REQUEST FOR PROPOSALS – ELECTRICAL INTEGRATOR

GUEMES ISLAND FERRY REPLACEMENT

000 INTRODUCTION

000.1 Objective

This Request for Proposals describes the requirements for the electrical system of the Guemes Island Ferry Replacement (GIFR) vessel, a 160-ft. battery electric passenger and vehicle ferry, which serves a ferry terminal in Anacortes, Washington. Skagit County owns and operates the Guemes Island ferry and ferry terminal. Glosten has been selected by Skagit County to design the replacement ferry and the associated charging system.

In 2020, a set of RFIs were released to obtain technical and cost information to progress the design of the ferry. Responses to those RFIs informed the current preliminary design and some technical updates have been made based on vendor recommendations.

As described in the resolution authorizing this RFP, responses will be used to select an electrical integrator to be responsible for both shore and ship equipment.

Planned timelines associated with this RFP are as follows:

Date	Event
29-Jul	RFP Published
22-Aug	Deadline for Questions
4-Sep	Deadline for Addenda responding to Questions
16-Sep	Deadline for Responses
16-Sep thru 14-Oct	Evaluation and Discussions
15-Oct	Integrator Selected

000.2 Attachments and Reference Documents

The complete RFP consists of the following documents:

1. Skagit County Commission Resolution
2. This RFP specification
3. Attachment #1, Signature Page
4. Attachment #2, Project Contracting Plan (Flowchart)

The following are documents referenced within this RFP:

1. *GIFR Transportation System Assessment*. Glosten, 17097-000-02, Rev. -, 14 December 2018.
2. *GIFR Electrical Power Load Analysis*. Glosten, 17097.02-300-01, Rev. P0, 23 September 2020.
3. *GIFR Electrical One Line*. Glosten, 17097.02-300-02, Rev. P0, 23 September 2020.

4. *Technical Specifications and Operating Protocols and Procedures for Interconnection of Generation Facilities Not Subject to FERC Jurisdiction*. Puget Sound Energy, Inc, Document 9022, 7 August 2019.

The above documents are for informational purposes only and should not be used for design and engineering beyond the purposes of this inquiry. Where conflicts exist, this document takes precedence. For example, propulsion power estimates have been revised since Reference 2 was developed. Although not referenced in this document, preliminary vessel arrangements drawings are also available.

To request these documents, please email Jake Gerlach at jmgerlach@glosten.com.

000.3 Acronyms

Acronyms used throughout this document are defined as follows:

ASCS	Automatic Shore Connection System
BOL	Beginning of (battery) life
CFR	Code of Federal Regulations
EOL	End of (battery) life
GIFR	Guemes Island Ferry Replacement
HMI	Human Machine Interface
LMFB	Last make/First break
NEC	National Electrical Code, NFPA 70
NESC	National Electrical Safety Code
PCS	Propulsion Control System
PMS	Power Management System
RFI	Request for Information
RFP	Request for Proposals
ROM	Rough Order of Magnitude
SES	Shoreside Electrical System
SOC	State of Charge
SOH	State of Health
VES	Vessel Electrical System
WAC	Washington Administrative Code

000.4 Project Overview

000.4.1 Vessel and Route

The preliminary design of the GIFR is shown in Figure 1; vessel particulars are shown in Table 1. It is estimated that the ferry will operate 365 days per year, with an average of 24 round-trip crossings per operating day. Route distance is 5/8 mile each way. Figure 2 depicts the timeline of a typical round-trip crossing, which takes 30 minutes. Battery charging will take place only in Anacortes.

Table 1 Vessel Particulars

Length, Overall	160'-0"
Beam	53'-0"
Draft	7'-6"
Car Capacity	28
Full Load Displacement	512 LT
Propulsors	(2) 650 kW L-Drive Azimuthing Propulsors
Speed, Cruise	11.5 kts

Figure 1 Preliminary design of the GIFR, port bow in foreground.

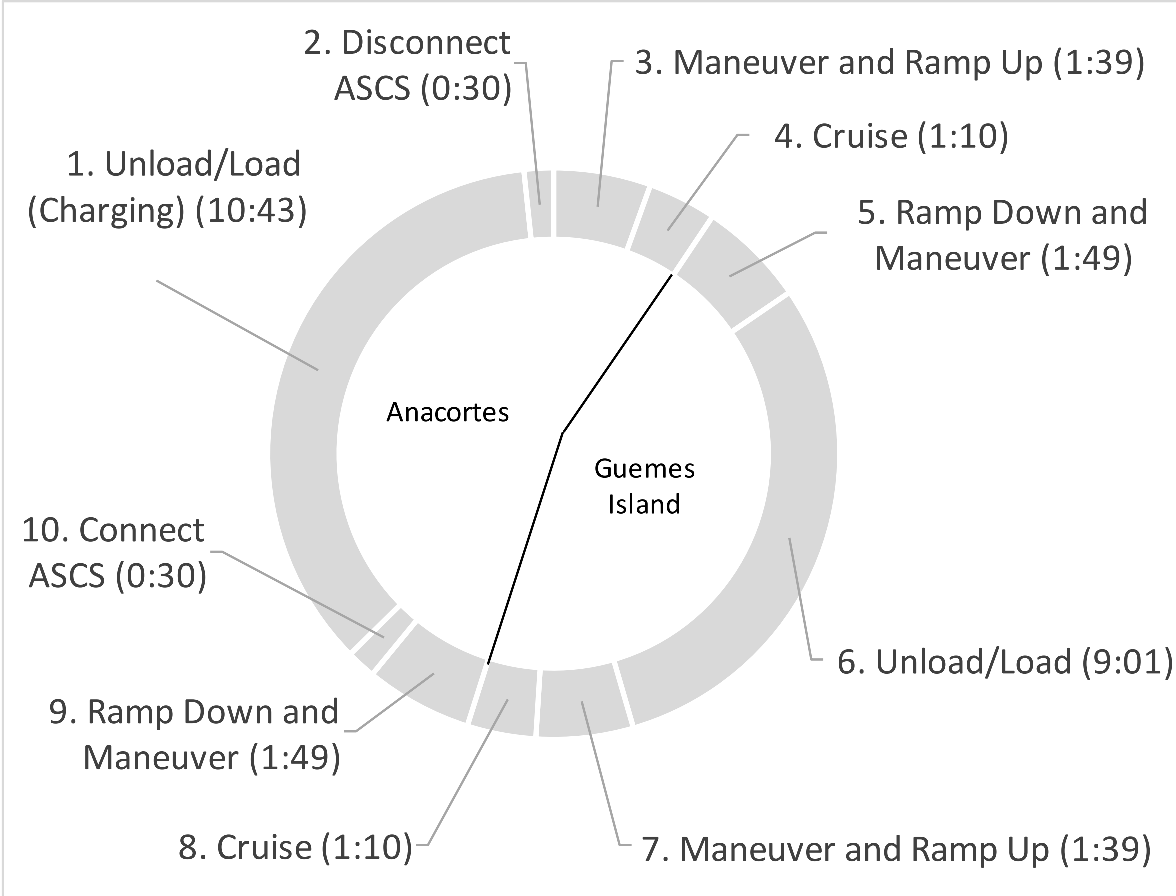

Figure 2 Typical round-trip transit

000.4.2 Scope of Supply

The GIFR project electrical system (see Figure 3 for overview) is subdivided into three subsystems: the Shoreside Electrical System (SES), the Automatic Shore Connection System (ASCS), and Vessel Electrical System (VES). Figure 1 is an outline of how the subsystems are expected to interface with each other; details of system architecture within each system may vary by integrator and technical solution. More detail can be found in Reference 3.

