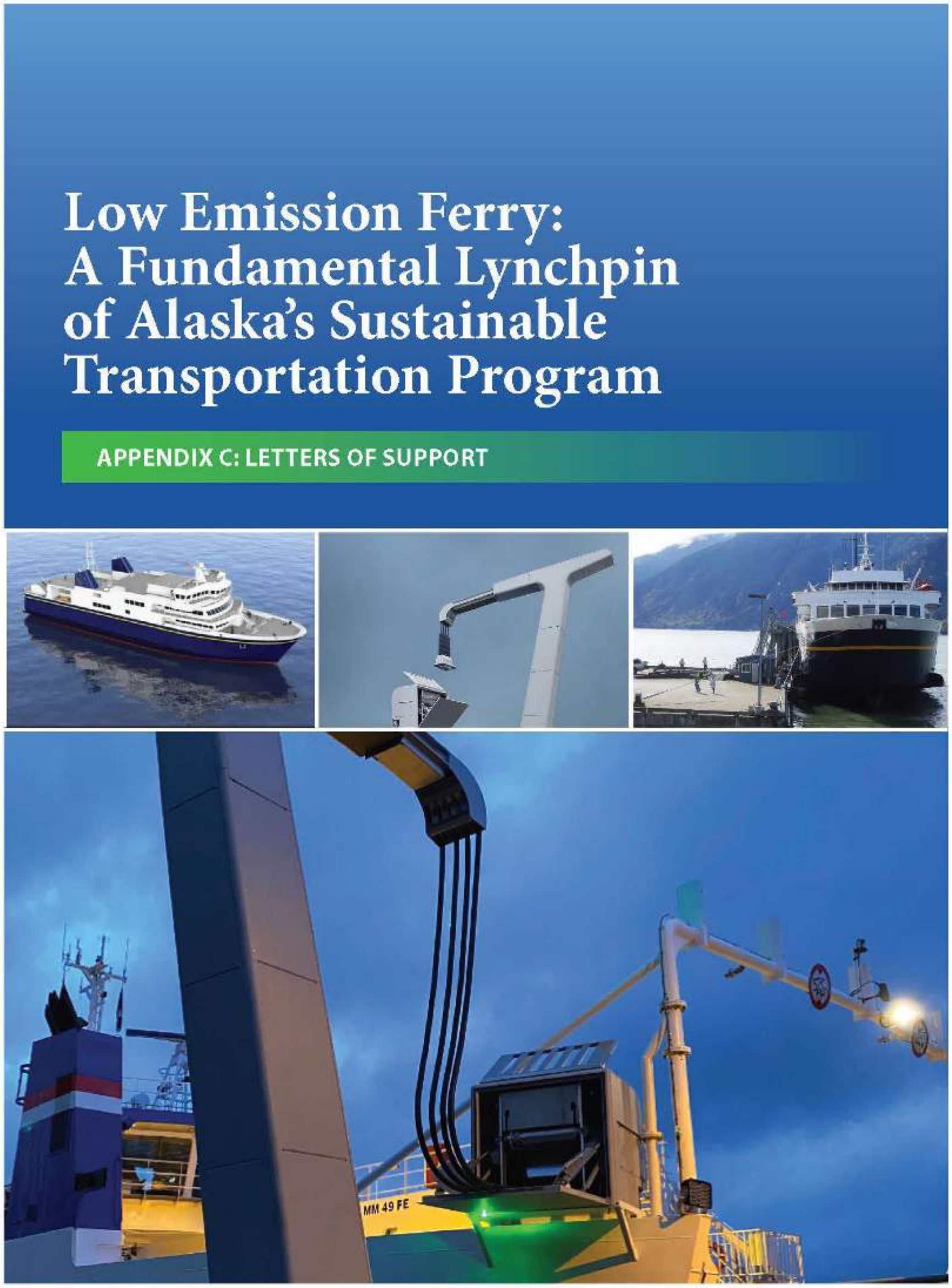
Shore Power Available:	2 MW
Approx. Charge Time:	1 hr
Round Trip Energy:	1770 kWh

NOTES:

- All charging performed at Skagway between round trips
- The hull and superstructure to be of welded steel construction utilizing a longitudinally stiffened deck
- CO2 savings based on a comparison to the efficiency of a representative diesel mechanical system and assuming all shore power for the electric version comes from renewable sources.

APPENDIX C

LETTERS OF SUPPORT


Low Emission Ferry:
A Fundamental Lynchpin
of Alaska's Sustainable
Transportation Program
APPENDIX C: LETTERS OF SUPPORT
MM 49 FE

THE STATE of ALASKA
GOVERNOR MIKE DUNLEAVY

Department of Transportation and Public Facilities

OFFICE OF THE COMMISSIONER
Ryan Anderson, Commissioner

PO Box 112500
Juneau, Alaska 99811-2500
Main: 907.465.3900
dot.alaska.gov

September 6, 2022

Electric or Low-Emitting Ferry Pilot Program
FTA-2022-007-TPM-FERRYPILOT
U.S. Department of Transportation (DOT)
Federal Transit Administration (FTA)
1200 New Jersey Avenue, SE
Washington, DC 20590

RE: Cultivating a Systems Approach to Sustainable Transportation by implementing Climate Responsive Ferry Vessel Options; Alaska DOT&PF Commitment to Non-Federal Match

To: FTA Low-No Emitting Ferry Pilot Program Review Committee

Please accept the Alaska Department of Transportation and Public Facilities (DOT&PF) submission for the U.S. Department of Transportation (DOT) FY2022 Electric or Low-Emitting Ferry Pilot Program funding opportunity under the Federal Transit Administration titled: '*Cultivating a Systems Approach to Sustainable Transportation by implementing Climate Responsive Ferry Vessel Options.*'

DOT&PF is the State Transportation Agency that plans, designs, constructs, maintains, and operates transportation infrastructure. The Alaska Marine Highway System (AMHS), a division of DOT&PF, provides safety, access, mobility, and equity for disadvantaged coastal Alaskan communities. DOT&PF has a long history of investing in multiple State and federal funding sources to ensure the AMHS can sustainably provide necessary and critical services. Unique in the nation, Alaska's ferry system is a critical link in Alaska's transportation landscape; it ties together ports, towns, and cities from Southeast, Southcentral to Southwest Alaska, with more than 3,500 miles of navigable waterway routes. Their service affects the lives and livelihoods of many Alaskans and many Justice40 areas.

DOT&PF's draft Long Range Term Plan "Alaska Moves 2050" drives strategic goals for the DOT&PF family of plans and includes investment programs for safety, state-of-good-repair, economic vitality, resiliency, sustainability, and mobility. DOT&PF'S Sustainable Transportation Program aims to help communities thrive through transportation investments that promote independence, efficiency, low-cost transportation, and a healthy environment. Developing sustainable transportation infrastructure involves a multi-modal lifecycle approach that considers environmental quality, economic development, and social equity.

DOT&PF has completed extensive research to arrive at vessel solutions that reduce fuel consumption and are scalable to reduce emissions entirely. Targeted to support Alaska

"Keep Alaska Moving through service and infrastructure."

communities within thirty miles of each other, a shuttle ferry can demonstrate a decarbonized solution for this essential form of transportation in varied Alaska weather, sea states, and routes.

DOT&PF requests $46,214,008 in federal funds to construct an electric ferry to improve and sustain essential transportation services to rural port communities, demonstrate innovative approaches that increase efficiency, decrease emissions, promote transportation sustainability, and increase grid resilience while improving the overall sustainability of Alaska's ferry system. The total project cost is $57,767,510, and the State of Alaska commits to providing the non-federal match of $11,553,502, or 20 percent of the total eligible project cost.

The Alaska Marine Highway is vital to the health of Alaska. The FY2022 Ferry Service for Rural Communities Program is essential to the DOT&PF mission of "Keeping Alaska Moving." This specific grant application, along with others submitted under theFY2022 program, is a first step in a five-year vision that will rebuild AMHS to ensure service for future generations of Alaskans. While we were anticipating that the Ferry Service for Rural Communities Program would be less restrictive, we look forward to this opportunity. I strongly support this project and urge your full and fair consideration of this proposal for the Ferry Service for Rural Communities Program.

Sincerely,

Ryan Anderson, P.E.
Commissioner

"Keep Alaska Moving through service and infrastructure."

ALEUTIANS EAST BOROUGH

August 30, 2022

Federal Highway Administration
U.S. Department of Transportation
1200 New Jersey Ave., SE.
Washington, DC 20590

Re: Letter of Support for State of Alaska's DOT&PF Applications for the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs

To the Honorable Pete Buttigieg,

Please accept this letter of support for the grant applications submitted by the State of Alaska Department of Transportation and Public Facilities to the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs. These projects will support the Alaska Marine Highway System (AMHS) in their efforts to provide an essential service throughout Coastal Alaska and beyond.

AMHS serves more than 30 communities covering 3,500 miles of coastline by transporting passengers, vehicles, and equipment between coastal communities. This service helps meet the social, educational, health and economic needs of Alaskans. AMHS provides year-round and seasonal scheduled ferry service throughout Southeast and Southwest Alaska, extending south to Prince Rupert, British Columbia and Bellingham, Washington. The system connects communities with each other, regional centers, and the continental road system. AMHS also provides a coastal transportation alternative between Anchorage and the "Lower 48" states versus driving the Alaska Highway.

