The business case for hybrid and electric technology in North America

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DF | Daniel Frank, HMS Ferries

Q&A Summary
What is the average life of this tug considering its propulsion system?

**PB** | For electric equipment in general, we expect lifecycle M&R costs to be reduced as there are few moving parts to maintain. Battery life is typically set to 10 years (at which time the existing batteries may be sold into a secondary market and replaced by a new ESS which is quickly decreasing in cost).
How will you deal with maintenance service in worldwide?

PB | ABB Marine maintains an active global service network operating in over 40 countries.
One of the slide mentions that there is no noise from the Zeetug. Does the Zeetug meet any of the current Silent or Silent R standard?

**PB** | Generally, underwater noise is driven more by propeller noise than onboard engines. While battery propulsion certainly helps, low-noise propeller design is a much bigger driver.
For battery hybrids and full battery applications what are the the longest operating times between recharging, particularly for tugboats and ferries? Have you analysed applications in container ships?

PB | Voyage length can be whatever the owner wants. However, as a practical matter, the more charging opportunities per day, the more favourable are the economics. Battery energy density and cost would have to improve several orders of magnitude to be considered for practical use in an oceangoing cargo vessel. ABB anticipates fuel cells will serve this market eventually.
Yes. There are two main reasons for a battery with a fuel cell:

(a) to handle transient loads since fuel cells are slow to adapt to power ramps. In this case, the ESS would be relatively small, with a usable capacity equal to the range of the typical power ramp - the time it takes the fuel cell to change its power output. This need is applicable to virtually any fuel cell vessel.

(b) to offer peak shaving. In this case, the goal is to avoid installing more-costly fuel cells and instead rely on the batteries for short periods of high power. This is only applicable to vessels with appropriate operating profiles, like a harbour tug.
When considering alternatives, when is battery power better than fuel cell-powered vessel?

**PB** | Use batteries whenever they are feasible - generally voyages that are short with high, predictable frequency. Ultimately, batteries will likely be limited to ferries, some harbour tugs, some towboats, and other vessels staying within a small geographic region.

From a technical perspective, fuel cells can work on most other vessels of any size and voyage length (the main challenges today are fuel storage, capital cost, and commercial availability of higher-power FC units).
Are US ports willing to absorb the costs of adding shore power to pier facilities or will these costs be borne by the workboat companies?

PB | For cold ironing (i.e. cargo ship plugs in while performing dock operations), typically, yes.

For charging a battery-powered boat, typically these vessels call at dedicated terminals that are owned/operated by the owner, so the operator absorbs the cost.
Merchant vessels are still planned to go with LNG, LPG and so on. Which is the most optimised non-fossil fuel model with such kind of vessels at the moment?

PB | It seems the most likely zero-emission solution for large cargo vessels is fuel cells with a hydrogen fuel carrier (e.g. ammonia).
Looking for partners as we scale our onsite seawater Hydrogen electrolysis solution, without desalination, and no need for deionized water. Yes, our technology works with tap water and wastewater. Gilman Industries - Cliff@InvestmentCapitalGrowth.com

PB | I will pass on to ABB's Energy Division.
For Will: besides capital costs, what are the infrastructure risks you perceive when moving towards all electric vessels?

**PB** | ABB sees reduced operating risk with electrifying vessels because redundancy is typically inherently improved and equipment tends to have higher MTBF than diesel engines.

**WM** | Coordination with the electric utility is a key component. One must understand the charging limitations, base rates, and demand charges. These shape what the shore charging setup will look like, if it has batteries or not, capacities, etc.
On YouTube I found an ABB solution called "Dynamic AC" for MV level (electrical) oriented to larger industrial vessels. Is this in the "proof of concept" stage or already commercially available?

**PB** | ABB's Dynamic AC is available for larger vessels, though for vessels with energy storage or fuel cells, ABB suggests a DC based power system.
Will existing crews be willing to lose the comfort of known diesel engines that require experienced operating engineers. How many jobs are lost with hybrid/pure e-propulsion?

PB | ABB doesn't see electrifying vessels as reducing crew sizes. However, operational and safety training will be required to understand how to operate some new equipment. Maintenance should be reduced.

WM | Crews must be willing to transition from pure mechanical systems to electric and digital systems. This skill transition is happening across all industries. We have not seen a reduction in crew on any vessels that have transitioned to hybrid or electric
Will - We've seen as much as 80% reduction in operating cost on Ampere - why don't these numbers come close to that?

PB | ABB has seen figures this high as well, but it is very dependent on the project and circumstances.

WM | The numbers presented in the slides are just one example - every vessel will be different. These include all electricity charges, battery replacements, maintenance, and fuel (for hybrid configurations), but do not include crew costs.
Question for all: What do you seek the most: a cheaper battery, a lighter battery, or a more compact battery?

DF | Cost is the main driver.

PB | All, but cost is the highest priority (if the economics work, we can work with the designer to find creative solutions to space/weight challenges).

WM | It is very dependent on the vessel. For the Glosten Foil Ferry, weight is of utmost concern. For a displacement speed double ended ferry, cost is likely the biggest driver.
I understand inverters were used to power the engine. I have serviced electronic components in a vessel that used inverters. Transient power in vessel was good enough to burn all electronic stuff in the boat. What kind of inverters is ABB suggesting?

**PB** | ABB utilises IGBT drives, either our ACS series (for large/medium-sized vessels) or HES series (for smaller vessels) drives.
We have been working on hybrid engines since 2009 and set several records, but we are unable to convince the owners.