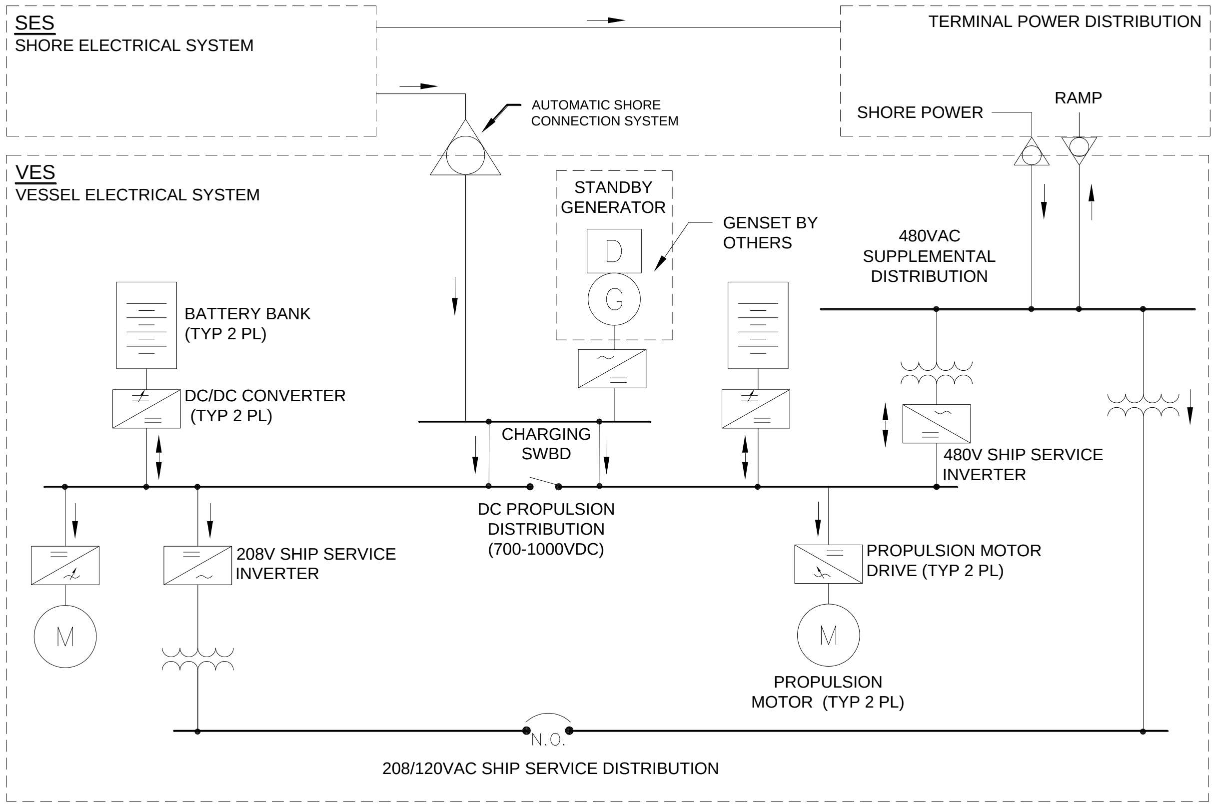

Figure 3 GIFR project electrical overview

Skagit County desires a single electrical integrator to integrate and provide the full scope described herein. Only proposals offering the fully integrated scope will be considered. The major equipment is summarized here and described in detail in the subsequent sections:

- Vessel Electrical System consisting of battery banks, main switchboards, propulsion motors and drives, auxiliary AC distribution switchboards, a power management system to control the same, and operator controls for interfacing with the shore system. The L-drive thrusters and auxiliary genset will be provided by others and are not in the scope of this RFP.

- Shore Electrical System consisting of transformers, battery banks, power conversion equipment, distribution switchboards to deliver power from the utility to the ASCS, and the SES structure and auxiliaries such as cooling and firefighting

- Automatic Shore Connection System consisting of a ship receptacle and shore plug, including the plug handling equipment required to accommodate vessel motions and provide automatic connection to and disconnection from the ferry.

The proposal should be inclusive of design efforts, engineering, analysis, permitting, regulatory approvals, acceptance testing, shipping/delivery, commissioning, and installation as described in subsequent sections.

Excluded from the integrator's scope are terminal and civil construction services including:

- The foundation for the SES house
- Interconnecting cabling between the SES house and ASCS, which will be installed by others to the integrator's specifications.
- Modification to the terminal, including the ASCS foundation.
- Installation of the ASCS onto the foundation (e.g. providing a crane barge).

000.4.3 Project Schedule

Table 2 Estimated project timeline

Integrator Selection	July to October 2021
Contract design complete	February 2022
Shipyard CFB and Contracting	February to September 2022
Vessel Construction	October 2022 to July 2024
Shore CFB and Contracting	November 2022 to February 2023
Shore Fab and Terminal Mods	May to September 2024
Acceptance Testing and Crew Training	July to September 2024
Ferry in service	September 2024

000.4.4 Terminal

The SES will be installed at the Anacortes terminal to provide high-power charging capability for the ferry. The SES will include a set of shore batteries to reduce the power draw from the medium voltage utility system, with cyclic higher power discharge to the ferry.

The ASCS will be installed at the Anacortes terminal docking facility to serve the ferry. The ASCS will transfer the required electrical energy from the SES to the VES to charge the propulsion batteries and power the ferry during connection. No shore charging connection will be installed on the Guemes Island side.

Existing Terminal

480VAC, 3-phase, 60 Hz power is currently supplied to machinery at the ramp apron and lifting tower. The shoreside vehicle loading infrastructure is depicted in Figure 4, and consists of a fixed approach span, movable transfer span and apron ramp, and the lifting tower and headframe. The transfer span is hinged at the approach span and the other end is supported at the lifting tower with an electric winch, cable and hydraulic pin system that allows for adjustment of the transfer span to match the tides. The apron ramp is hinged at the end of the transfer span and is raised and lowered by a hydraulic system. When the ferry arrives at the terminal, a deckhand on the ferry lowers the apron ramp to the ferry car deck using a control pendant attached to the end of the apron ramp. The apron ramp will extend full width between the wingwalls, the full width is required to allow simultaneous vehicle and passenger loading/unloading.

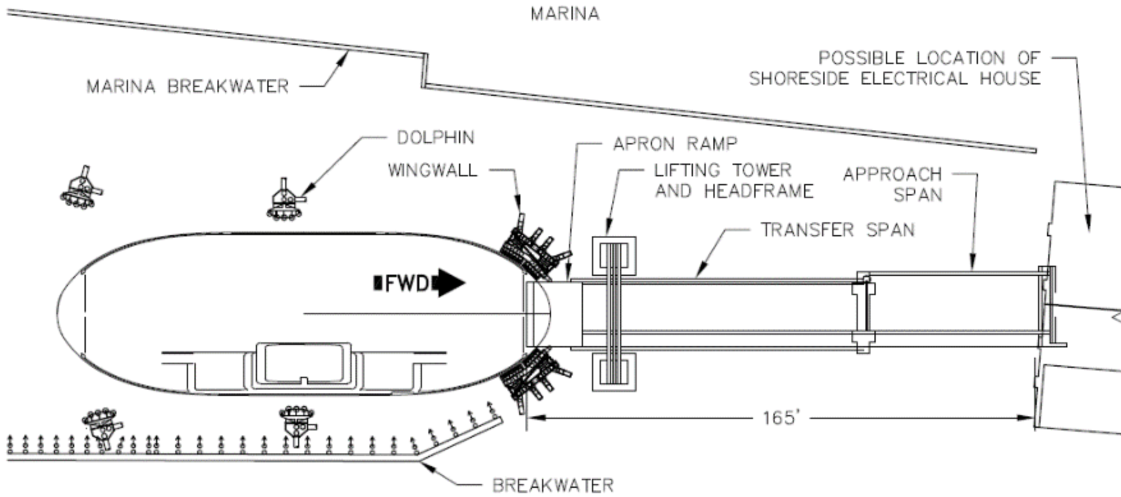

Figure 4 Anacortes terminal

000.4.5 Regulatory

The ferry will be required to satisfy the regulations for a USCG Inspected Small Passenger Vessel under US CFR Title 46, Subchapter T. This includes all aspects of the vessel electrical system which are installed on the ferry, and may also include review of the shoreside system for information. Per Title 46, the electric propulsion system is required to meet the applicable portions of Section 4-8-5/5 of the ABS Steel Vessel Rules. The USCG has limited experience reviewing and inspecting this type of all-electric vessel and the rules and requirements pertaining to a large battery installation of this type are not well defined. The selected integrator will be required to coordinate with the organizations performing regulatory submittals and will be responsible for addressing regulatory comments and facilitating testing for specific regulatory requirements.

The shore electrical installation in Anacortes will be required to satisfy the requirements of WAC-296-46B *Electrical Safety Standards, Administration and Installation*, the NEC, and NESC. Detailed utility requirements are documented in Reference 4.

The integration of an ASCS of this nature on the vessel is unique in the United States and we expect both the USCG and the Washington State electrical inspectors to review this aspect of the project.