Funding support for shoreside improvements including shoreside power, fleet modernization, and operations through the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs helps to sustain and improve an essential transportation system for Alaska, and beyond. We look forward to working with DOT&PF and the AMHS in their efforts, including discussions about installation of shore-side charging should electric ferry serve our community in the coming years.

These projects will support the Justice40 Initiative by strengthening the resiliency of a vital transportation system in the face of extreme impacts from climate change and by connecting disadvantaged rural communities to commerce, health and social services, and providing an economical way to bring food and other goods and services in. As a public transportation system, AMHS is an integral part of Alaska's highway system, reaching many rural communities that would otherwise be cut off from the rest of the state and nation. The AMHS and its ferries are a lifeline for many communities, ensuring the ability to access goods and services, and delivering necessary construction materials and freight for infrastructure improvements. Oftentimes, the

ANCHORAGE OFFICE • 3380 C Street, Ste 205 • Anchorage, AK 99503-3952 • (907)274-7555 • Fax: (907)276-7569
KING COVE OFFICE • P.O. Box 49 • King Cove, AK 99612 • (907)497-2588 • Fax: (907)497-2386
SAND POINT OFFICE • P.O. Box 349 • Sand Point, AK 99661 • (907)383-2699 • Fax: (907)383-3496

AMHS is the only alternative transportation for freight to be shipped by barge or air, which is highly weather dependent and extremely expensive. The AMHS also plays an integral role in supporting and stabilizing commerce in the maritime, tourism and fishing industries.

AMHS is vitally important to the continued well-being of the communities of the Aleutians East Borough. The Aleutians East Borough supports the grant applications submitted by the State of Alaska to the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs

Together, these projects and the support from Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs will make a true impact on the lives of Alaskans, as well as the future of Alaska's economy and environment.

Sincerely,

Alvin D. Osterback
Mayor

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SAND POINT OFFICE • P.O. Box 349 • Sand Point, AK 99661 • (907)383-2699 • Fax: (907)383-3496

City of False Pass
P.O. Box 50 ~ False Pass, Alaska 99583-0050
Telephone (907)548-2319 ~ Fax (888)433-6444

September 1, 2022

Federal Highway Administration
U.S. Department of Transportation
1200 New Jersey Ave., SE.
Washington, DC 20590

Re: Letter of Support for State of Alaska's DOT&PF Applications for the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs

To the Honorable Pete Buttigieg,

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Funding support for shoreside improvements including shoreside power, fleet modernization, and operations through the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs helps to sustain and improve an essential transportation system for Alaska, and beyond. We look forward to working with DOT&PF and the AMHS in their efforts, including discussions about installation of shore-side charging should electric ferry serve our community in the coming years.

These projects will support the Justice40 Initiative by strengthening the resiliency of a vital transportation system in the face of extreme impacts from climate change and by connecting disadvantaged rural communities to commerce, health and social services, and providing an economical way to bring food and other goods and services in. As a public transportation system, AMHS is an integral part of Alaska's highway system, reaching many rural communities that would otherwise be cut off from the rest of the state and nation. The AMHS and its ferries are a lifeline for many communities, ensuring the ability to access goods and services, and delivering necessary construction materials and freight for infrastructure improvements. Oftentimes, the AMHS is the only alternative transportation for freight to be shipped by barge or air, which is highly weather dependent and extremely expensive. The AMHS also plays an integral role in supporting and stabilizing commerce in the maritime, tourism and fishing industries.

False Pass, along with many other rural communities along the Aleutian Chain, highly depends on the Alaska Marine Highway System. We continue to rely on AMHS for freight, be it heavy equipment, auto vehicles, ATV's, trailers, commercial fishing gear and so much more. Travel by air is so expensive, that AMHS is one of the affordable options for people to visit relatives in nearby communities. We are happy to support this Program and look forward to ferry service to continue and improve in our region.

Together, these projects and the support from Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs will make a true impact on the lives of Alaskans, as well as the future of Alaska's economy and environment.

Sincerely,

Nikki Hoblet
Mayor

City of Homer
www.cityofhomer-ak.gov

Office of the City Manager
491 East Pioneer Avenue
Homer, Alaska 99603
citymanager@cityofhomer-ak.gov
(p) 907-235-8121 x2222
(f) 907-235-3148

August 30, 2022

Federal Highway Administration
U.S. Department of Transportation
1200 New Jersey Ave., SE.
Washington, DC 20590

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As the community at the end of the highway system that connects the Lower 48 to Alaska, Homer provides the launch point for the ferry to Seldovia, the Kodiak Archipelago, and the Alaska Peninsula. This point of transition from state highways to marine highways is very important to Homer, and critical to the physical health and economic resiliency of ferry connected communities.

Together, these projects and the support from Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs will make a true impact on the lives of Alaskans, as well as the future of Alaska's economy and environment.

Sincerely,

Rob Dumouchel
City Manager

Office of the Mayor and City Council
710 Mill Bay Road, Room 110, Kodiak, Alaska 99615

August 29, 2022

Federal Highway Administration
U.S. Department of Transportation
1200 New Jersey Ave., SE.
Washington, DC 20590

Re: Letter of Support for State of Alaska's DOT&PF Applications for the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs

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Telephone (907) 486-8636 / Fax (907) 486-8633
mayor@city.kodiak.ak.us

These projects will support the Justice40 Initiative by strengthening the resiliency of a vital transportation system in the face of extreme impacts from climate change and by connecting disadvantaged rural communities to commerce, health and social services, and providing an economical way to bring food and other goods and services in. As a public transportation system, AMHS is an integral part of Alaska's highway system, reaching many rural communities that would otherwise be cut off from the rest of the state and nation. The AMHS and its ferries are a lifeline for many communities, including Kodiak. The ferry system provides a way for a variety of things to happen in Kodiak including:

- Buying vehicles, building supplies, appliances from off island and transporting here.
- Large Construction projects (including DOT) use the ferry system for mobilization with materials and equipment
- Our school sports and activities rely on the ferry because the cost is almost triple to fly versus ferry transportation, and
- Lastly, the US Coast Guard transfers about 1/3 of their personnel in and off the island each summer season. The Kodiak Ferry Terminal estimates that over 75% of the folks that transfer each year use the ferry system as a part of their move.

Together, these projects and the support from Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs will make a true impact on the lives of Alaskans, as well as the future of Alaska's economy and environment.

Please contact Mike Tvenge, City Manager at 907.486.8640 or via email – mtvenge@city.kodiak.ak.us should you require additional information or have questions about the City's position on the matter.

Respectfully,
CITY OF KODIAK

Pat Branson

Pat Branson, Mayor

August 30, 2022

Federal Highway Administration
U.S. Department of Transportation
1200 New Jersey Ave., SE.
Washington, DC 20590

Re: Letter of Support for State of Alaska's DOT&PF Applications for the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs

To the Honorable Pete Buttigieg,

Please accept this letter of support for the grant applications submitted by the State of Alaska Department of Transportation and Public Facilities to the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs. These projects will support the Alaska Marine Highway System (AMHS) in their efforts to provide an essential service throughout Coastal Alaska and beyond.

AMHS serves more than 30 communities covering 3,500 miles of coastline by transporting passengers, vehicles, and equipment between coastal communities. This service helps meet the social, educational, health and economic needs of Alaskans. AMHS provides year-round and seasonal scheduled ferry service throughout Southeast and Southwest Alaska, extending south to Prince Rupert, British Columbia and Bellingham, Washington. The system connects communities with each other, regional centers, and the continental road system. AMHS also provides a coastal transportation alternative between Anchorage and the "Lower 48" states versus driving the Alaska Highway.

Funding support for shoreside improvements including shoreside power, fleet modernization, and operations through the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs helps to sustain and improve an essential transportation system for Alaska, and beyond. We look forward to working with DOT&PF and the AMHS in their efforts, including discussions about installation of shore-side charging should electric ferry serve our community in the coming years.

These projects will support the Justice40 Initiative by strengthening the resiliency of a vital transportation system in the face of extreme impacts from climate change and by connecting disadvantaged rural communities to commerce, health and social services, and providing an economical way to bring food and other goods and services in. As a public transportation system, AMHS is an integral part of Alaska's highway system, reaching many rural communities that would otherwise be cut off from the rest of the state and nation. The AMHS and its ferries are a lifeline for many communities, ensuring the ability to access goods and services, and delivering necessary construction materials and freight for infrastructure improvements. Oftentimes, the AMHS is the only alternative transportation for freight to be shipped by barge or air, which is highly weather dependent and extremely expensive. The AMHS also plays an integral role in supporting and stabilizing commerce in the maritime, tourism and fishing industries.

2841 S. Tongass •Route 2 Box 1 Ketchikan AK 99901• 907-225-4166

CITY OF Saxman

In the City of Saxman we are looking forward to connecting the only Native Reservation, Metlakatla, to the Native Village, City of Saxman with low emission electric ferries. All fuel must be barged up so the change to low emission not only effects the operation of the ferry but results in less fuel needing to be barged and handled. The decrease in emissions are exponential when you factor in not only the electric ferry decrease but the risks avoided in the transportation and handling of fossil fuels.

Together, these projects and the support from Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs will make a true impact on the lives of Alaskans, as well as the future of Alaska's economy and environment.

