Royal Caribbean's Oasis of the Seas, the world's largest cruise ship powered by electricity. ABB photo

The Future of Transport is Electric, and It's Already Here

Bob Fesmire

Transportation accounts for 31 per cent of all energy use in Canada and 37 percent of all greenhouse gas (GHG) emissions, according to Environment Canada. In the realm of clean energy, electrified transport is much more than just hybrid cars and state-of-the-art metro lines. It's being used in whole new ways to make the movement of goods and people more efficient and environmentally sustainable.

Recently, the NASA Mars rover Opportunity celebrated its 10th birthday, which is remarkable when you consider its original mission was only scheduled to last 90 days. Opportunity's endurance is the result of multiple elements—design, testing, materials science—but at its core is a technology that dates to the first half of the 19th century: the humble electric motor. It might not be considered humble for much longer.

The fact is that there is a quiet revolution going on in the world of transportation, but if you think that it's mostly about electric vehicles (EVs) like the Nissan Leaf or even hybrids

like the Prius or the Volt, you'd be missing most of the bigger picture. Electricity is being used not only to provide propulsion for everything from cars to ships, it's being applied in a variety of less obvious applications to make the movement of goods and people more efficient, cost-effective and environmentally sustainable.

Transportation accounts for 31 per cent of all energy use in Canada and 37 percent of all greenhouse gas (GHG) emissions, according to Environment Canada. That alone makes the sector a target for improvements. Understandably, public attention is focused primarily on the auto industry, if for no other reason than that it touches consumers directly. The Canadian government has set a goal to have 500,000 EVs on the road by 2018, but as of 2008 there were fewer than 100,000 hybrids driving Canadian roads, according to the advocacy group Electric Mobility Canada. Industry analyst Green Car Reports expects the number of all-electrics in Canada to reach 10,000 by the end of this year.

EV supporters often highlight the fact that much of the true cost of traditional vehicles is externalized. EMC in particular points to the societal cost of carbon. At $25 per ton, the group says EVs would save society around $2,500 per vehicle per year thanks to the difference in emissions between petro-cars and their electric counterparts. But if we examine the entire energy value chain from "well to wheels," something interesting appears.

The fact is that the extraction, refining and distribution of gasoline is more energy efficient than the generation and distribution of electricity. It's only when the energy is used to actually do the work of moving a vehicle that the electric vehicle pulls ahead. But does it ever pull ahead.

Today's typical gasoline engines convert about 30 per cent of the energy contained in the fuel to traction. Diesels do a bit better at around 40 per cent. The rest of the energy is lost in the form of heat. Electric motors, by contrast, convert around 90 per cent of the energy supply to traction.

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They're also quiet and, with few moving parts, virtually maintenance-free.

EVs still have a way to go before they reach widespread adoption, and overcoming challenges like the weight and cost of batteries will be paramount. But EVs are only the most visible tip of a much larger iceberg.

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Railways provide an example of another mode of transport where electrification has already made an impact but could be expanded much further. Nearly all heavy rail systems in North America use locomotives that are technically hybrids, relying on diesel generators to serve electric motors for final drive. Outside of intra-city metro lines, there are almost no all-electric trains running in Canada or the US. Canada itself has almost 50,000 km of railways, and of that number only 129 km is electrified. The reason is simple: installing catenary wires or a third rail is extremely capital-intensive. Still, if you consider that diesel locomotives use 2.5 to three times as much energy as electric locomotives, the economics become more promising for electrification.

In Ontario, GO Transit published a study in 2010 that found electrifying certain lines would make financial sense in the long term thanks to maintenance cost savings in addition to lower fuel costs. For heavy rail, though, rising oil prices will likely be the central motivating force behind any substantial effort to go electric. Light rail and commuter systems, on the other hand, are moving forward.

Many light rail systems use "electric multiple units," trains in which each car is equipped with its own propulsion system. The specialty transformers needed to convert power from the grid to a useful voltage onboard historically have been located in "machine rooms" that occupy space inside the car that otherwise could be used for passenger seating. Now a new, more efficient generation of traction transformers uses a compact design that allows them to be placed under the floor or on the roof.

In addition, while regenerative braking has been used in trains for decades, advances in power electronics and energy storage have made it possible for more of the energy from decelerating trains to be captured. In a pilot project at SEPTA, the Philadelphia area transit operator, a wayside energy storage system not only supplies the recaptured energy to trains as they depart, it also provides power back to the grid, a service for which SEPTA is paid. The agency estimates that between energy savings and new revenues, the energy storage system delivered returns of $250,000 in its first six months.

Those are remarkable results, but to date perhaps no segment of the transportation market has made better use of electrification than the shipping industry. Indeed, in some markets (e.g., cruise ships) electric propulsion has become the industry standard. Part of the reason is that podded propulsion systems can rotate 360 degrees, acting like a giant outboard motor and giving even the largest ships tremendous maneuverability. But the business case for electric ships mainly comes down to fuel costs, which have tripled in the past 20 years.

One ferry line in Japan, for example, realized fuel savings of 20 per cent when it moved to electric propulsion. The

Charging an electronic vehicle. It's estimated 10,000 EVs are now on the road in Canada. The auto space is just one segment of the transport sector increasingly powered by electricity. ABB photo

lack of a traditional engine and driveshaft also allowed more of the interior of the ship to be used for cargo, and the reduced noise and vibration were appreciated by passengers and crew alike. Now, similar systems are being used widely in tugboats, ice breakers, and specialty vessels like offshore platform service ships that employ dynamic positioning to hold position in open water.

What all of these have in common is a working environment that requires frequent changes in the demand being placed on the ship's engines. Constant ramping up and down puts stress on mechanical systems. By contrast, electric motors are better able to handle the variations in demand that such applications require.

Now, shipyards are taking the improved efficiencies of electrification one step further by looking to onboard systems, and ports are changing the way ships use power when docked. Instead of running their engines, ships in many ports around the world now have the option of plugging into the local grid via shore side connections. This, again, saves fuel and avoids harmful emissions.

Onboard, ship builders are beginning to experiment with DC power systems to replace the traditional AC networks that ships use today. AC systems typically have multiple points where the power supply is transformed (i.e., where the voltage is shifted up or down), and every one of these incurs losses. A DC system does not require as many conversions and is therefore more efficient.

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The Electric Power Research Institute has funded research projects that demonstrate the value of going electric in everything from warehouse forklifts to the cranes used to move shipping containers, to the vehicles pulling carts full of luggage across the tarmac at airports. Southwest Airlines saves $50 million per year by tapping into the local grid instead of relying on diesel generators to serve onboard electrical needs while planes are parked at the gate. Another EPRI program showed long-haul truckers could save around $4,000 per year if they were able to plug in at rest stops instead of running their engines to heat and power their sleeper cabs.

Electrification may not be a panacea, but its potential for Canada is hard to overstate. Indeed, we are already reaping the benefits of electrified transport, whether we know it or not. P

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