000.4.6 Domestic Preference

Currently, this project has no federal funding and therefore no domestic preference requirements. Future vessel funding could be received via the US Federal Highway Administration (FHWA), which would trigger “Buy America” requirements for the ferry, including the VES. These regulations consider the source of steel and iron (only), and the work location for steel manipulation steps such as forming and machining. Assembly, testing, and other work outside the US is not disqualifying if no steel work is performed. All steel is considered, including minor items such as fasteners.

It is expected that all equipment provided in the integrator's scope for the VES would fall under the FHWA ferryboat waiver and therefore be exempt from Buy America requirements. Notwithstanding, information about domestic content is of interest to Skagit County. Information about the degree to which the proposed scope of supply complies with FHWA Buy America regulations or otherwise relies on domestic supply and assembly may be included in the commercial proposal. This information will be for reference only and will not be a factor in evaluation or selection.

001 RESPONSE PROCESS

001.1 Response Organization and Submittal

Responses should consist of separate technical and commercial proposals. Responses should be transmitted by email to jmgerlach@glosten.com.

001.2 Commercial Proposal

Commercial proposals shall consist of three sections:

- Project Approach: describe the proposed approach to the project, including pre-contract work with Glosten to finish the contract design, support for preparation of bid specifications, coordination with prime contractors for production and installation, and the integrator's approach to internal management and quality control

- Cost Proposal: report costs broken down for each major subsystem: VES, ASCS, and SES. Cost estimates should include the following elements for each subsystem, at a minimum:

    - Equipment design and approvals
    - Equipment fabrication and factory testing
    - Installation supervision
    - Testing and commissioning
    - Equipment shipping FOB Anacortes, WA

  See Attachment #1 for additional information about costs and cost changes.

- Project experience: provide descriptions of up to four (4) similar projects completed within the past five years. Include a description of the scope of electrical supply, integrator's design responsibilities, and customer's contact information. A reference for at least one project executed with a US or other North American shipyard is desired.

The selected integrator will be required by name in the construction specifications. Contractual terms will need to be negotiated by the integrator separately with the selected shipyard prime contractor and shoreside construction prime contractor. Although future contracts will be between Skagit County and prime contractors (shipyard and shore construction contractor), integrators are encouraged to include lead times, payment schedules, or other significant commercial terms in their proposals. This will ensure that the vessel design schedule and contracting can incorporate major elements.

001.3 Technical Proposal

Technical proposals should be organized similarly to this RFP, with sections for each major subsystem (VES, ASCS, SES).

The following technical information should be provided for evaluation:

- Power system single line diagrams of VES and SES showing connections internal to the systems and interfaces to external equipment.

- Narrative description of system operations during charging and while underway. Due to the integrated nature of the control systems, the proposed approach to charging should be described in a single narrative addressing ferry approach, wireless communication, ASCS connection, electrical control, response to safety or other abnormal events, completion of charging, electrical and physical disconnection, and ferry departure.

- Dimensional drawings and weight estimates for all major components, including switchboards, power conversion equipment, battery banks, transformers, and significant auxiliary or control enclosures.

- Efficiency ratings for all major components involved in power transfer from the utility to the propulsion thrusters. This includes main transformers, rectifiers, shore batteries, DC/DC converters, vessel batteries, propulsion motor drives, and propulsion motors.

- Detailed description of battery safety features, including BMS functions to prevent thermal runaway, the mechanism by which cell-to-cell propagation is prevented in the event of a thermal runaway, and handling of toxic gasses produced by thermal events.

- Proposed arrangement of SES, including the house, pad-mounted outdoor equipment, metering, etc.

- Auxiliary equipment in the SES house, including cooling, fire suppression, lighting, etc

- Auxiliary system requirements such as heat rejection, cooling media, flowrate, and fluid and ambient temperature specifications.

- Propulsion motor characteristics, including weight and dimensions, electrical requirements, and key performance attributes (torque, efficiency, etc) vs. speed.

- For ship and shore battery installations, proposals shall report the EOL SoH, along with the following information for each load profile at BOL and EOL:

    - Proposed range of battery State of Charge (SoC).

    - Battery temperatures and heat rejection. Note: care should be taken to ensure that temperature simulations include enough cycles that peak temperatures for each load case are stabilized.

- Range of motion for the proposed ASCS, with a detailed comparison to the requirements specified in Section 004. Compliance with both static range and dynamic velocity requirements shall be documented.

- Consolidated maintenance strategy detailing the requirements of Section 009 for the entire scope of supply.

- Recommended changes or deviations from the specified requirements, with cost and/or performance justification.

001.4 Proposal Evaluation

Three evaluation categories will be used to identify the proposal best suited to the County's needs. The categories, listed in order of importance, are:

- **Combined technical performance and project risk.** Technical performance may include such factors as system efficiency, reliability, space and weight requirements, and the quality of the proposed control system. Project risk may consider factors like the integrator's past performance, commissioning strategy, or technical complexity.

- **Maintenance support and strategy.** Integrators are encouraged to provide as much information on maintenance and support strategy as possible.

- **Cost.** Integrators are encouraged to balance cost and performance, provided that the minimum requirements from this RFP are satisfied.

Within each category, subcategories may be defined to streamline the evaluation process. Each proposal will be evaluated, with strengths, weaknesses, and deficiencies assigned to each (sub)category per the following definitions:

Discriminator	Description
Significant Strength	An aspect of an Integrator's proposal that has merit or exceeds specified performance or capability requirements in a way that appreciably decreases the risk of an unsuccessful project or inadequate in-service vessel performance
Strength	An aspect of an Integrator's proposal that has merit or exceeds specified performance or capability requirements in a way that will be advantageous to the County during the project or while the vessel is in service
Weakness	A flaw in the proposal that increases the risk of an unsuccessful project or inadequate in-service vessel performance

Significant Weakness	A flaw in the proposal that appreciably increases the risk of an unsuccessful project or inadequate in-service vessel performance
Deficiency	A material failure of a proposal to meet a requirement or a combination of significant weaknesses in a proposal that increases the risk of an unsuccessful project to an unacceptable level

The compiled strengths and weaknesses will be reviewed to assign each proposal an overall adjectival rating for each evaluation category. Adjectival ratings will be assigned as follows:

Adjectival Rating	Description
Outstanding	Proposal indicates an exceptional approach and understanding of the requirements and contains multiple strengths, and risk of unsuccessful performance is low.
Good	Proposal indicates a thorough approach and understanding of the requirements and contains at least one strength, and risk of unsuccessful performance is low to moderate.
Acceptable	Proposal meets requirements and indicates an adequate approach and understanding of the requirements, and risk of unsuccessful performance is no worse than moderate.
Marginal	Proposal has not demonstrated an adequate approach and understanding of the requirements, and/or risk of unsuccessful performance is high.
Unacceptable	Proposal does not meet requirements of the solicitation, and thus, contains one or more deficiencies, and/or risk of unsuccessful performance is unacceptable. Proposal is unawardable.

002 VESSEL ELECTRICAL SYSTEM

The Vessel Electrical System (VES) shall be an all-electric system which allows the ferry to transit back and forth between the Anacortes and Guemes terminals using energy stored in propulsion batteries. The batteries will be charged during the regular loading/unloading period at the Anacortes terminal via the ASCS.

The VES shall include two (2) independent propulsion battery banks. The propulsion battery banks shall serve as the two independent power sources required by the USCG, and all ship service and propulsion loads must be able to be powered from either battery bank. The main propulsion bus shall be capable of being split so that a fault on one portion of the bus allows vessel operation with full ship service power capacity and one of the two propulsion motors.

The VES shall provide for connection to a standby generator to supplement the battery capacity when schedule constraints limit available charging time or failed equipment impacts the availability of utility power. The standby generator is anticipated to operate less than 5% of the time the ferry is operating but could run for up to 24 hours continuously if needed. Load cases presented in this RFP are simplified to focus on battery sizing. The integrator shall not include the standby generator as a normal power source for energy capacity calculations.

Table 3 provides a summary of the major electrical power sources and loads on the ferry.