Sincerely,

L L Richmond

Lori Richmond, City Administrator

City of Saxman

2841 S. Tongass •Route 2 Box 1 Ketchikan AK 99901• 907-225-4166

August 29, 2022

Federal Highway Administration
U.S. Department of Transportation
1200 New Jersey Ave., SE.
Washington, DC 20590

Re: Letter of Support for State of Alaska's DOT&PF Applications for the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs

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Together, these projects and the support from Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs will make a true impact on the lives of Alaskans, as well as the future of Alaska's economy and environment.

Sincerely,

Jon Erickson

Jon Erickson EdD Yakutat City and Borough Manager

CITY & BOROUGH of YAKUTAT
P.O. Box 160
Yakutat, Alaska 99689
Phone (907) 784-3323
Fax (907) 784-3281

August 31, 2022

Federal Highway Administration
U.S. Department of Transportation
1200 New Jersey Ave., SE.
Washington, DC 20590

Re: Letter of Support for State of Alaska's DOT&PF Applications for the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs

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Together, these projects and the support from Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs will make a true impact on the lives of Alaskans, as well as the future of Alaska's economy and environment.

Sincerely,

Jon Erickson EdD Yakutat City and Borough Manager

City of Pelican

BOX 737 - PELICAN, ALASKA 99832 - PHONE: 735-2202/2203 - FAX: 735-2258 - EMAIL: cityhall@pelicancity.org - WEBSITE: www.pelican.net

August 30, 2022

EQUAL OPPORTUNITY EMPLOYER

Federal Highway Administration
U.S. Department of Transportation
1200 New Jersey Ave., SE.
Washington, DC 20590

Re: Letter of Support for State of Alaska's DOT&PF Applications for the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs

To the Honorable Pete Buttigieg,

I support the grant applications submitted by the State of Alaska Department of Transportation and Public Facilities to the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs. These projects will support the Alaska Marine Highway System (AMHS) in their efforts to provide an essential service throughout Coastal Alaska and beyond.

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Pelican, Alaska does not have barge service, we rely on the AMHS for transporting freight, food and other goods. Food security for local citizens is tied to the AMHS servicing our community. The local seafood processor relies on the AMHS to ship out their custom processed seafood products to markets. Infrastructure improvements can only happen with materials brought in by the AMHS.

Together, these projects and the support from Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs will make a true impact on the lives of Alaskans, as well as the future of Alaska's economy and environment.

Sincerely, Patricia Phillips

Patricia Phillips, Mayor

OFFICE OF THE MAYOR - PUBLIC WORKS DEPARTMENT - PELICAN HEALTH CLINIC - PELICAN VOLUNTEER FIRE DEPARTMENT

Kodiak Island Borough

Office of the Borough Mayor
710 Mill Bay Road
Kodiak, AK 99615
Phone (907) 486-9310 Fax (907) 486-9391
Email: clerks@kodiakak.us

September 1, 2022

Federal Highway Administration
U.S. Department of Transportation
1200 New Jersey Ave., SE.
Washington, DC 20590

Re: Letter of Support for State of Alaska's DOT&PF Applications for the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs

To the Honorable Pete Buttigieg,

Please accept this letter of support for the grant applications submitted by the State of Alaska Department of Transportation and Public Facilities to the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs. These projects will support the Alaska Marine Highway System (AMHS) in their efforts to provide an essential service throughout Coastal Alaska and beyond.

AMHS serves more than 30 communities covering 3,500 miles of coastline by transporting passengers, vehicles, and equipment between coastal communities. This service helps meet the social, educational, health and economic needs of Alaskans. AMHS provides year-round and seasonal scheduled ferry service throughout Southeast and Southwest Alaska, extending south to Prince Rupert, British Columbia and Bellingham, Washington. The system connects communities with each other, regional centers, and the continental road system. AMHS also provides a coastal transportation alternative between Anchorage and the "Lower 48" states versus driving the Alaska Highway.

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Letter to Federal Highway Administration
Ferry Service
Page 2 of 2
September 1, 2022

These projects will support the Justice40 Initiative by strengthening the resiliency of a vital transportation system in the face of extreme impacts from climate change and by connecting disadvantaged rural communities to commerce, health and social services, and providing an economical way to bring food and other goods and services in. As a public transportation system, AMHS is an integral part of Alaska's highway system, reaching many rural communities that would otherwise be cut off from the rest of the state and nation.

The AMHS and its ferries are a lifeline for Kodiak and other coastal communities. For the Kodiak Archipelago, AMHS is of particular importance since there is not a road system that connects with mainland Alaska. AMHS facilitates the ability to receive construction materials, freight, and new vehicles. AMHS is the only alternative transportation for freight to be shipped by barge or air, which is highly weather dependent and extremely expensive, to both the City of Kodiak and the villages located around the Kodiak Island Borough.

Each Spring and Summer, the AMHS is integral in assisting with the transportation of hundreds of active-duty US Coast Guard members and their dependents as they transfer to and from the United States' largest Coast Guard base located on Kodiak Island. Additionally, the AMHS offers an irreplaceable option for tourists visiting Alaska to bring their cars and recreational vehicles to Kodiak. During the Fall season, the Kodiak Island Borough School District depends on the AMHS to transport student athletes to and from other areas of Alaska for sporting events of all types.

Together, these projects and the support from Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs will make a true impact on the lives of Kodiak Island Borough residents, as well as the future of Alaska's economy and environment.

Sincerely,
Kodiak Island Borough

Bill Roberts, Mayor

KPEDD
KENAI PENINSULA ECONOMIC DEVELOPMENT DISTRICT

14896 Kenai Spur Highway, Suite 103-A • Kenai, AK 99611
Phone: (907) 283-3335 • Fax: (907) 283-3913
www.kpedd.org

Leadership to enhance, foster and promote economic development

August 29, 2022

Federal Highway Administration
U.S. Department of Transportation
1200 New Jersey Ave., SE.
Washington, DC 20590

Re: Letter of Support for State of Alaska's DOT&PF Applications for the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs

To the Honorable Pete Buttigieg,

Please accept this letter of support for the grant applications submitted by the State of Alaska Department of Transportation and Public Facilities to the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs. These projects will support the Alaska Marine Highway System (AMHS) in their efforts to provide an essential service throughout Coastal Alaska and beyond.

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Funding support for shoreside improvements including shoreside power, fleet modernization, and operations through the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs helps to sustain and improve an essential transportation system for Alaska, and beyond. We look forward to working with DOT&PF and the AMHS in their efforts, including discussions about installation of shore-side charging should electric ferry serve our community in the coming years.

These projects will support the Justice40 Initiative by strengthening the resiliency of a vital transportation system in the face of extreme impacts from climate change and by connecting disadvantaged rural communities to commerce, health and social services, and providing an economical way to bring food and other goods and services in. As a public transportation system, AMHS is an integral part of Alaska's highway system, reaching many rural communities that would otherwise be cut off from the rest of the state and nation. The AMHS and its ferries are a lifeline for many communities, ensuring the ability to access goods and services, and delivering necessary construction materials and

Alaska Regional Development Organization (ARDOR)
The State of Alaska Department of Commerce, Community and Economic Development certified KPEDD as an ARDOR in 1989.

Economic Development District (EDD)
The U.S. Department of Commerce, Economic Development Administration (EDA) recognized KPEDD as an Economic Development District in 1988.

freight for infrastructure improvements. Oftentimes, the AMHS is the only alternative transportation for freight to be shipped by barge or air, which is highly weather dependent and extremely expensive. The AMHS also plays an integral role in supporting and stabilizing commerce in the maritime, tourism and fishing industries.

As the Executive Director of the Kenai Peninsula Economic Development District, I cannot stress the importance of reliable transportation enough. Coastal communities are reliant on DOT infrastructure to meet basic needs such as medical access and groceries. Together, these projects and the support from Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs will make a true impact on the lives of Alaskans, as well as the future of Alaska's economy and environment. Thank you for your time and consideration.

Respectfully,

Tim Dillon
Executive Director
Kenai Peninsula Economic Development District
Tim@kpedd.org

SOUTHEAST CONFERENCE

612 W. Willoughby Ave., Suite B
P.O. Box 21989, Juneau, AK 99802
Phone (907) 586-4360
www.seconference.org
Email info@seconference.org
SOUTHEAST ALASKA REGIONAL DEVELOPMENT ORGANIZATION

August 29, 2022

Federal Highway Administration
U.S. Department of Transportation
1200 New Jersey Ave., SE.
Washington, DC 20590

Re: Letter of Support for State of Alaska's DOT&PF Applications for the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs

To the Honorable Pete Buttigieg:

Southeast Conference strongly supports the grant applications submitted by the State of Alaska Department of Transportation and Public Facilities to the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs. These projects will support the Alaska Marine Highway System (AMHS) in their efforts to provide an essential service throughout Coastal Alaska and beyond.

AMHS serves more than 30 communities covering 3,500 miles of coastline by transporting passengers, vehicles, and equipment between coastal communities. The service helps meet the social, educational, health and economic needs of Alaskans. AMHS provides year-round and seasonal scheduled ferry service throughout Southeast and Southwest Alaska, extending south to Prince Rupert, British Columbia and Bellingham, Washington. The system connects communities with each other, regional centers, and the continental road system. AMHS also provides a coastal transportation alternative between Anchorage and the "Lower 48" states versus driving the Alaska Highway.

Funding support for shoreside improvements including shoreside power, fleet modernization, and operations through the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs helps to sustain and improve an essential transportation system for Alaska, and beyond. We look forward to working with Alaska DOT&PF and the AMHS in their efforts, including discussions about installation of shore-side charging should electric ferry serve our community in the coming years.

