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Editorial Office
230 Park Ave., 7th Floor, New York, NY 10169 (800) 543-6862
www.lexisnexis.com

MATTHEW BENDER

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Editor-in-Chief, Editor & Board of Editors

Hydraulic Fracturing Developments
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Carbon-Free Ships: The EVs of the Seas?

By Frederick M. Lowther*

In this article, the author considers the cost and environmental impacts of carbon-free ships.

Much has been made of the future of electronic vehicles ("EVs"). Governments around the world are setting ambitious goals for EVs based on the notion that the vehicles themselves are carbon-free and thus a climate-friendly alternative to internal combustion vehicles. Among other things, the prospect of millions of EVs has supercharged the battery industry and spurred efforts to develop new energy storage technologies. So why not electric vessels, or vessels which are in other respects carbon-free?

There are many obvious differences between EVs and oceangoing vessels: size, weight, distance traveled, water resistance, etc. Nonetheless, there is no inherent limitation on using an electric propulsion system for a vessel; it is more a matter of scale rather than feasibility. The real issues are cost (capital and operating) and, just as important, the net environmental impacts.

COST AND OPERATIONAL CONSIDERATIONS

On the cost and operational side, there are a number of key considerations. In listing the issues, this article focuses on newly constructed vessels versus retrofits (but some of the same considerations would apply to retrofits). What is the weight of a battery/electric propulsion system versus diesel or turbine engines and a load of fossil fuel? Batteries are very heavy, and weight is a significant factor for vessel operations. What is the cost of the system(s) to keep the batteries charged, both at sea and in port?

The single biggest issue with EVs is the operating distance between charges, and that would be a significantly greater issue with oceangoing vessels, especially those traveling over vast stretches of water. It is the difference between hundreds of miles and increasingly frequent options for recharging EVs versus thousands of miles with no "in transit" recharging stations for oceangoing vessels.

To the extent that batteries are recharged in port, the time required for recharging becomes crucial since the in-port turnaround time for many vessels is very short, often measured in hours. If (as is highly likely) the vessels are hybrids (i.e., include engines or other devices that can charge batteries while the

* Frederick M. Lowther, a partner in the Washington, D.C., office of Blank Rome LLP, represents clients in connection with the development of large energy and natural resource projects in the United States and abroad. He may be contacted at flowther@blankrome.com.

vessel is in motion), that adds to the cost/weight equation (as well as the environmental equation). What is the operating life of the batteries and what is the cost of replacing them and disposing of the spent batteries (another environmental issue)? Battery life/disposal has not (yet) been a major problem with EVs, but that platform is far different from an oceangoing vessel platform where the constant demand for power over long periods of time and against the resistance of water impacts battery functionality and life.

Finally, batteries stacked in large bundles (as is the case for wind and solar generator storage installations) are known to have elevated fire risks. What is the cost of appropriate onboard vessel fire suppression systems?

It goes without saying that many of the cost and operational issues will undoubtedly be addressed by changes in technology. For those of you who recall the movie *The Graduate* where the uncle whispers "plastics" to a young Dustin Hoffman, the uncle today would likely say "batteries," because literally billions of dollars are being spent on batteries and other energy storage/delivery technologies. Improvements are inevitable, but are still (some would say "very") far away.

ENVIRONMENTAL CONSIDERATIONS AND NET ENVIRONMENTAL IMPACTS

The environmental issues with electric vessels are especially important, in part because the move to carbon-free vessels would be justified primarily (if not exclusively) on environmental grounds. It is on this subject that significant disagreements exist. Batteries (assuming that's the relevant source of power) must be charged. If the charging mechanism is renewable (e.g., wind, solar, motion-overwater), charging is not a carbon emissions issue.

However, if charging in port involves electricity delivered by the local utility or charging at sea involves a fossil fuel-driven engine, the carbon emissions become a factor. How the "net" impacts are measured is a subject of great controversy, but it is nonetheless an important factor in the environmental equation for electric vessels.

Batteries must be manufactured. Most propulsion batteries today are lithium ion batteries of some sort. Aside from the cost of constructing the battery itself, the mining, processing, and transportation of the chemical elements (lithium, cobalt, and graphite) and encasement materials must be considered.

Further, disposal of spent batteries deserves more serious attention than has been given to date. The composition of lithium ion batteries involves elements (e.g., lithium and cobalt) on the Periodic Table. They are stable elements that do not degrade.

What few rules there are today regarding battery disposal are honored mostly in the breach, but the day will come when deposits of spent batteries will raise issues of soil and water contamination, health effects, etc. We have wrestled for decades with the disposal of spent nuclear fuel, and we can expect to wrestle with spent lithium batteries in the not-too-distant future.

NUCLEAR POWER AS A CARBON-FREE OPTION

So far, the discussion has been about battery-derived electricity as the source of propulsion power. There are, of course, other carbon-free sources of propulsion. The most obvious one is nuclear power. Whether the nuclear energy converts directly to electricity powering motors or converts to steam-driven propulsion, the carbon footprint is minimal. We have had nuclear-powered submarines, aircraft carriers, and ice breakers for decades. Why not nuclear-powered commercial vessels?

Up to now, in this new era of climate sensitivity, all of the safety, proliferation, and disposal issues that have plagued the electric utility industry have kept nuclear power out of the mix for commercial vessels. But just as it is for the electric utility industry, the nuclear option should not be swept to one side based on past perceptions.

Nuclear generating technologies are improving, and indeed some of the most significant developments involve "miniaturization" of nuclear generators (as small as 25 megawatt electrical ("MWe")) that are potentially suitable for large oceangoing vessels. Safety concerns and issues of spent nuclear fuel (and contaminated reactor at end of life) disposal are enduring, and I am not suggesting that the nuclear power option is, at this point, a near-term option. But, again, it must not be swept off the table if we are intent on improving the carbon footprint of the maritime industry.

THE TIMETABLE

Given the almost daily reports of climate-related disasters, the worldwide focus on climate change is more than just a "movement." Despite the spirited (and sometimes acrimonious) debate about whether the climate crisis is man-made, it is hard to argue with the premise that measures to mitigate further damage to the environment are necessary. The maritime industry is in a position to start making responsive changes. Carbon-free ships could indeed be the "wave" of the future.