Table 3 Summary of major electrical power source and load estimates

Equipment	Qty.	Rating (each)	Notes
DC Propulsion Dist. and ASCS Interface	1	1.85 MW 1000V DC (nom.)	See Section 003.3
Propulsion Battery Banks	2	750 ekW (charge/discharge) 10 year life	Energy storage capacity to be based on operating profile, see Section 002.1.4
Propulsion Motors/Drives	2	650 ekW Variable speed drive	See Section 002.1.1
Auxiliary AC Generator	1	550 ekW	See Section 002.2.1
Ship Service AC Switchboard	1	160 ekW 208Y/120V, 3Ø, 4W, 60 Hz	See Section 002.3
480V Aux. Panel	1	200 ekW 480V, 3Ø, 3W, 60 Hz	
Ship Service Shore Connection	1	60 Amps 480V, 3Ø, 3W, 60 Hz	For use when moored and not in operation, see Section 002.2.2

The basic arrangement shown in Figure 3 and Reference 3 is a firm requirement. Integrators are encouraged to propose minor variations that provide the best value to Skagit County. Four main variations are anticipated:

- **Battery and DC bus voltage:** voltages other than 1000VDC are acceptable
- **Battery connection:** batteries may be directly connected to the DC bus, utilize a separate DC/DC converter for each string, or use parallel strings through a single converter
- **Charging interface:** Charging through the ASCS may utilize AC or DC power
- **Interconnecting arrangements:** variations in the connection arrangements for the ASCS, auxiliary generator, and bus-tie concept are acceptable. Proposals shall clearly indicate whether DC bus ties are intended to be normally closed or normally open.

Attention is drawn to Section 005.3, as some variations submitted in response to any previous RFIs do not meet the new reliability criteria.

002.1 Electric Propulsion

002.1.1 Propulsion Motors

Two (2) 650 ekW variable speed motors powered by variable speed inverters will provide power for the azimuthing L-drive propulsors. The following are general motor characteristics which should be used for the purposes of this proposal:

a. Water-jacket cooled.

b. Permanent magnet (PM) synchronous type. Alternative motor topologies, if proposed, should be accompanied with detailed cost and performance justification.

c. V1 flange mount (vertical, shaft facing down, to interface with propulsor).

d. Continuous duty.

e. Embedded winding temperature sensors.

f. DE & NDE bearing temperature sensors.

g. 0-100% speed control.

h. 5200 Nm torque at 1200 rpm.

i. 1200 rpm maximum (both directions).

The above characteristics are preliminary and will be confirmed as the design progresses. The motor height above the thruster flange shall not exceed 38”.

Up to 25% of the ferry’s annual energy consumption will occur while pushing the dock. Efficiency at all motor speeds is critical. Curves of efficiency vs. speed/power for the proposed motor and drive should be included in proposals.

002.1.2 Propulsion Motor Drives

Propulsion motors shall be driven by variable speed drives. The propulsion drives must interface with the power management system and power limiting functions (see Sections 002.1.2 and 005.1).

Proposals shall document integration requirements between the motors and drives such as switching frequencies, filters, or dU/dt limits.

002.1.3 Propulsion Control System (PCS)

A basic PCS provided with the thrusters will allow for thrust and azimuth control of the two L-drives from the pilothouse. The PCS is outside of the integrator’s scope of supply. The propulsion drives shall interface with the PCS to provide the required control, feedback, and safety functions. The PMS shall interface with the PCS for power limit control functions. The PCS interface is not intended to be used for primary control of charging equipment.

002.1.4 Propulsion Batteries

Two sets of propulsion battery banks must be configured to serve as the two electrical power sources required by USCG. The batteries should be sized to provide a 10-year operational life based on the load profiles and trip counts listed in Table 4 (based on 24 round-trips per day, 350 operating days per year). The power values in Table 4 are the total propulsion and auxiliary load for the ship and will be shared between the two battery banks. Note that propulsion power will be split unevenly forward and aft. The expected split will be determined later in design and finalized during sea trials, but may be as high as 80% aft/20% forward. Designs intended to operate with split DC busses shall account for this split when sizing batteries.

In addition to meeting the specified lifetime performance, each battery bank shall be capable of 750kw continuous power for 3 minutes for contingencies such as extremis maneuvering.

Integrators are optionally requested to additionally submit cost and performance data for one alternate battery configuration, sized for a shorter replacement interval such as 5 or 7 years. All other battery requirements remain the same, including load profiles, number of runs per year, and minimum continuous power rating. This configuration will be for information only; cost and performance evaluations of proposals will be based solely on the baseline 10-year configuration.

Each battery bank shall have the following features/capabilities:

a. Independent battery management system.

b. Battery modules equipped for isolation and mitigation of thermal runaway.

c. Meet the requirements of USCG Policy Letter CG-ENG 02-19 and ASTM F3353-19, *Shipboard Use of Lithium-Ion Batteries*.

d. IEC 62619 certified. Batteries certified to UL 1642 may be accepted if they have also been tested for cell-to-cell propagation.

e. Classification society type-approval is not required, but will be viewed as beneficial to the program risk reduction.

Table 4 Load profiles for propulsion batteries based on environmental and operational variation

Segment		4620 trips per year		2520 trips per year		1260 trips per year	
		Average Run		*Above Average Run*		*Maximum Run*	
		Time [minute]	Power[1] [kW]	Time [minute]	Power[1] [kW]	Time [minute]	Power[1] [kW]
Anacortes to Guemes Isl.	*Maneuver*	0.9	381	0.9	433	0.9	480
	Ramp Up	0.8	552	0.8	631	0.8	700
	Cruise	1.2	467	1.3	532	1.4	590
	Ramp Down	0.8	338	0.8	384	0.8	424
	Maneuver	1.0	381	1.0	433	1.2	480
	Unload/Load	9.0	138	9.7	227	10.2	406
Guemes Isl. to Anacortes	*Maneuver*	0.9	381	0.9	433	0.9	480
	Ramp Up	0.8	552	0.8	631	0.8	700
	Cruise	1.2	467	1.3	532	1.4	590
	Ramp Down	0.8	338	0.8	384	0.8	424
	Maneuver	1.0	381	1.0	433	1.2	480
	Connect/Disconnect	1.0	138	1.0	227	1.0	406
	Unload/Load (charging)[2,3]	10.7	-522	9.8	-751	8.7	-1197
Round Trip Energy		30 min	89 kwh	30 min	117 kwh	30 min	165 kwh
Profile RMS Power[4]			401 kw		529 kw		760 kw

1. The indicated power includes nominal efficiencies applicable during battery discharge: 2.5% battery losses and 1.5% DC/DC converter losses
2. The profile includes 30 seconds to transition between arrival and charging, and between charge completion and departure. This includes time for the ASCS to connect and for the electrical systems to ramp up to full charging power. If more time is needed, profiles and equipment ratings shall be adjusted appropriately.
3. Battery charging power only. During charging, propulsion and hotel power are provided by the SES/ASCS. See section 003.2 for power requirements at the SES
4. Time-weighted RMS power calculated as:

$$\mathrm{P}_{\mathrm{RMS}} = \sqrt{\frac{1}{\mathrm{t}_{\mathrm{total}}} \sum_{i=0}^{n} \mathrm{t}_i \cdot \mathrm{p}_i^2}$$

002.1.5 Power Management System (PMS)

Requirements for the ferry PMS are described in section 005.1.

002.2 Supplemental Power Sources

002.2.1 Auxiliary Generator

A 550 ekW diesel generator will serve as an auxiliary power source in addition to the main battery electric system. The generator is expected to operate in the following instances:

a. Utility blackout at the Anacortes terminal which prevents charging of the propulsion batteries through the ASCS.
b. Preventive or corrective maintenance on the SES or ASCS.
c. Schedule issues or unusually high propulsion loads that prevent maintaining acceptable battery charge level in the available charging time between trips.
d. Transit off-site or emergency operations outside of typical operating profile.

To minimize the need for additional transformers, the integrator shall specify an appropriate AC voltage to allow the genset connect to the main DC bus via the proposed rectifier. The genset will be procured to the integrator's specifications.

The VES shall include all required interfaces to connect, control, and provide electrical protection of the standby generator, including the following:

a. Base load operation in parallel with battery banks. Baseload setpoint as percent power to be manually adjustable through the PMS interfaces.

b. Manual start/stop and connection capability through PMS.

c. Standard generator protection features including overcurrent, short-circuit, reverse power, and functions to automatically disconnect the generator upon high voltage or 100% battery SOC.

The standby generator skid is planned to include a local operator panel to handle standard alarm and protection functions such as over-speed, high-temperature, low-pressure. These functions are expected to be outside the scope of the VES.