These projects will support the Justice40 Initiative by strengthening the resiliency of a vital transportation system in the face of extreme impacts from climate change and by connecting disadvantaged rural communities to commerce, health and social services, and providing an economical way to bring food and other goods and services in. As a public transportation system, AMHS is an integral part of Alaska's highway system, reaching many rural communities that would otherwise be cut off from the rest of the state and nation. The AMHS and its ferries are a lifeline for many communities, ensuring the ability to access goods and services, and delivering necessary construction materials and freight for infrastructure improvements. Oftentimes, the AMHS is the only alternative transportation for freight to be shipped by barge or

ARDOR

air, which is highly weather dependent and extremely expensive. The AMHS also plays an integral role in supporting and stabilizing commerce in the maritime, tourism and fishing industries.

I cannot stress enough the importance of reliable transportation. Coastal communities are reliant on DOT infrastructure to meet basic needs such as medical access and groceries. Together, these projects and the support from Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs will make a true impact on the lives of Alaskans, as well as the future of Alaska's economy and environment.

Southeast Conference's origins are grounded in the establishment of the AMHS. We are proud to continue that support more than sixty years later as the AMHS works to perpetuate this iconic Alaska institution.

Thank you for your time and consideration.

Respectfully,

Robert Venables

Robert Venables
Executive Director

SWAMC
Southwest Alaska Municipal Conference
Southwest Alaska Municipal Conference
3300 Arctic Boulevard, Suite 203 Anchorage, AK 99503 p: 907.562.7380 www.swamc.org
Alaska Peninsula
Aleutian Chain
Bristol Bay
Kodiak Island
Pribilof Islands

August 30, 2022

Federal Highway Administration
U.S. Department of Transportation
1200 New Jersey Ave., SE.
Washington, DC 20590

Re: Letter of Support for State of Alaska's DOT&PF Applications for the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs

To the Honorable Pete Buttigieg,

Please accept this letter of support for the grant applications submitted by the State of Alaska Department of Transportation and Public Facilities to the Electric or Low-Emitting Ferry Pilot and Ferry Service Rural Communities Programs.

The AMHS is unique. It serves 35 mostly rural, coastal communities covering 3,500 miles of coastline by transporting passengers, vehicles, food, construction materials and heavy equipment between multiple communities un-connected by roads. This critical service helps meet the social, educational, health and economic needs of Alaskans from Ketchikan to Unalaska/Dutch Harbor. The system connects communities with each other, regional centers, and the continental road system. *The AMHS also provides an efficient year-round marine transportation alternative for thousands of active duty military personnel transiting their families between Alaska and the "Lower 48" states versus driving the seasonal and challenging Alaska Canadian Highway for days.*

Submitted projects will support the Justice40 Initiative by strengthening the resiliency of a vital transportation system by more reliably connecting disadvantaged rural communities to commerce, health and social services. The AMHS is a well-documented lifeline for many communities and plays an integral role in supporting and stabilizing commerce in the maritime, tourism and fishing industries as well.

The Southwest Alaska Municipal Conference (SWAMC) is a non-profit regional economic development organization for Southwest Alaska. SWAMC serves three subregions of Southwest Alaska: the Aleutian/Pribilofs, Bristol Bay, and Kodiak. The majority of our region is significantly dependent on a reliable, sustainable AMHS, and it's continued service is a top priority of our municipalities, tribal organizations, and seafood partners.

Sincerely,

Shirley Marquardt, Executive Director Southwest Alaska Municipal Conference

3300 Arctic Blvd. Suite 203, Anchorage Alaska 99503 smarquardt@swamc.org

Economic development and advocacy for Southwest Alaska
Economic Development District (EDD) and Alaska Regional Development Organization (ARDOR)

APPENDIX D

Route Energy and Emissions Assessment
Shoreside Utility / Battery Analysis
Notional Vessel Capital Cost Estimate
Existing Fleet Carbon Intensity Indices

ROUTE ENERGY AND EMISSIONS ASSESSMENT

Route Summary

Assumptions

1. Operation in Sea State 4. Calm weather operations may be faster.
2. 60 Minutes at each dock for charging batteries.
3. Crossing energies and battery sizes are measured between charging.
4. Hotel power assumed to be 150kW. **Hotel power provided at all docks whether or not charging.**
5. "Slow" operation assumes cruise is at 50% of "installed power", or 1500 of the assumed 3000hp onboard.
6. Shore power is assumed available to supply hotel loads for longer-term dock periods.
7. Vessel is assumed to not push the dock at ports.
8. CO2 saved reflects fuel not burned at 22.4lb CO2 produced per gallon of diesel burned. Assumes charging electricity is renewable.

			"95% MCR" Operation (Cruise Speed = 13.2kt)				Slow Operation (Cruise Speed = 9.7kt)		
Route	Distance nm	Charging	Crossing Energy kWh	Battery Size kWh	Crossing Time min	CO2 saved MT	Crossing Energy kWh	Battery Size kWh	Crossing Time min
Skagway - Haines	12.6	One Port	4262	5730	62	3.0	3274	4402	80
		Both Ports	2131	2865			1637	2201	
Ketch. - Met.	7.0	One Port	2285	3073	36	1.7	1783	2398	46
		Both Ports	1143	1536			892	1199	
Homer - Seldovia	15.6	One Port	5321	7153	76	3.7	4073	5476	99
		Both Ports	2660	3577			2037	2738	

Representative Emissions from Conventional Diesel Mechanical Vessel (kg per round trip)

Route	NO_X	CO	PM
Skagway - Haines	27	8	0.9
Ketch. - Met.	14	4	0.5
Homer - Seldovia	33	11	1.1

Skagway - Haines

SKAGWAY - HAINES **EPA TIER 4 DIESEL MECHANICAL**

Engine	Tier IV Nominal	Generator	CAT C9
Power	1100	Power	300
No Installed	2	No Installed	2
No Operating	2	No Operating	1

Operational Profile		Power Demand				Power Supply		Engine Usage			
Loading Condition	**Duration** min	**Prop. Load** kW	**Hotel Load** kW	**Other** kW	**Total** kW	**Engine Power** kW	**Generator Power** kW	**Eng. Pwr** %	**Eng. Time** min	**Gen. Pwr** %	**Gen. Time** min
Included Efficiency		DM	Gen			Eng	Gen				
Value		0.97	0.98			1.00	0.98				
Maneuvering	5	576.5	153.1		729.5	576.5	153.1	26%	5.0	51%	5.0
Cruise	51.98	2190.5	153.1		2343.6	2190.5	153.1	100%	52.0	51%	52.0
Maneuvering	5	576.5	153.1		729.5	576.5	153.1	26%	5.0	51%	5.0
Time at dock	60	0.0	153.1		153.1	0.0	153.1	0%	0.0	51%	60.0
Maneuvering	5	576.5	153.1		729.5	576.5	153.1	26%	5.0	51%	5.0
Cruise	51.98	2190.5	153.1		2343.6	2190.5	153.1	100%	52.0	51%	52.0
Maneuvering	5	576.5	153.1		729.5	576.5	153.1	26%	5.0	51%	5.0
Time at dock	60	0.0	153.1		153.1	0.0	153.1	0%	0.0	51%	60.0
								0%		0%	0.0
								0%		0%	0.0
	Trip Duration min				**Total Energy** kWh	**Eng. Energy** kWh	**Gen. Energy** kWh		**Eng. Time** hr		**Gen. Time** hr
	243.95519				4610	3987	622		124.0		244.0

			Engine Emissions				Generator Emissions			
Loading Condition	**Eng. BSFC** lb/kWh	**Gen. BSFC** lb/kWh	**NOX** g/kWh	**CO** g/kWh	**HC** g/kWh	**PM** g/kWh	**NOX** g/kWh	**CO** g/kWh	**HC** g/kWh	**PM** g/kWh
Maneuvering	0.467	0.489	2.638	0.003	0.000	0.016	4.894	1.929	0.320	0.213
Cruise	0.454	0.489	1.724	0.192	0.000	0.011	4.894	1.929	0.320	0.213
Maneuvering	0.467	0.489	2.638	0.003	0.000	0.016	4.894	1.929	0.320	0.213
Time at dock	0.474	0.489	0.000	0.000	0.000	0.000	4.894	1.929	0.320	0.213
Maneuvering	0.467	0.489	2.638	0.003	0.000	0.016	4.894	1.929	0.320	0.213
Cruise	0.454	0.489	1.724	0.192	0.000	0.011	4.894	1.929	0.320	0.213
Maneuvering	0.467	0.489	2.638	0.003	0.000	0.016	4.894	1.929	0.320	0.213
Time at dock	0.474	0.489	0.000	0.000	0.000	0.000	4.894	1.929	0.320	0.213
	0.000	0.000	0.000	0.000	0.000	0.000	5.230	13.008	4.559	0.751
	0.000	0.000	0.000	0.000	0.000	0.000	5.230	13.008	4.559	0.751
	Fuel Cons. gal	**Fuel Cons.** gal	**NOX** g	**CO** g	**HC** g	**PM** g	**NOX** g	**CO** g	**HC** g	**PM** g
	255.3	42.9	7050	728	0	46	19516	7692	1275	849

