Ferries and Electricity – Some Recent Insights

The EBDG designed diesel-electric ***M/V Amadeo Saenz*** owned and operated by the Texas Department of Transportation. EBDG performed a feasibility study for a possible conversion to hybrid diesel-electric propulsion. Photo courtesy of Travis Bergh, Southwest Shipyard.

By John Waterhouse and Eileen Tausch

Over the past five years the marine press has had numerous articles on electric propulsion. Beginning with the ferry AMPERE in 2015, new vessels have entered service with a variety of propulsion schemes, whether all-electric, battery hybrid, diesel-electric with battery boost, or even hydrogen fuel cells. As a consequence, operators, vendors, designers and shipbuilders are being asked by customers, oversight boards, or key stakeholders whether electricity should be considered for their operation. The questions may be prompted by a desire to reduce emissions, save operating costs, or provide a better customer experience. Regardless of the motivation, there is a keen interest in this new technology.

Elliott Bay Design Group is working with several ferry operators on the feasibility of electric propulsion. This may be for new vessels that are under design or existing vessels due for repowering. In response, we have developed a process to analyze the pros and cons of electrification and to estimate the outcomes. The latter can include capital costs, operating costs, emissions impacts, reliability assessments and maintenance schedules. Our electrical and marine engineers are avidly attending conferences and meeting with operators to gather hard data wherever possible. As a result, we have learned some key lessons that we wish to share with others looking at electric propulsion.

Electric ferries are fundamentally about energy usage to move passengers and vehicles between fixed points. Therefore, the feasibility assessment must begin with an understanding of the route dynamics. This includes distance, weather and hydrographic conditions, maneuvering distances, dock configurations, vessel speed and time in dock loading and unloading the vessel.

Since energy usage goes beyond propulsion, the loads due to air conditioning, heating, lighting, steering, pumps, etc. must be included. Engine electronics can provide most of the data, but older mechanical engines and generator sets may need to have data logging equipment temporarily installed to collect information for a week or so.

Each ferry operation is different. For operators that move ferries among different routes, each route needs to be assessed. For example, Washington State Ferries operates six 130-car ferries. These vessels may be deployed on the shortest route in the system (Clinton to Mukilteo at 2.9 nautical miles) or on the longest route (Anacortes to Friday Harbor at over 30 nautical miles). Clearly, these two routes will have very different energy profiles.

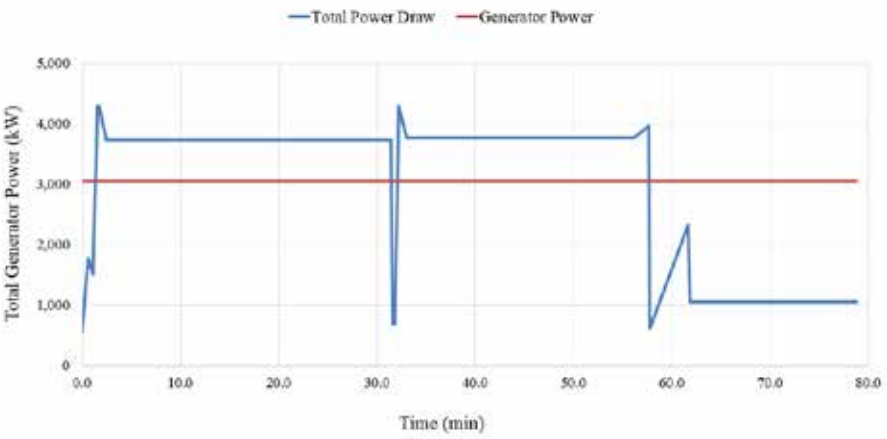
After gathering a thorough understanding of the energy usage, an operator can then begin looking at the issue of electric supply. This may be from shipboard generator sets, energy storage from batteries, overnight shore power, fuel cells, intermediate shore charging, solar cells, or some combination of all of these sources. The more shore power that can be supplied during the operating day, the smaller the onboard energy storage requirements. Some factors that may influence the electric supply decision include the following:

What are the electric rates from the local utility? Are there special rates for non-peak energy usage or for allowable service interruption?

What infrastructure will be required for shore charging? Is there a high capacity electric feed already at the dock? On both ends of the route or just one end? Who pays for electric charging infrastructure?

What philosophy applies to battery life? Are they consumables that can be disposed after 5 years? What new technologies are in the pipeline that may improve battery performance or reduce costs? Does one spend cap-ex or op-ex funds to replace batteries?

What non-routine situations need to be allowed for? Does the vessel need to reposition a long distance for dry-docking? What happens if the electrical grid is unavailable? Does the vessel need to respond to emergency situations?



A sample power profile for a representative load-levelling ferry route. The blue line represents the total power required for a transit, while the red line represents the constant power supplied by the propulsion generator sets. Where the blue line is above the red line, batteries are discharging to supplement the generator power. Where the blue line is below the red line, the generator sets are charging the batteries. Artwork courtesy of EBDG.