Other than the exception described below, supply of the Auxiliary Generator itself should not be included in the scope of the VES proposal; the genset skid is intended to be provided by the shipyard.

Exception: Integrators may propose an alternator where unique equipment is required to interface with the integrator's conversion equipment. In this case, include the proposed equipment in the technical proposal. Itemize the alternator as a line item in the commercial proposal to allow equitable comparisons of differing scope.

002.2.2 Auxiliary Shore Power

A ship service shore power receptacle rated for 480V, 3-phase will provide power for the ship service system while the ferry is moored at the Anacortes terminal and unattended (ASCS not intended to operate while ferry is not crewed). The rating of the circuit will be approximately 60 amps, to be finalized later in the design process. The receptacle will be located on the Anacortes end of the ferry and will be used for manual connection to the shore power cable. The receptacle is outside the scope of this RFP and will be provided by others. The grid converter supplying the 480V switchboard shall have bidirectional capability so that shore power can be supplied to auxiliary loads on the main DC bus.

002.3 AC Distribution

The integrator shall supply 480V and 208/120V switchboards as shown in References 2 and 3, including appropriate control and interlocking arrangements to prevent paralleling across the 208V tie breaker.

The panelboards supplying distributed loads (P1 thru P4) and the 24VDC system are not in the scope of this RFP and will be provided by the shipyard.

It is assumed that power conversion equipment (transformers and inverters) supplying the AC distribution switchboards will be considered to be part of a "source of power" as defined by the USCG. See Section 006.1 for reliability requirements for this equipment.

003 SHORESIDE ELECTRICAL SYSTEM (SES)

The SES includes the infrastructure required to bring utility power to the ASCS. This includes a shoreside battery bank to provide energy storage to accommodate high charging power without incurring high utility demand (peak) costs. Figure 3 shows the scope of supply for the SES. The SES shall be installed at the Anacortes ferry terminal.

Cables and wireways to interconnect the utility, SES, and ASCS will be provided by others to the integrator's specifications.

Table 5 provides a summary of the major electrical power sources and loads on the shore.

Table 5 Summary of major electrical power source and loads

Equipment	Qty.	Rating (each)	Notes
ASCS Interface	1	1.85 MW 1000V DC (nom.)	See Section 003.2
Shore Battery Banks	1	600 ekW (charge) 1200 ekW (discharge)	Energy storage capacity to be based on operating profile, see Section 003.3
Main Transformer and AC/DC Converter	1	800 ekW	See Section 003.2 Includes 600 ekW for charging the ship and 200 ekW for supplying the terminal. Increase size as necessary for proposed cooling or other auxiliary equipment.
AC Terminal Distribution	1	400A supply 480V, 3Ø, 3W, 60 Hz	See Section 003.5

003.1 Electrical House

The SES must be installed in a weather-proof electrical house or other purpose-built structure located as shown in Figure 5. The electrical house shall include the medium-voltage distribution switchgear, the shoreside DC charging system, shoreside battery bank, low-voltage AC terminal distribution, and the related transformers and converters.

The electrical house shall be complete with lighting, ventilation, and all necessary safety and monitoring equipment for the electrical distribution system and battery installation. Cooling equipment, if required, shall be included in the proposed scope and shall be supplied from electrical panels in the integrator's scope. Water cooled equipment on shore is not permitted. Proposals shall describe the intended approach to battery safety, including actions to combat a fire or thermal event. Fire-extinguishing equipment should be automatically actuated.

Building foundation and other civil and structural modifications required to facilitate the electrical house will be provided by others.

The estimated area for all electrical equipment, including the electrical house including all access, inspection areas, and clearances is 20' x 40'. Outdoor-rated equipment, such as primary transformers, may be utilized outside of the house.

Figure 5 Proposed location for SES electrical house and utility connection infrastructure

003.2 Utility Connection

Puget Sound Energy is the electrical power utility which serves the Anacortes ferry terminal. Existing utility primary distribution to the terminal is through four-wire, medium voltage (12.47kV), effectively grounded, overhead lines.

The new utility connection service will be under PSE Schedule 26 for large demand general service (>350kW) at primary voltage. The SES must include all equipment required by PSE beyond the Point of Delivery, including switches, cut-outs, and other items related to utility service at the primary voltage. These items should be installed as part of the electrical house and provisions should be made for access as required by PSE. A pad-mounted primary meter will be provided by PSE.

The connection shall comply with applicable requirements including Reference 4 and articles 712 and 705 of the NEC.

Proposals shall describe the approach to prevent export of power in the event of a utility blackout. This could include inherent limitations of power conversion equipment, or anti-islanding control features for the utility disconnect.

003.3 Shoreside Batteries

Shoreside batteries are specified to reduce power demand charges from the utility. The batteries shall be sized to provide a 10-year operational life based on the load profiles listed in Table 6. The times listed for ferry charging are based on the expected time available for charging during unloading and loading of passengers and vehicles at the Anacortes terminal. “Vessel Charging Power” includes the power associated with recharging the VES battery banks, a profile-dependent propulsion allowance to push the ferry against the dock, and an allowance for ferry hotel loads. Typical efficiency factors were applied to account for power losses between the end consumers and the SES battery bank.

The shore batteries are recharged from utility power while the ferry makes the next trip. A constant charging rate is desired to minimize utility demand charges.

The shoreside battery installation shall be complete with a battery management system, and other required safety equipment.

Table 6 Shoreside battery load profiles based on environmental and operational variation

Operation	4620 trips per year		2520 trips per year		1260 trips per year	
	Average Run		*Above Average Run*		*Maximum Run*	
	Time [minute]	Power [kW]	Time [minute]	Power [kW]	Time [minute]	Power [kW]
Vessel Charging (Shore Battery Discharge)[1,2]	10.7	427	9.8	670	8.7	1160
Shore Battery Charging[2]	19.3	-258	20.2	-354	21.3	-517
Profile RMS Power[4]		328		481		762

1. The indicated power includes nominal efficiencies applicable during battery discharge: 2.5% battery losses, 1.5% shore DC/DC converter losses, and 4.5% transmission losses from shore to ship. Transmission losses include 3% for cabling and 1.5% for a DC/DC converter.
2. The profile includes 30 seconds to transition between arrival and charging, and between charge completion and departure. This includes time for the ASCS to connect and for the electrical systems to ramp up to full charging power. If more time is needed, profiles and equipment ratings shall be adjusted appropriately.
3. Charging power includes nominal efficiencies including 2% battery losses and 1.5% converter losses.
4. See Table 4, Note 4

003.4 Charging Bus

To provide interconnection of the shore batteries, utility power, and ASCS, a main bus shall be provided in the SES. This bus may be AC or DC, as appropriate for the proposed architecture. Appropriate power conversion equipment shall be provided to connect AC and DC systems.

AC/DC conversion equipment shall be designed to meet the utility's requirements for power quality at the point of common coupling. Limits include 3% for an individual harmonic, and 5% total harmonic distortion. The integrator shall be responsible for any studies or calculations needed to show power quality requirements are satisfied.

003.5 AC Terminal Distribution

Low voltage 480 V, 3-phase terminal distribution shall be provided. The existing terminal ramp infrastructure are supplied by a circuit fed from a utility transformer. This project will relocate this circuit to the SES in its entirety. No further modifications to the existing terminal electrical infrastructure are planned. An additional circuit shall be provided to allow for future expansion, such as electric car charging. Terminal loads are variable, including overnight shore power, terminal building HVAC, ramp hydraulic motor operation, and car charging. Owner required loads are summarized here:

Load	Characteristics
Terminal/Ramp Supply	400A, 480V, 3Ø, 3W, 60 Hz
Reserved Circuit (Future EV charging)	90kw, 480V, 3Ø, 3W, 60 Hz

Circuits shall also be provided for any equipment in the integrator's scope that requires power. Note that contrary to Reference 3, auxiliary power to the ASCS should be supplied directly from the 480V distribution in the SES. The ramp distribution panel will not be modified with new circuits to supply the ASCS.

Power consumption of the terminal distribution loads should be coordinated with the charging system through the PMS. This information should be included in optimization of the SES charging cycle. See Section 005.2.

004 AUTOMATIC SHORE CONNECTION SYSTEM (ASCS)

The ASCS includes the physical interface between the ship and the shore, including the socket on the ship.