Engine Summary

Main Engine Time (hr)	2.1
Generator Time (hr)	4.1
Fuel Consumption (gal)	298.2

Emissions Summary

Nox (g)	26567
CO (g)	8421
HC (g)	1275
PM (g)	895

SKAGWAY - HAINES BATTERY ONLY OPERATION, CHARGING ONE END

Operational Profile		Power Demand					Battery Sizing	
Loading Condition	**Duration** min	**Prop. Load** kW	**Hotel Load** kW	**Total** kW	**Shore Power** kW	**Battery Power** kW	**Battery Energy** kWh	**Battery SoC** kWh
Included Efficiency		Gen	Inv		none	none	Eff_Chg	
Value		0.98	0.986		1	1	Eff_Disch	
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	52	2168.6	152.1	2320.7		2320.7	2162.39	-2227.2
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-2292.0
Time at dock	60	0.0	152.1	152.1	152.1	0.0	0.00	-2292.0
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-2356.8
Cruise	52	2168.6	152.1	2320.7		2320.7	2162.39	-4519.2
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-4583.9
Time at dock	60	0.0	152.1	152.1	4829.6	-4677.5	-4583.94	0.0

	Trip Duration min			**Total Energy** kWh	**Shore Trip Energy** kWh	**Chg Loss** kWh		**End SoC** kWh
	243.95519			4566	4982	-416		0.00
Energy between charging				4262				

Battery Sizing

Battery Type	NMC
Charge C Rate	2
Discharge C Rage	3
Charge/Discharge Losses (kWh)	-416
Max Charge (kW)	4773
Max Dischage (kW)	2393
C-Rate Sizing (kWh)	2386
Max Dischage (kWh)	4584
DOD of C-Rate-sized	192%
Desired Cycle Life	4680
Battery Cycle Life at 80%DOD	6000
Desired IEEE Multiplier	0.78
Max Allowable DOD	100%
Battery Bank for Cycle Life	4584
Theoretical Cycle Life (yr)	12.67
Minimum Bank for Capacity Fade (kWh)	5730

Shore Power

Required Power at Dock (kW)	4829.6
Shore Energy (kWh)	4982

SKAGWAY - HAINES BATTERY ONLY OPERATION, CHARGING BOTH ENDS

Operational Profile		Power Demand					Battery Sizing	
Loading Condition	**Duration** min	**Prop. Load** kW	**Hotel Load** kW	**Total** kW	**Shore Power** kW	**Battery Power** kW	**Battery Energy** kWh	**Battery SoC** kWh
Included Efficiency		Gen	Inv		none	none	Eff_Chg	
Value		0.98	0.986		1	1	Eff_Disch	
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	51.977594	2168.6	152.1	2320.7		2320.7	2162.39	-2227.2
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-2292.0
Time at dock	60	0.0	152.1	152.1	2490.9	-2338.7	-2291.97	0.0
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	51.977594	2168.6	152.1	2320.7		2320.7	2162.39	-2227.2
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-2292.0
Time at dock	60	0.0	152.1	152.1	2490.9	-2338.7	-2291.97	0.0
	Trip Duration min			**Total Energy** kWh	**Shore Trip Energy** kWh	**Chg Loss** kWh		**End SoC** kWh
	243.95519			4566	4982	-416		-0.01
Energy between charging				2131				

Battery Sizing

Battery Type	NMC
Charge C Rate	2
Discharge C Rage	3
Charge/Discharge Losses (kWh)	-416
Max Charge (kW)	2386
Max Dischage (kW)	2393
C-Rate Sizing (kWh)	1193
Max Dischage (kWh)	2292
DOD of C-Rate-sized	192%
Desired Cycle Life	4680
Battery Cycle Life at 80%DOD	6000
Desired IEEE Multiplier	0.78
Max Allowable DOD	100%
Battery Bank for Cycle Life	2292
Theoretical Cycle Life (yr)	12.67
Minimum Bank for Capacity Fade (kWh)	2865

Shore Power

Required Power at Dock (kW)	2490.9
Shore Energy (kWh)	4982

SKAGWAY - HAINES **SLOW BATTERY ONLY OPERATION, CHARGING ONE END**

Operational Profile		Power Demand					Battery Sizing	
Loading Condition	**Duration** min	**Prop. Load** kW	**Hotel Load** kW	**Total** kW	**Shore Power** kW	**Battery Power** kW	**Battery Energy** kWh	**Battery SoC** kWh
Included Efficiency		Gen	Inv		none	none	Eff_Chg	
Value		0.98	0.986		1	1	Eff_Disch	
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	70.354386	1141.4	152.1	1293.5		1293.5	1631.36	-1696.2
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-1760.9
Time at dock	60	0.0	152.1	152.1	152.1	0.0	0.00	-1760.9
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-1825.7
Cruise	70.354386	1141.4	152.1	1293.5		1293.5	1631.36	-3457.1
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-3521.9
Time at dock	60	0.0	152.1	152.1	3745.9	-3593.8	-3521.89	0.0
	Trip Duration min			**Total Energy** kWh	**Shore Trip Energy** kWh	**Chg Loss** kWh		**End SoC** kWh
	280.70877			3579	3898	-319		0.02
Energy between charging				3274				

Battery Sizing

Battery Type	NMC
Charge C Rate	2
Discharge C Rage	3
Charge/Discharge Losses (kWh)	-319
Max Charge (kW)	3667
Max Dischage (kW)	1334
C-Rate Sizing (kWh)	1834
Max Dischage (kWh)	3522
DOD of C-Rate-sized	192%
Desired Cycle Life	4680
Battery Cycle Life at 80%DOD	6000
Desired IEEE Multiplier	0.78
Max Allowable DOD	100%
Battery Bank for Cycle Life	3522
Theoretical Cycle Life (yr)	12.67
Minimum Bank for Capacity Fade (kWh)	4402

Shore Power

Required Power at Dock (kW)	3745.9
Shore Energy (kWh)	3898

SKAGWAY - HAINES   SLOW BATTERY ONLY OPERATION, CHARGING BOTH ENDS

Operational Profile		Power Demand					Battery Sizing	
Loading Condition	**Duration** min	**Prop. Load** kW	**Hotel Load** kW	**Total** kW	**Shore Power** kW	**Battery Power** kW	**Battery Energy** kWh	**Battery SoC** kWh
Included Efficiency		Gen	Inv		none	none	Eff_Chg	
Value		0.98	0.986		1	1	Eff_Disch	
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	70.4	1141.4	152.1	1293.5		1293.5	1631.36	-1696.2
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-1760.9
Time at dock	60	0.0	152.1	152.1	1949.0	-1796.9	-1760.93	0.0
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	70.4	1141.4	152.1	1293.5		1293.5	1631.36	-1696.2
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-1760.9
Time at dock	60	0.0	152.1	152.1	1949.0	-1796.9	-1760.93	0.0
	Trip Duration min			**Total Energy** kWh	**Shore Trip Energy** kWh	**Chg Loss** kWh		**End SoC** kWh
	280.70877			3579	3898	-319		-0.01
Energy between charging				1637				

Battery Sizing

Battery Type	NMC
Charge C Rate	2
Discharge C Rage	3
Charge/Discharge Losses (kWh)	-319
Max Charge (kW)	1834
Max Dischage (kW)	1334
C-Rate Sizing (kWh)	917
Max Dischage (kWh)	1761
DOD of C-Rate-sized	192%
Desired Cycle Life	4680
Battery Cycle Life at 80%DOD	6000
Desired IEEE Multiplier	0.78
Max Allowable DOD	100%
Battery Bank for Cycle Life	1761
Theoretical Cycle Life (yr)	12.67
Minimum Bank for Capacity Fade (kWh)	2201

Shore Power

Required Power at Dock (kW)	1949.0
Shore Energy (kWh)	3898

Homer - Seldovia

HOMER - SELDOVIA	EPA TIER 4 DIESEL MECHANICAL		
Engine	Tier IV Nominal	Generator	CAT C9
Power	1100	Power	300
No Installed	2	No Installed	2
No Operating	2	No Operating	1

Operational Profile		Power Demand				Power Supply		Engine Usage			
Loading Condition	**Duration** min	**Prop. Load** kW	**Hotel Load** kW	**Other** kW	**Total** kW	**Engine Power** kW	**Generator Power** kW	**Eng. Pwr** %	**Eng. Time** min	**Gen. Pwr** %	**Gen. Time** min
Included Efficiency		DM	Gen			Eng	Gen				
Value		0.97	0.98			1.00	0.98				
Maneuvering	5	576.5	153.1		729.5	576.5	153.1	26%	5.0	51%	5.0
Cruise	65.66	2190.5	153.1		2343.6	2190.5	153.1	100%	65.7	51%	65.7
Maneuvering	5	576.5	153.1		729.5	576.5	153.1	26%	5.0	51%	5.0
Time at dock	60	0.0	153.1		153.1	0.0	153.1	0%	0.0	51%	60.0
Maneuvering	5	576.5	153.1		729.5	576.5	153.1	26%	5.0	51%	5.0
Cruise	65.66	2190.5	153.1		2343.6	2190.5	153.1	100%	65.7	51%	65.7
Maneuvering	5	576.5	153.1		729.5	576.5	153.1	26%	5.0	51%	5.0
Time at dock	60	0.0	153.1		153.1	0.0	153.1	0%	0.0	51%	60.0
								0%		0%	0.0
								0%		0%	0.0
	Trip Duration min				**Total Energy** kWh	**Eng. Energy** kWh	**Gen. Energy** kWh		**Eng. Time** hr		**Gen. Time** hr
	271.32955				5679	4987	692		151.3		271.3