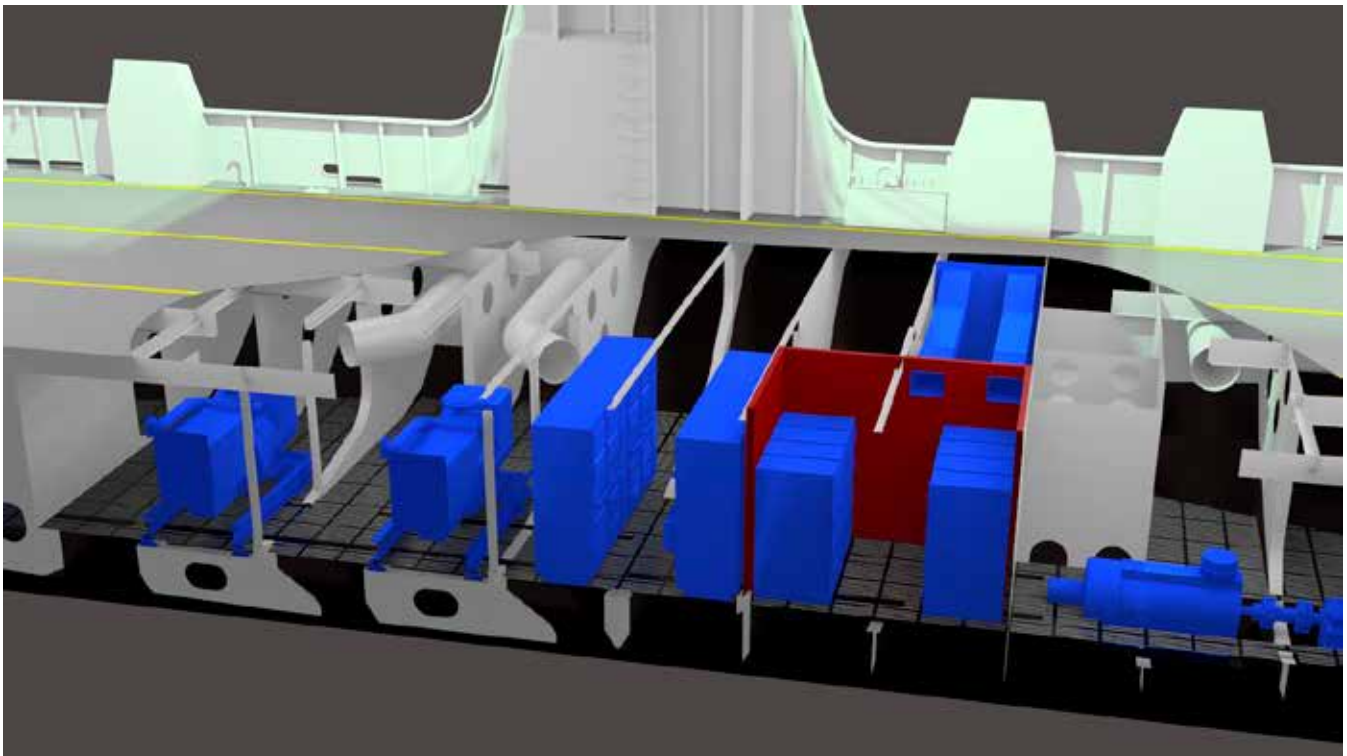
How important is it to reduce emissions? How "green" is the electricity that is being purchased? Can EPA Tier 4 requirements be avoided by having smaller generator sets? What future technologies can be anticipated and perhaps accommodated in the design?

After gathering answers to the electric supply questions, the next step is to establish criteria for evaluating different technologies. These typically will involve capital costs, fuel costs, maintenance impacts and reliability. Other factors may include customer experience (quieter, no exhaust smell), environmental footprint (emissions, noise impacts on aquatic species, disposal of batteries, use of renewable energy sources), or training for crew and maintenance personnel (special classes, vendor support/availability, USCG requirements for vital systems). Electric ferries will certainly have higher capital costs than conventional geared diesel ferries. The big question for operators is whether the benefits will outweigh the costs.

The operator can now pull out all the brochures and sales materials that vendors have developed to identify some combinations that may make sense for their needs. For short routes at low speed, an all-electric configuration may be possible. For long routes, some combination of diesel generators and battery storage may be one candidate combination, while geared diesels with an electric motor connected to a power-take-in on the gearbox might be another. The latter would allow use of batteries or smaller generator sets for slow speed operation or while at the dock, with efficient diesels for transit operations. Shore charging may reduce the size of the battery bank or extend the life of the batteries.

There may be additional choices as to whether the fundamental system architecture uses alternating current or direct current. Different battery chemistries are available, each with their own positives and negatives. Hydrocarbon fuels may still be needed to provide sufficient winter heat, or to give an alternative source of energy should the energy storage be insufficient or disabled. There is a bewildering thicket of choices so good research is imperative.

Repowering an existing vessel will have more constraints than a new design that will need to be understood. The operator needs to identify available spaces that can be used for motors, batteries and electrical switchgear. The weight impacts of removing mechanical drives and perhaps some fuel capacity and replacing them with electrical



The rendered image shows the engine room of the diesel-electric ferry ***M/V Amadeo Saenz*** with two propulsion generator sets, switchgear and drives, dedicated battery room and electric motor. Artwork courtesy of EBDG.

propulsion equipment should be evaluated. Shafting that might be adequate for a specific power and shaft speed may not be safe with a high torque electric drive. Issues of fire suppression and venting of toxic gases in the event of a battery fire need consideration.

It should be noted that the US Coast Guard is challenged by some of the new technologies that do not fit neatly into existing regulations. Any project involving large battery installations need to go through a risk analysis and approval process. The electrical engineering staff at the Marine Safety Center should be included in the planning at an early stage to ensure the safety concerns have been properly identified. All parties (operator, designer, vendor and shipyard) need to understand their roles and responsibilities as new technologies are installed, commissioned and operated.

Two things are clear to the EBDG team. Electric ferries have been around for more than 100 years, so in that sense they are old news. Electric ferries with new forms of energy storage and energy control will be an increasing presence on the waters of the world as communities look to improve transportation while respecting the environment. In that sense they are definitely new news and worthy of attention. We encourage the marine industry to share their knowledge and lessons learned from electric ferries. EBDG will certainly be sharing what we learn as we work with our clients and these new/old ways of moving ferries. PMM

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Elliott Bay Design Group is a sponsor of the 2019 Ferries Conference. More information can be found at www.ferriesconference.com