004.1 Power Transfer and Connection Requirements

Table 7 Connection requirements

Energy Transfer	165 kWh
Power Transfer*	1.2 MW
Connect/disconnect duration*	30 seconds (each)
Available duration for connection	~10 minutes

*Estimated values, including time to ramp up to full power delivery. This may be adjusted by integrator based on proposed ASCS capabilities, but VES and SES battery profiles must be adjusted accordingly to maintain the schedule.

The ASCS must be capable of completing a full connection, charge, disconnect cycle with minimal supervision from the crew. Operation of the ASCS will be primarily monitored from the pilothouse. The pilothouse should be equipped with controls for one-touch commands for connection and disconnection, emergency stop/disconnect, and other manual operations. All other aspects of the charging cycle should be automated through interfaces between the SES, ASCS, and VES.

Viable ASCS options using both AC and DC charging were submitted during the first RFI process. Either option is acceptable; the basis for the selected transmission method should be described in the proposal.

004.2 Equipment Location and Configuration

Based on various project limitations, Glosten has determined that the nominal location of the ship-side ASCS socket will be on the upper deck, forward of the house, as shown in Figure 6. Although alternate locations may be submitted, the departure from the current preliminary design will be considered a proposal weakness and should only be suggested if outweighed by significant benefits.

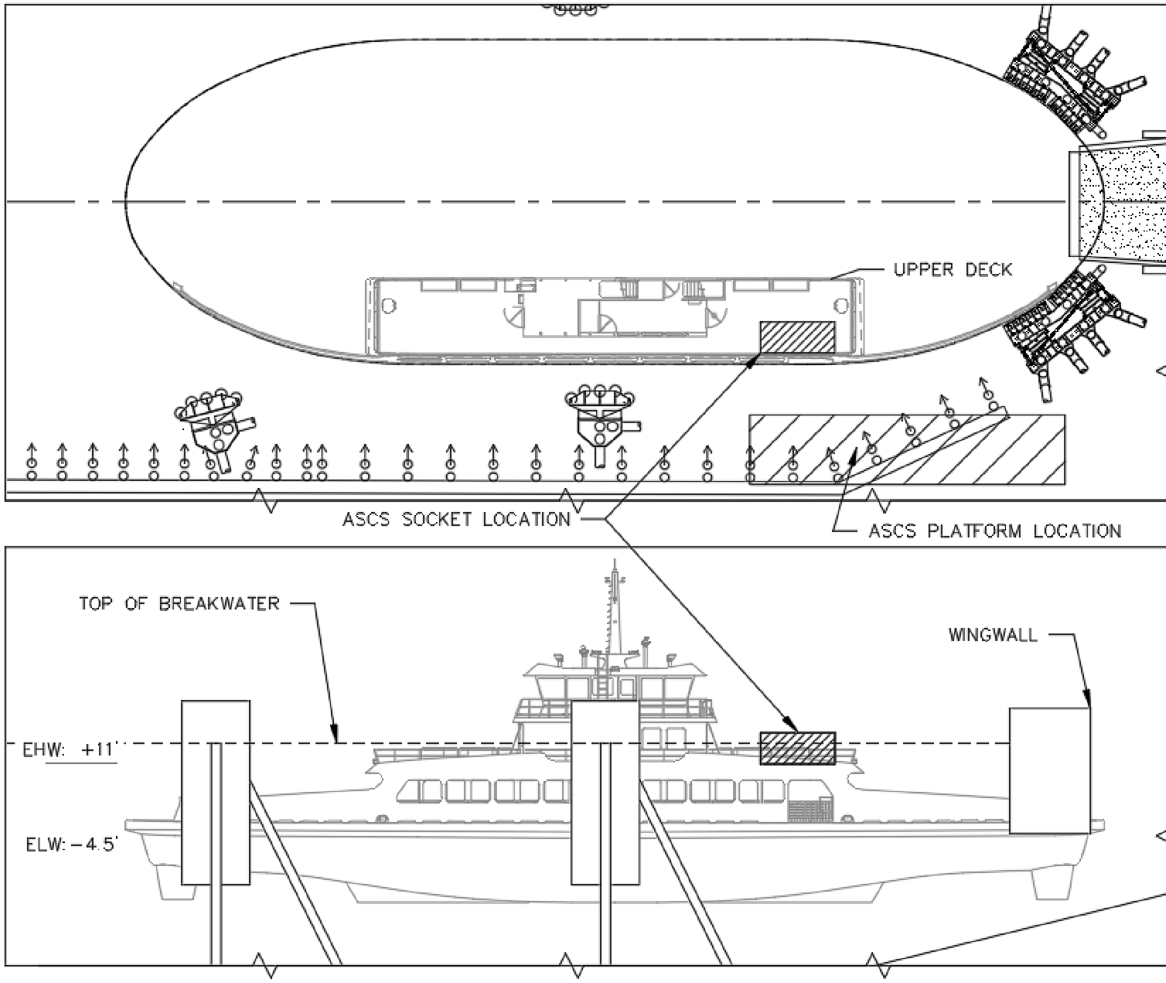

Figure 6 Vessel layout and selected location for vessel portion of ASCS (vessel shown in low tide position)

004.3 Range of Motion Requirements

The expected range of motions for the ferry while the ASCS is active are listed in Table 8. The ASCS must be able to connect to the ferry across a wide range of tidal heights, and then follow the ferry through dynamic movements without interrupting power transfer to the ferry or damaging equipment.

The range of motion listed in Table 8 does not account for the range required for the ASCS to deploy from a standby position out of the way of the ferry. See Section 004.2 regarding positions and clearances around the ferry while docking.

Table 8 Range of vessel motion

	Static Range of Motion	Slow Range of Motion	Fast Range of Motion	Additional Details
Transverse Motion	NA	6’ 6”	± 4”	Section 004.3.1
Vertical Motion	16 ft	NA	± 21”	Section 004.3.2
Angular Motion			± 4°	Section 004.3.3

004.3.1 Yaw and Transverse Motion

During loading operations, the ferry normally rests against one set of dolphins as wind and waves dictate (see limiting positions in Figure). During a given loading/charging operation, the ferry will use propulsion to keep position in the center of the terminal to facilitate loading long vehicles. To meet these operational requirements, the ASCS shall have the capability to charge the ferry in either extreme position and move between the two positions during charging.

Due to the interaction of the bow of the ferry with the wing walls, the center of yaw is assumed to be at a point 20' aft of the bow (60' forward of amidships). The bow refers to the Anacortes end of the ferry, as shown in Figure . Based on the center of yaw and the nominal charging socket location, the estimated range of motion required to meet the yaw requirement is 6'-6". The specifics of a given ASCS installation may require a greater range of motion.

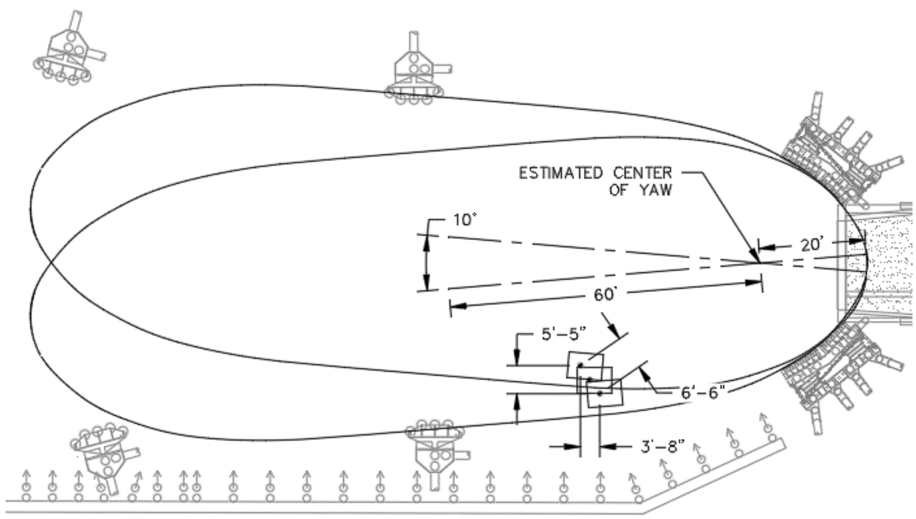

Figure 7 Required yaw range

004.3.2 Tidal Compensation

The shoreside portion of the ASCS will be installed on a fixed foundation supported by steel piles. The ASCS shall be able to compensate for 16’ of static vertical variation, including 15.5' of tidal range and 6” of variation in vessel draft. At any position within the 16’ vertical range, the ASCS must also accommodate the dynamic motion specified in Table 8 and Section 004.3.3.