			Engine Emissions				Generator Emissions			
Loading Condition	**Eng. BSFC** lb/kWh	**Gen. BSFC** lb/kWh	**NOX** g/kWh	**CO** g/kWh	**HC** g/kWh	**PM** g/kWh	**NOX** g/kWh	**CO** g/kWh	**HC** g/kWh	**PM** g/kWh
						Emissions_6				Emissions_3
Maneuvering	0.4666323	0.4894731	2.6376702	0.0031506	0	0.0160022	4.8944561	1.9291557	0.3196558	0.2129214
Cruise	0.4540627	0.4894731	1.7241077	0.1917037	0	0.011271	4.8944561	1.9291557	0.3196558	0.2129214
Maneuvering	0.4666323	0.4894731	2.6376702	0.0031506	0	0.0160022	4.8944561	1.9291557	0.3196558	0.2129214
Time at dock	0.4739995	0.4894731	0	0	0	0	4.8944561	1.9291557	0.3196558	0.2129214
Maneuvering	0.4666323	0.4894731	2.6376702	0.0031506	0	0.0160022	4.8944561	1.9291557	0.3196558	0.2129214
Cruise	0.4540627	0.4894731	1.7241077	0.1917037	0	0.011271	4.8944561	1.9291557	0.3196558	0.2129214
Maneuvering	0.4666323	0.4894731	2.6376702	0.0031506	0	0.0160022	4.8944561	1.9291557	0.3196558	0.2129214
Time at dock	0.4739995	0.4894731	0	0	0	0	4.8944561	1.9291557	0.3196558	0.2129214
	0	0	0	0	0	0	5.2299852	13.007912	4.5594743	0.7509722
	0	0	0	0	0	0	5.2299852	13.007912	4.5594743	0.7509722
	Fuel Cons. gal	**Fuel Cons.** gal	**NOX** g	**CO** g	**HC** g	**PM** g	**NOX** g	**CO** g	**HC** g	**PM** g
	319.3	47.7	8773	920	0	57	24408	9620	1594	1062

Engine Summary	
Main Engine Time (hr)	2.5
Generator Time (hr)	4.5
Fuel Consumption (gal)	367.0
Emissions Summary	
Nox (g)	33181
CO (g)	10540
HC (g)	1594
PM (g)	1119

HOMER - SELDOVIA BATTERY ONLY OPERATION, CHARGING ONE END

Operational Profile		Power Demand					Battery Sizing	
Loading Condition	**Duration** min	**Prop. Load** kW	**Hotel Load** kW	**Total** kW	**Shore Power** kW	**Battery Power** kW	**Battery Energy** kWh	**Battery SoC** kWh
Included Efficiency		Gen	Inv		none	none	Eff_Chg	
Value		0.98	0.986		1	1	Eff_Disch	
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	66	2168.6	152.1	2320.7		2320.7	2731.81	-2796.6
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-2861.4
Time at dock	60	0.0	152.1	152.1	152.1	0.0	0.00	-2861.4
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-2926.2
Cruise	66	2168.6	152.1	2320.7		2320.7	2731.81	-5658.0
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-5722.8
Time at dock	60	0.0	152.1	152.1	5991.7	-5839.6	-5722.78	0.0
	Trip Duration min			**Total Energy** kWh	**Shore Trip Energy** kWh	**Chg Loss** kWh		**End SoC** kWh
	271.32955			5625	6144	-519		0.00
Energy between charging				5321				

Battery Sizing

Battery Type	NMC
Charge C Rate	2
Discharge C Rage	3
Charge/Discharge Losses (kWh)	-519
Max Charge (kW)	5959
Max Dischage (kW)	2393
C-Rate Sizing (kWh)	2979
Max Dischage (kWh)	5723
DOD of C-Rate-sized	192%
Desired Cycle Life	4680
Battery Cycle Life at 80%DOD	6000
Desired IEEE Multiplier	0.78
Max Allowable DOD	100%
Battery Bank for Cycle Life	5723
Theoretical Cycle Life (yr)	12.67
Minimum Bank for Capacity Fade (kWh)	7153

Shore Power

Required Power at Dock (kW)	5991.7
Shore Energy (kWh)	6144

HOMER - SELDOVIA BATTERY ONLY OPERATION, CHARGING BOTH ENDS

Operational Profile		Power Demand					Battery Sizing	
Loading Condition	**Duration** min	**Prop. Load** kW	**Hotel Load** kW	**Total** kW	**Shore Power** kW	**Battery Power** kW	**Battery Energy** kWh	**Battery SoC** kWh
Included Efficiency		Gen	Inv		none	none	Eff_Chg	
Value		0.98	0.986		1	1	Eff_Disch	
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	66	2168.6	152.1	2320.7		2320.7	2731.81	-2796.6
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-2861.4
Time at dock	60	0.0	152.1	152.1	3071.9	-2919.8	-2861.37	0.0
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	66	2168.6	152.1	2320.7		2320.7	2731.81	-2796.6
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-2861.4
Time at dock	60	0.0	152.1	152.1	3071.9	-2919.8	-2861.37	0.0
	Trip Duration min			**Total Energy** kWh	**Shore Trip Energy** kWh	**Chg Loss** kWh		**End SoC** kWh
	271.32955			5625	6144	-519		-0.03
Energy between charging				2660.3255				

Battery Sizing

Battery Type	NMC
Charge C Rate	2
Discharge C Rage	3
Charge/Discharge Losses (kWh)	-519
Max Charge (kW)	2979
Max Dischage (kW)	2393
C-Rate Sizing (kWh)	1490
Max Dischage (kWh)	2861
DOD of C-Rate-sized	192%
Desired Cycle Life	4680
Battery Cycle Life at 80%DOD	6000
Desired IEEE Multiplier	0.78
Max Allowable DOD	100%
Battery Bank for Cycle Life	2861
Theoretical Cycle Life (yr)	12.67
Minimum Bank for Capacity Fade (kWh)	3577

Shore Power

Required Power at Dock (kW)	3071.9
Shore Energy (kWh)	6144

**HOMER - SELDOVIA	SLOW BATTERY ONLY OPERATION, CHARGING ONE END**

Operational Profile		Power Demand					Battery Sizing	
Loading Condition	**Duration**	**Prop. Load**	**Hotel Load**	**Total**	**Shore Power**	**Battery Power**	**Battery Energy**	**Battery SoC**
	min	kW	kW	kW	kW	kW	kWh	kWh
Included Efficiency		Gen	Inv		none	none	Eff_Chg	
Value		0.98	0.986		1	1	Eff_Disch	
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	88.880702	1141.4	152.1	1293.5		1293.5	2060.95	-2125.7
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-2190.5
Time at dock	60	0.0	152.1	152.1	152.1	0.0	0.00	-2190.5
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-2255.3
Cruise	88.880702	1141.4	152.1	1293.5		1293.5	2060.95	-4316.3
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-4381.0
Time at dock	60	0.0	152.1	152.1	4622.6	-4470.5	-4381.06	0.0
	Trip Duration			**Total Energy**	**Shore Trip Energy**	**Chg Loss**		**End SoC**
	min			kWh	kWh	kWh		kWh
	317.7614			4377	4775	-397		0.01
Energy between charging				4073				

Battery Sizing

Battery Type	NMC
Charge C Rate	2
Discharge C Rage	3
Charge/Discharge Losses (kWh)	-397
Max Charge (kW)	4562
Max Dischage (kW)	1334
C-Rate Sizing (kWh)	2281
Max Dischage (kWh)	4381
DOD of C-Rate-sized	192%
Desired Cycle Life	4680
Battery Cycle Life at 80%DOD	6000
Desired IEEE Multiplier	0.78
Max Allowable DOD	100%
Battery Bank for Cycle Life	4381
Theoretical Cycle Life (yr)	12.67
Minimum Bank for Capacity Fade (kWh)	5476

Shore Power

Required Power at Dock (kW)	4622.6
Shore Energy (kWh)	4775

HOMER - SELDOVIA SLOW BATTERY ONLY OPERATION, CHARGING BOTH ENDS

Operational Profile		Power Demand					Battery Sizing	
Loading Condition	**Duration** min	**Prop. Load** kW	**Hotel Load** kW	**Total** kW	**Shore Power** kW	**Battery Power** kW	**Battery Energy** kWh	**Battery SoC** kWh
Included Efficiency		Gen	Inv		none	none	Eff_Chg	
Value		0.98	0.986		1	1	Eff_Disch	
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	88.880702	1141.4	152.1	1293.5		1293.5	2060.95	-2125.7
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-2190.5
Time at dock	60	0.0	152.1	152.1	2387.4	-2235.2	-2190.53	0.0
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	88.880702	1141.4	152.1	1293.5		1293.5	2060.95	-2125.7
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-2190.5
Time at dock	60	0.0	152.1	152.1	2387.4	-2235.2	-2190.53	0.0

	Trip Duration min			**Total Energy** kWh	**Shore Trip Energy** kWh	**Chg Loss** kWh		**End SoC** kWh
	317.7614			4377	4775	-397		0.00
Energy between charging				2037				

Battery Sizing

Battery Type	NMC
Charge C Rate	2
Discharge C Rage	3
Charge/Discharge Losses (kWh)	-397
Max Charge (kW)	2281
Max Dischage (kW)	1334
C-Rate Sizing (kWh)	1140
Max Dischage (kWh)	2191
DOD of C-Rate-sized	192%
Desired Cycle Life	4680
Battery Cycle Life at 80%DOD	6000
Desired IEEE Multiplier	0.78
Max Allowable DOD	100%
Battery Bank for Cycle Life	2191
Theoretical Cycle Life (yr)	12.67
Minimum Bank for Capacity Fade (kWh)	2738