PB | ABB appreciates any efforts to consider hybrid propulsion. ABB is prepared to help shipowners evaluate whether it is the right solution for their operation.
How big is this ferry? battery size? how many cars/passengers can it transport per trip?

**DF** | Length 95 ft, Beam 42 ft; battery energy 270kWh; 15 cars or 149 passengers

**PB** | ABB advises that an ESS system can power a vessel of any size. However, economics usually improve with shorter, more frequent voyages, which tend to be ferries.

ABB references the Washington State Ferries as, currently, the largest ESS system on a ferry planned in the world:

What percentage of the costs for the HMS Ferry Project went to shore power vs the vessel costs?

DF | A little over 10%
What is the design life for the car ferry Li-ion batteries?

**DF** | 10 years

**PB** | ABB notes standard battery life is 10 years, however we might size batteries for less life if there are other constraints (e.g. cost, weight, space) that limits battery size.
Will: Has Seattle City Light or Snohomish PUD delayed the timeline to install shore side infrastructure for the WSF Jumbo Mark II Ferries?

**PB** | ABB isn't involved directly in this, but of the many issues being addressed by WSF does not understand interaction with the utility to be a major challenge.

**WM** | Glosten continues to support Washington State Ferries and Siemens with the Jumbo Mark II conversion with ongoing design work. We are unable to comment on project schedule at this time.
Will hydrocarbon fuel-powered sets still be required for power generation and recharging batteries?

PB | This entirely depends on the power source of the local power grid.
To HMS Ferries: we want to learn about what is USCG requirements for electric or hybrid applications. Can you point us to where we can find them?

**DF** | USCG Marine Safety Center

**PB** | The 46 CFR is generally not designed with electrified propulsion in mind. There is one section that refers to ABS Rules for diesel electric vessels. Battery or fuel cell power is not currently contemplated by the CFR. The USCG Marine Safety Center is addressing vessel approvals via equivalencies for the time being until CFR’s are updated.
Why is the cost of the propulsion package for a small vessel like a fishing vessel in the Latin American market so high?

**PB** | Typically electrified propulsion systems are higher CAPEX in exchange for lower OPEX. In some cases that calculation isn't the case, and conventional diesel power is lowest cost (though is never the lowest emission). ABB will help shipowners perform this analysis.

**WM** | High capital costs are certainly barriers to this technology. Grants can sometimes be acquired to offset this. We calculate lifecycle cost and can compare different systems to identify the best system for the operations to ensure a return on your investment.
Any examples of small passenger vessels operating in high river current conditions?

PB | Electrified vessels can operate in all of the same conditions conventional diesel vessels can. One impact to consider when sizing a battery is head-current condition.

WM | The Skagit County ferry replacement that we are working on operates in significant tidal currents, up to about 4.5 knots. It is fitted with azimuthing thrusters and can perform better than an equivalent diesel-powered ferry due to electric propulsion.
Comparing the expected service life of the batteries vs diesel engines vs fuel cells, is there any case where one is preferred over another?

**DF** | Each option would be application-specific as to what is most important.

**PB** | Batteries are typically sized for 10 years, but can be sized for less time if there are other constraints on battery size (e.g. space/weight/cost).

**WM** | Each vessel operation is unique but in general, electric propulsion is great for short predictable runs. Ocean-going vessels would want to look to fuel cells, and high power but weight sensitive vessels may be stuck with diesels.
Electrons may be cheaper if not generated by NG or diesel power. From a kWh perspective, what is more expensive?

PB | In the US, in most locations, the normalized cost of brake power at the propeller shaft ($/kWh) is lower with grid power than diesel.

At $2.70/gal and an SFOC of 220g/kWh, the cost is about 19 cents per kWh. Industrial electricity pricing in the US, and in most advanced economies globally, is much lower than this.

However, high power charging may lead to demand charges from the utility, which can challenge this economic benefit.
What about simple adaptation of hybrid technology with peak shaving for high load requirements or for loitering operations in smaller vessels?

PB | ABB refers to its presentation which included various "design cases." Our Cases C and D combine diesel generators with batteries, and have clear use cases.

WM | Vessel operational profiles with high variability in both time and power may benefit from hybrid installations. To make pure peak shaving works financially, the fuel savings need to pay for the additional equipment.
Is the Maiden of Mist in operations?

**PB** | The new, all-electric Maid of the Mist vessels are indeed operating. 2020 is their first season.
What are the battery manufacturers (Corvus, Spear) guarantees for replacing defective batteries? What is their delivery time for a new unit? Do you keep any spare packs in your stock?

DF | SPEAR provided a warranty, and we purchased a spare module.

PB | The vendors do provide a warranty against equipment defects. Battery cell performance is quite reliable as the cells are typically industrially mass produced. Some other components (e.g. Battery Management System, racks) are produced in much lower quantities, but still have strong performance records.

The bigger risk with batteries is ensuring the route profile is properly estimated by the owner/ naval architect for battery sizing.
Peter - You mentioned weight as a consideration for refits / conversions where engine weight adds to the stability of the vessel. Would the battery weight be at all comparable to engine weight?

PB | Absolutely. What is interesting is that once fuel tanks are reduced/eliminated with battery-powered vessels, we end up finding that overall propulsion equipment weight requirements are often comparable to diesel-mechanical equivalents (while fuel is far more energy-dense, (a) fuel tanks are usually sized for days/weeks while batteries are only sized per-voyage and (b) electric propulsion is far more efficient, requiring less energy).