004.3.3 Dynamic motions and socket velocities

Actual motion of the ASCS socket will be relatively complex due to interaction roll, pitch, and heave on the ferry. The ASCS shall be capable of accommodating angular motion of the socket as listed in Table 8. Angular motion could be along any horizontal axis.

For evaluation purposes, it can be assumed that the main linear movement resulting from vessel roll is simple vertical harmonic motion with a period of 6.6 seconds. For the fast vertical motion listed in Table 8, this corresponds to a peak vertical velocity of ±1.6 ft/s. The ASCS shall accommodate this velocity without disconnecting.

004.4 Safety Provisions

The size and arrangement of the ferry requires the charging connection on the ferry to be located near crew areas and various structures. Any shore connection system must be able to provide a high level of protection for passengers and crew and minimize the risk of physical damage to the ferry and shore connection equipment.

Proposals shall describe in detail safety provisions and protections that are either integral to the system or should be provided by others as part of the overall ferry and terminal installations. This should include prevention or mitigation of risks associated with planned and unplanned events, including:

- Movement of ASCS components between standby and charging positions.
- Unplanned or unexpected actuation of automatically controlled ASCS equipment.
- Electrical faults.
- Failure of electrical disconnects, ground connections, or safety controls and monitoring.
- Interference from water spray, or other foreign objects into normal deployment and charging.
- Vessel motions outside the allowable range that could cause physical damage to the charging connection.
- Unplanned disconnection due to extreme vessel motion or ferry departure.

004.5 ASCS Maintenance Requirements

ASCS maintenance presents a significant operational challenge for Skagit County. The planned location of the ASCS platform is approximately 200 feet from shore and can not be accessed with trucks or portable lifts. Required access for preventive and corrective maintenance will be a major design criteria for the ASCS platform. Proposals shall describe in detail the periodicity and physical access requirements of routine preventive maintenance items. Preventive or corrective maintenance requirements that require lifting support shall be minimized and described. It is accepted that initial installation will require a crane barge, but routine maintenance and repair work should not require a barge.

005 CONTROLS AND INTEGRATION

Concepts for HMI screens and panel/console faces shall be submitted for owner comment and approval during the contract design phase.

The power management system should be a non-proprietary system that allows adjustment over the life of the ferry to meet a changing energy market. A qualified person shall be capable of future modifications to the system.

005.1 VES Power Management System

The Power Management System (PMS) will provide control and monitoring of the power sources, switchboard configurations, and interface with the BMS. The PMS shall incorporate integrator-furnished HMIs and other operator interfaces at the main switchboard and two pilothouse control stations (one facing each direction). The PMS should include the following features:

a. Automatic power-limit control of propulsion motor drives as required to avoid prolonged overload and blackouts.

b. Control, monitoring, and safety function interfaces with the ASCS and SES to enable automated charging and safety disconnections as described in section 005.3.

c. Controls to remotely bring the standby generator on and off-line and set the power generation level.

    1. Normal operation of the standby generator will be manual only, with no automatic start/stop functions except for safety related shutdowns.

    2. When shore charging is unavailable (to the ship or to a bus), the power management system shall be capable of both charging batteries from the genset and supplementing genset power with battery discharge.

d. Alarm, monitoring, and control of equipment within the scope of the electric propulsion system, including equipment faults, motor alarms, propulsion battery health and status, breaker status, voltage, frequency, current, etc. Thruster alarms will be integrated with a separate vessel alarm system.

e. Monitoring of power consumption and battery SOC with options for real time comparison to a range of previous trip profiles, averages, and targets.

f. Monitoring and alarm of the battery SOC which provides indication of various SOC thresholds and a range of alarms activated by SOC levels outside of the nominal range.

The PMS shall include or interface with a method of logging parameters of the electric propulsion system such as energy consumed, propulsion power, ship service power, and SOC. The goal is a system that easily allows management analysis of energy consumption.

005.2 SES Power Management System

A PMS must be provided as part of the shoreside DC charging system. The purpose of the PMS is to coordinate ferry charging and charge/discharge of the shoreside batteries with power demand from the utility, to optimize operational costs. The primary function will be to reduce the peak monthly power demand from the utility, with a secondary function to optimize the cycling of the shoreside batteries to maximize battery life.

A desired function, though not required, is the ability for the PMS to respond to intermittent AC terminal loads with the goal to reduce peak power draw from the utility. These terminal loads include cycling loads in the terminal and the ramp machinery.

005.3 Bonding and Grounding

During charging, the VES and SES shall be bonded together to prevent dangerous touch voltages resulting from differences in the two electrical ground planes. However, bonding the ship to the shore has been associated with corrosion problems in some applications. The lack of standardized solutions for this problem is noted. Integrators are encouraged to propose strategies to minimize corrosion enabled by the ship-shore bonding connection.

The ferry will be equipped with an Impressed Current Cathodic Protection (ICCP) system (provided by others).

Effective corrosion control strategies are valued; reasonable mitigation costs will not disadvantage a proposal.

005.4 Primary Charging Control and Safety

Proposals shall describe in detail the proposed approach to primary control of charging operations, including basic sequencing for safety, any strategies utilized to minimize excessive transients, and the basic control philosophy used to regulate charging.

Regulation of power flow during charging will depend on the specific integrator solution, but the following attributes are desired:

a. Provide a high level of automation and integration to simplify the operation for the crew.

b. Minimize wear from operating components under load

c. Minimize the need for real time communication between SES/VES by maximizing functional separation.

d. Optimization of demand charges and battery lifetime

This section should be interpreted as providing minimum functional requirements. Alternative approaches that provide a safe and efficient charging operation are encouraged and should be described and justified in proposals.

The following outlines the interfaces and connections expected to be required between the VES, SES, and ASCS to provide for basic control and electrical safety:

a. SES-VES ground continuity, with the VES and SES disconnection switches interlocked against closure until continuity is verified and opened on a continuity fail.

b. SES pilot circuit, circuit made by LMFB contacts in ASCS. The circuit will be energized by the SES control power, and the SES isolation switch will not be able to close unless the circuit is closed and will open if the circuit is broken. The VES shall provide a contact in series with the circuit to coordinate operation of the isolation switches. The ASCS shall also provide a contact in series, opened prior to any disconnection triggered by ASCS software. Electrical isolation shall not depend on disconnection of the pilot pins when an ASCS disconnect is triggered intentionally (e.g. if range of motion is exceeded).

c. VES pilot circuit, made by LMFB contacts in the ASCS. The circuit shall be energized by the VES, and the VES shore isolation switch shall not be able to close unless the circuit is closed and shall open if the circuit is broken. The SES and ASCS will provide contacts in series with the circuit to coordinate operation of the isolation switches.

d. Emergency shutdown circuit. Hardwired emergency stop capability shall be provided. This function may be integrated with the pilot circuits described above. An emergency stop command shall sequentially open the VES and SES isolation switches, disconnect the ASCS, and command the ASCS to a safe standby position. Three emergency pushbuttons shall be provided: one in the pilothouse, one at a TBD main deck location, and one at a TBD shore location.

005.5 Remote Communications and Data Transfer

In addition to the wired primary control circuits described in Section 005.4, a remote control and data transfer interface is anticipated to allow communication between the ship and shore systems. This interface is expected to include:

a. ASCS pilothouse control interface, providing signals to initiate connection, stop ASCS movement, or return the ASCS to a stowed/standby position.
b. Energy required and charging duration feedback to the SES during the ferry charging cycle, as required to optimize shore battery discharge to limit peak utility demand charges.
c. Feedback to the SES while the ferry is operating, including required energy and duration predictions for upcoming charge cycles, time remaining before next charge cycle, and other relevant data. This is intended to inform the shoreside battery charging rates while the ASCS is not connected as a means to further optimize each SES cycle.
d. Monitoring information from the SES to alert ferry operators of equipment faults, utility blackouts, or other shoreside electrical conditions which will impact ferry operations.

The functional requirements of this interface necessitate wireless communications. Proposals shall describe the proposed approach to ensure the security and reliability of this wireless link, system response to degradation or loss of the link during charging, and any backup modes that could allow charging to be initiated without a wireless connection.