Shore Power

Required Power at Dock (kW)	2387.4
Shore Energy (kWh)	4775

Ketchikan – Metlakatla

KETCHIKAN - MET.	EPA TIER 4 DIESEL MECHANICAL		
Engine	Tier IV Nominal	Generator	CAT C9
Power	1100	Power	300
No Installed	2	No Installed	2
No Operating	2	No Operating	1

Operational Profile		Power Demand				Power Supply		Engine Usage			
Loading Condition	**Duration** min	**Prop. Load** kW	**Hotel Load** kW	**Other** kW	**Total** kW	**Engine Power** kW	**Generator Power** kW	**Eng. Pwr** %	**Eng. Time** min	**Gen. Pwr** %	**Gen. Time** min
Included Efficiency		DM	Gen			Eng	Gen				
Value		0.97	0.98			1.00	0.98				
Maneuvering	5	576.5	153.1		729.5	576.5	153.1	26%	5.0	51%	5.0
Cruise	26.43	2190.5	153.1		2343.6	2190.5	153.1	100%	26.4	51%	26.4
Maneuvering	5	576.5	153.1		729.5	576.5	153.1	26%	5.0	51%	5.0
Time at dock	60	0.0	153.1		153.1	0.0	153.1	0%	0.0	51%	60.0
Maneuvering	5	576.5	153.1		729.5	576.5	153.1	26%	5.0	51%	5.0
Cruise	26.43	2190.5	153.1		2343.6	2190.5	153.1	100%	26.4	51%	26.4
Maneuvering	5	576.5	153.1		729.5	576.5	153.1	26%	5.0	51%	5.0
Time at dock	60	0.0	153.1		153.1	0.0	153.1	0%	0.0	51%	60.0
								0%		0%	0.0
								0%		0%	0.0
	Trip Duration min				**Total Energy** kWh	**Eng. Energy** kWh	**Gen. Energy** kWh		**Eng. Time** hr		**Gen. Time** hr
	192.85637				2614	2122	492		72.9		192.9

			Engine Emissions				Generator Emissions			
Loading Condition	**Eng. BSFC** lb/kWh	**Gen. BSFC** lb/kWh	**NOX** g/kWh	**CO** g/kWh	**HC** g/kWh	**PM** g/kWh	**NOX** g/kWh	**CO** g/kWh	**HC** g/kWh	**PM** g/kWh
			Tier IV Nominal			Emissions_6	Tier IV Nominal			Emissions_3
Maneuvering	0.47	0.49	2.64	0.00	0.00	0.02	4.89	1.93	0.32	0.21
Cruise	0.45	0.49	1.72	0.19	0.00	0.01	4.89	1.93	0.32	0.21
Maneuvering	0.47	0.49	2.64	0.00	0.00	0.02	4.89	1.93	0.32	0.21
Time at dock	0.47	0.49	0.00	0.00	0.00	0.00	4.89	1.93	0.32	0.21
Maneuvering	0.47	0.49	2.64	0.00	0.00	0.02	4.89	1.93	0.32	0.21
Cruise	0.45	0.49	1.72	0.19	0.00	0.01	4.89	1.93	0.32	0.21
Maneuvering	0.47	0.49	2.64	0.00	0.00	0.02	4.89	1.93	0.32	0.21
Time at dock	0.47	0.49	0.00	0.00	0.00	0.00	4.89	1.93	0.32	0.21
	0.00	0.00	0.00	0.00	0.00	0.00	5.23	13.01	4.56	0.75
	0.00	0.00	0.00	0.00	0.00	0.00	5.23	13.01	4.56	0.75
	Fuel Cons. gal	**Fuel Cons.** gal	**NOX** g	**CO** g	**HC** g	**PM** g	**NOX** g	**CO** g	**HC** g	**PM** g
	136.0	33.9	3834	371	0	25	10385	4093	678	452

Engine Summary	
Main Engine Time (hr)	1.2
Generator Time (hr)	3.2
Fuel Consumption (gal)	170.0
Emissions Summary	
Nox (g)	14219
CO (g)	4464
HC (g)	678
PM (g)	477

KETCHIKAN - MET. **BATTERY ONLY OPERATION, CHARGING ONE END**

Operational Profile		Power Demand					Battery Sizing	
Loading Condition	**Duration** min	**Prop. Load** kW	**Hotel Load** kW	**Total** kW	**Shore Power** kW	**Battery Power** kW	**Battery Energy** kWh	**Battery SoC** kWh
Included Efficiency		Gen	Inv		none	none	Eff_Chg	
Value		0.98	0.986		1	1	Eff_Disch	
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	26.428186	2168.6	152.1	2320.7		2320.7	1099.48	-1164.3
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-1229.1
Time at dock	60	0.0	152.1	152.1	152.1	0.0	0.00	-1229.1
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-1293.8
Cruise	26.428186	2168.6	152.1	2320.7		2320.7	1099.48	-2393.3
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-2458.1
Time at dock	60	0.0	152.1	152.1	2660.4	-2508.3	-2458.10	0.0

	Trip Duration min			**Total Energy** kWh	**Shore Trip Energy** kWh	**Chg Loss** kWh		**End SoC** kWh
	192.85637			2590	2813	-223		0.00
Energy between charging				2285				

Battery Sizing

Battery Type	NMC
Charge C Rate	2
Discharge C Rage	3
Charge/Discharge Losses (kWh)	-223
Max Charge (kW)	2559
Max Dischage (kW)	2393
C-Rate Sizing (kWh)	1280
Max Dischage (kWh)	2458
DOD of C-Rate-sized	192%
Desired Cycle Life	4680
Battery Cycle Life at 80%DOD	6000
Desired IEEE Multiplier	0.78
Max Allowable DOD	100%
Battery Bank for Cycle Life	2458
Theoretical Cycle Life (yr)	12.67
Minimum Bank for Capacity Fade (kWh)	3073

Shore Power

Required Power at Dock (kW)	2660.4
Shore Energy (kWh)	2813

KETCHIKAN - MET. **BATTERY ONLY OPERATION, CHARGING BOTH ENDS**

Operational Profile		Power Demand					Battery Sizing	
Loading Condition	**Duration** min	**Prop. Load** kW	**Hotel Load** kW	**Total** kW	**Shore Power** kW	**Battery Power** kW	**Battery Energy** kWh	**Battery SoC** kWh
Included Efficiency		Gen	Inv		none	none	Eff_Chg	
Value		0.98	0.986		1	1	Eff_Disch	
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	26.428186	2168.6	152.1	2320.7		2320.7	1099.48	-1164.3
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-1229.1
Time at dock	60	0.0	152.1	152.1	1406.3	-1254.1	-1229.06	0.0
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	26.428186	2168.6	152.1	2320.7		2320.7	1099.48	-1164.3
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-1229.0
Time at dock	60	0.0	152.1	152.1	1406.3	-1254.1	-1229.06	0.0
	Trip Duration min			**Total Energy** kWh	**Shore Trip Energy** kWh	**Chg Loss** kWh		**End SoC** kWh
	192.85637			2590	2813	-223		0.01
Energy between charging				1143				

Battery Sizing

Battery Type	NMC
Charge C Rate	2
Discharge C Rage	3
Charge/Discharge Losses (kWh)	-223
Max Charge (kW)	1280
Max Dischage (kW)	2393
C-Rate Sizing (kWh)	798
Max Dischage (kWh)	1229
DOD of C-Rate-sized	154%
Desired Cycle Life	4680
Battery Cycle Life at 80%DOD	6000
Desired IEEE Multiplier	0.78
Max Allowable DOD	100%
Battery Bank for Cycle Life	1229
Theoretical Cycle Life (yr)	12.67
Minimum Bank for Capacity Fade (kWh)	1536

KETCHIKAN - MET. SLOW BATTERY ONLY OPERATION, CHARGING ONE END

Operational Profile		Power Demand					Battery Sizing	
Loading Condition	**Duration** min	**Prop. Load** kW	**Hotel Load** kW	**Total** kW	**Shore Power** kW	**Battery Power** kW	**Battery Energy** kWh	**Battery SoC** kWh
Included Efficiency		Gen	Inv		none	none	Eff_Chg	
Value		0.98	0.986		1	1	Eff_Disch	
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	35.77193	1141.4	152.1	1293.5		1293.5	829.47	-894.3
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-959.0
Time at dock	35	0.0	152.1	152.1	152.1	0.0	0.00	-959.0
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-1023.8
Cruise	35.77193	1141.4	152.1	1293.5		1293.5	829.47	-1853.3
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-1918.1
Time at dock	35	0.0	152.1	152.1	3507.4	-3355.3	-1918.10	0.0

	Trip Duration min			**Total Energy** kWh	**Shore Trip Energy** kWh	**Chg Loss** kWh		**End SoC** kWh
	161.54386			1961	2135	-174		0.00
Energy between charging				1783				