If the SES control system includes external connections to the internet, e.g. for remote diagnostics, the system shall be fully capable of performing normal functions without an internet connection available. Proposals shall describe the cybersecurity measures used to protect the external connection.

006 RELIABILITY

In order to minimize ferry downtime and maximize use of shore electricity, the following reliability criteria must be satisfied.

006.1 Vessel Electrical System Reliability

006.1.1 Maintaining Propulsion After Faults

Following isolation of a faulty battery string or DC/DC converter, at least 50% of each propulsion motor’s design power shall be available via battery. This includes the unaffected battery strings connected through other converters on the affected side of the electric plant and, if a bus tie is provided, the other end's battery bank. Examples of arrangements that meet this requirement are shown in Figure 8.

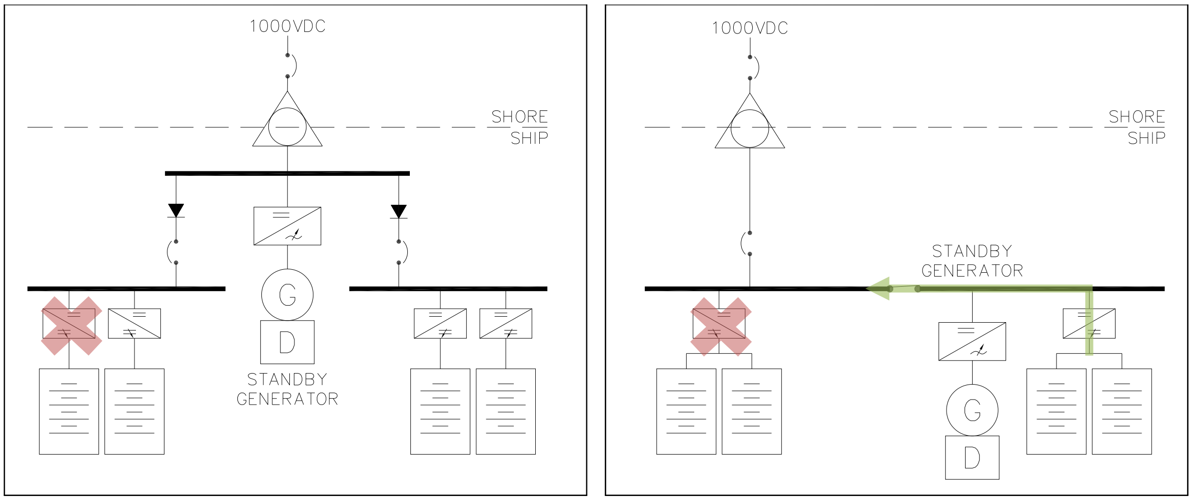

Figure 8 Two approaches that maintain 50% of each end's normal battery power following a single failure

006.1.2 Preventing Power Source Common Mode Failures

Upon failure of any single component, power supply to the DC bus must be possible from either the ASCS or the auxiliary generator. A single failure must not cause both sources to be unavailable. This includes mechanical devices such as breakers and contactors, but does not include cables or switchboard bus bars.

006.1.3 Maintaining Two Sources of Power

Following isolation of a faulty Ship Service Inverter (SSI), two separate sources of power to the 208VAC switchboard will not be available. This would preclude ferry operations until repaired.

Proposals should address this situation in one of two ways:

1. Describe the SSI components most likely to fail, suggest spare parts that should be stocked to allow immediate repair, and describe repair procedures including duration and whether specialized training is needed.
2. Design redundancy into the VES such that two independent sources of power are still available after an inverter fault. For example, splitting the 140kw rating of the SSI's into two parallel modules is an acceptable solution if the modules are capable of independent operation.

If method #1 is chosen, the estimated cost of recommended spare parts maintained on board shall be included in the commercial proposal.

006.2 Shore Electrical System Reliability

006.2.1 Charging Without Shore Batteries

Following isolation of a faulty battery string or DC/DC converter, the SES shall be capable of charging the ferry at rated power of the utility transformer. Partial use of unaffected batteries is beneficial but not required.

006.2.2 Limit Single Point Failures

The number of single points of failure between the utility and ASCS shall be kept as low as practicable. Favorable consideration will be given to designs that provide cost-effective redundancy for critical components such as contactors.

006.2.3 Graceful Degradation

If AC/DC conversion equipment (e.g. AFE or DFE rectifier) is modular and remains operable with reduced ratings following an equipment failure, this should be noted and will receive favorable consideration.

007 CONTRACT DATA, DESIGN STUDIES, AND SUBMITTALS

007.1 Design Studies

The selected integrator shall be responsible for conducting all required electrical design studies, including short circuit analysis, breaker coordination, etc. This may include studies during the Contract Design stage needed to fully develop bid specifications and regulatory submittals.

Harmonic analysis of the SES, as required to show compliance with the utility's requirements, shall be the integrator's responsibility.

After selection, the integrator shall perform a lifecycle cost study to evaluate favorable alternatives to the battery chemistry and replacement interval specified in the foregoing sections.

The overall vessel one-line diagram and electrical load analyses will be completed by others; the integrator shall supply information related to equipment in their scope to allow development of these documents.

Torsional vibration analysis of the thrusters will be performed by others; the integrator shall supply any motor characteristics needed for the analysis.

The integrator shall support the detailed design of the ASCS platform, providing any required information on structural loads, maintenance envelopes, and installation/repair procedures. The integrator will certify that the final location of the ASCS foundation achieves the required range of motion.

007.2 Regulatory Submittals

007.2.1 USCG

USCG submittals will be coordinated by a single point of contact. This will be Glosten during the contract design phase and the shipyard during the construction phase. The integrator shall prepare all drawings, diagrams, reports and other information necessary to obtain approvals on their scope of supply. This includes:

- Design studies
- Switchboard schematics, wiring diagrams, bills of material, and nameplate lists
- Wiring diagrams for electrical automation equipment
- Battery Qualitative Failure Analysis

The integrator will also assist in the development of

- Design Verification Test Procedures
- Periodic Safety Test Plans
- Manufacturer's recommendations for battery/battery room firefighting
- A propulsion control description of operation
- Any additional documents required by USCG under 46CFR §110.20-1 for equivalency determination.

007.2.2 Washington State/Puget Sound Energy

The integrator shall be responsible for obtaining shore electrical permits, including preparation and submittal of all approval documents to shoreside electrical inspectors and utility authorities.

008 TESTS AND COMMISSIONING

Proposals shall describe:

- The planned testing and commissioning approach
- Estimated durations for each phase.
- Estimated costs for testing and commissioning shall be included in the commercial proposal.

Minimum requirements include:

- Factory Acceptance Testing (FAT) for batteries, switchboards, the ASCS, and associated control systems. FAT will be attended by an Owner's representative. FAT procedures shall be submitted for review and comment prior to the FAT and must be approved at least one month prior to test execution.

- Commissioning support for the VES at the shipyard, including dock and sea trials. The integrator shall be responsible for preparing test procedures that can be performed at the building yard without the ASCS available. For cost estimation purposes, assume the shipyard is in Washington.

- Commissioning support in Anacortes for the SES and ASCS

- Commissioning support for integrated vessel/shore testing

009 MAINTENANCE AND SUPPORT STRATEGY

Proposals shall include the following information to allow evaluation of maintenance requirements:

- Warranty coverage offered for major equipment

- Preventive maintenance schedules for the VES, SES, and ASCS. Schedules should include frequent tasks (e.g. weekly/monthly inspections or cleaning) and infrequent tasks (e.g. replace batteries every 10 years). Schedules should identify the following for each task:

    - Task qualifications (i.e. which tasks can be completed by ferry crew and which require specialists)

    - Labor-hour estimates

    - Operational impact (shore charging unavailable, ferry out of service, etc)

- Options for specialist support from technicians certified by equipment manufacturers, including

    - Location of the nearest certified technicians/support facility

    - Response time for technician on site (typical and worst-case guarantee)

    - Day rates for support

    - Service contract options

    - Remote troubleshooting and problem diagnosis capabilities

- Spare parts strategies
  - List and cost of recommended spare part inventories to be maintained by the county
  - Estimated lead times for spare parts not stocked by the county
  - Note: the vessel is designed for in-water replacement of propulsion thrusters. Skagit County plans to maintain a spare thruster to minimize downtime in the event of a failure.
- Strategies for and past experience with training crewmembers in routine preventive and corrective maintenance tasks