Battery Sizing

Battery Type	NMC
Charge C Rate	2
Discharge C Rage	3
Charge/Discharge Losses (kWh)	-174
Max Charge (kW)	3424
Max Dischage (kW)	1334
C-Rate Sizing (kWh)	1712
Max Dischage (kWh)	1918
DOD of C-Rate-sized	112%
Desired Cycle Life	4680
Battery Cycle Life at 80%DOD	6000
Desired IEEE Multiplier	0.78
Max Allowable DOD	100%
Battery Bank for Cycle Life	1918
Theoretical Cycle Life (yr)	12.67
Minimum Bank for Capacity Fade (kWh)	2398

Shore Power

Required Power at Dock (kW)	3507.4
Shore Energy (kWh)	2135

KETCHIKAN - MET. SLOW BATTERY ONLY OPERATION, CHARGING BOTH ENDS

Operational Profile		Power Demand					Battery Sizing	
Loading Condition	**Duration** min	**Prop. Load** kW	**Hotel Load** kW	**Total** kW	**Shore Power** kW	**Battery Power** kW	**Battery Energy** kWh	**Battery SoC** kWh
Included Efficiency		Gen	Inv		none	none	Eff_Chg	
Value		0.98	0.986		1	1	Eff_Disch	
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	35.77193	1141.4	152.1	1293.5		1293.5	829.47	-894.3
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-959.0
Time at dock	35	0.0	152.1	152.1	1829.8	-1677.6	-959.05	0.0
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-64.8
Cruise	35.77193	1141.4	152.1	1293.5		1293.5	829.47	-894.3
Maneuvering	5	570.7	152.1	722.8		722.8	64.79	-959.1
Time at dock	35	0.0	152.1	152.1	1829.8	-1677.6	-959.05	0.0
	Trip Duration min			**Total Energy** kWh	**Shore Trip Energy** kWh	**Chg Loss** kWh		**End SoC** kWh
	161.54386			1961	2135	-174		0.00
Energy between charging				892				

Battery Sizing

Battery Type	NMC
Charge C Rate	2
Discharge C Rage	3
Charge/Discharge Losses (kWh)	-174
Max Charge (kW)	1712
Max Dischage (kW)	1334
C-Rate Sizing (kWh)	856
Max Dischage (kWh)	959
DOD of C-Rate-sized	112%
Desired Cycle Life	4680
Battery Cycle Life at 80%DOD	6000
Desired IEEE Multiplier	0.78
Max Allowable DOD	100%
Battery Bank for Cycle Life	959
Theoretical Cycle Life (yr)	12.67
Minimum Bank for Capacity Fade (kWh)	1199

Shore Power

Required Power at Dock (kW)	1829.8
Shore Energy (kWh)	2135

SHORESIDE UTILITY / BATTERY ANALYSIS

Port	Destination	Crossing Energy (KWH) Note 1	Round Trip Energy (KWH) Note 1	Travel Time (Hrs)	Trips per Day	Layover Time (Hrs)	Hotel Power (KW)	Charging Power Reqd (KW) Note 5	Min. Shoreside Battery (KWH) Note 5	Utility Charging Time (Hrs)	Charging Utility	Utility Load (KW) Note 8	Notes
Homeport: Skagway													
Skagway	Haines	2131		1.0	2	1	150	2,436	3,240	6	Haines	750	
Haines	Skagway	2131		1.0	1	4	150	838	1,114	6	Skagway	356	6
Haines	Skagway	2131		1.0	1	12	150	483	642	12	Skagway	209	7
Skagway-Haines-Skagway			4262	2.1	1	4	150	1,526	2,029	6	Skagway	526	3
Skagway-Haines-Skagway			4262	2.1	1	12	150	815	1,084	12	Skagway	250	4
Homeport: Metlakatla													
Metlakatla	Ketchikan	1143		0.6	2	1	150	1,383	1,839	6	Ketchikan	491	
Ketchikan	Metlakatla	1143		0.6	1	4	150	526	699	6	Metlakatla	279	6
Ketchikan	Metlakatla	1143		0.6	1	12	150	335	446	12	Metlakatla	191	7
Metlakatla-Ketchikan-Metlakatla			2285	1.2	1	4	150	901	1,199	6	Metlakatla	372	
Metlakatla-Ketchikan-Metlakatla			2285	1.2	1	12	150	520	692	12	Metlakatla	214	4
Homeport: Homer													
Homer	Seldovia	2660		1.3	1	1	150	3,000	3,990	6	Seldovia	343	
Seldovia	Homer	2660		1.3	1	18	150	340	452	18	Homer	172	4
Homer-Seldovia-Homer			5321	2.5	1	18	150	826	1,098	18	Homer	203	4

Notes

1. Energy consumption based on MCR Operation
2. Hotel Power (KW) 150
3. First trip with mid day Layover at the primary port
4. Second trip with overnight layover at the primary port.
5. Includes energy needed to restore consumption for the propulsion system and hotel load in transit.
6. First trip with 4 hour layover at the primary port
7. Second trip with overnight layover at the primary port
8. Load presented to the utility based on controlling the battery charge rate to the time in port, plus the hotel load

NOTIONAL VESSEL CAPITAL COST ESTIMATE

Vessel Data

Vessel	LOA	LWL	Beam	Depth	Lightship Δ	Eng. Power	Gen. Capacity	Battery Capacity	Passenger Deck Area
	ft	*ft*	*ft*	*ft*	*LT*	*HP*	*kW*	*kWh*	*ft ^{2}*
JOHN W JOHNSON	263.333	256	65.33	15.5	1399	2280	2396	1898	
CASCO BAY FERRY	164	159	39.88	12	498	1475	1312	904	
GOVERNORS ISLAND FE	190	185	62.33	13.25	598	1502	1791	792	
PRINCE OF WALES	197.5	175.5	52.9	17.3	932	3000	111.855	0	
LOW E FERRY	197.5	175.5	52.9	17.3		3000	1800	6000	

Weight Data

Vessel	110	150	200	300	400	500	600	Total
	lb	*lb*	*lb*	*lb*	*lb*	*lb*	*lb*	*LT*
JOHN W JOHNSON								
CASCO BAY FERRY	465761	254190	137086	19615	1431	56209	180288	498
GOVERNORS ISLAND FE	731072	207100	155179	35877	2001	65416	143363	598
PRINCE OF WALES	1339516.5	262500	77131	50275	3142	148273	206958	932
LOW E FERRY	1339516.5	262500	294376	40000	3142	163100.78	227653.89	1040

Cost Data

Vessel	110	150	200	300 yard	300 PSI	Motors	Motors	400	500	600	000, 800 & 900	Total Cost
	$	*$*	*$*	*$*	*$*			*$*	*$*	*$*	*$*	*$*
JOHN W JOHNSON					8305000	172134	280532					
CASCO BAY FERRY	1815382	679552	824879	1725711	7192616	61274	181500	662977	2114975	3744802	4044571	23048239
GOVERNORS ISLAND FE	2552516	723084	617000	2355753	6366047			844700	3787500	4858800	3945200	26050600
PRINCE OF WALES						114674	369122					
Average $/lb	3.7	3.1						442.7	47.8	27.3		
Average $/prop_hp			485.0									
Average $/gen_kW				1315.3								
Average % of other											20%	
					**							
LOW E FERRY	4948937	809140	872994	2367591	15978938	incl.	incl.	1390842	7790155	6222101	7900550	$ 48,281,248
Inflation, labor adjustment												1.1
Total for first vessel												$ 53,109,373
Cost Reduction for additional vessels in class												18%
Total for three vessels												$ 140,208,744

* JWJ Includes alternators, swbds, distribution, controls, batteries, alarm and monitoring, UPS, does not include motors

* Group 300 PSI based on PSI quotes, adj. for battery capacity variation

FLEET CARBON INTENSITY INDICIES

Fuel Consumption

Year	AUR	COL	KEN	LEC	LIT	MAL	MAL	TAZ	TUS
2017	235406	505546	1187476	321671	26598	457298	520655	0	330693
2018	577107	2015211	2234238	766497	35410	1177486	0	19000	655315
2019	508966	1863051	1202011	419203	34701	1221950	236978	227028	546893
2020	0	0	1664635	410655	46596	0	596792	140951	252351
2021	434439	184751	2076309	639493	45441	0	991527	33380	441451

CII Calculation (2019)

	AUR	COL	KEN	LEC	LIT	MAL	MAL	TAZ	TUS
Gross Tonnage (ITC)	3124	13009	12635	3124	758	9121	9214	5304	4529
Distance (2019, nm)	46162	75972	48640	36390	7944	71423	8420	14340	44775
FC (2019, gal)	508966	1863051	1202011	419203	34701	1221950	236978	227028	546893
M (kg-CO_2)	5191453	19003120	12260512	4275866	353946	12463894	2417173	2315689	5578313
CII (g-CO_2 / GT*nm)	36	19	20	38	59	19	31	30	28

$$CII_{ref} = aCapacity^{-c}$$

a	7540								
c	0.587								
CII_{ref}	67.0	29.0	29.5	67.0	153.8	35.7	35.5	49.1	53.9

Maximum Allowable Future CII

Year	AUR	COL	KEN	LEC	LIT	MAL	MAL	TAZ	TUS
2019	67.0	29.0	29.5	67.0	153.8	35.7	35.5	49.1	53.9
2023	63.6	27.5	28.0	63.6	146.1	33.9	33.7	46.6	51.2
2024	62.3	27.0	27.4	62.3	143.1	33.2	33.0	45.7	50.1
2025	61.0	26.4	26.8	61.0	140.0	32.5	32.3	44.7	49.0
2026	59.6	25.8	26.3	59.6	136.9	31.8	31.6	43.7	47.9