PLUG-IN HYBRIDS— PROGRESS AND PROSPECTS
C40 Notes
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Slide 1: Plug-in hybrids: Prospects and Progress

I am going to take you on a brief tour of a technology that can replace petroleum in light duty vehicles. They are plug-in hybrid electric vehicles or PHEVs.

Why electricity? Because electric motors are far more efficient than internal combustion engines. Furthermore, petroleum prices are rising so fast that carbon intensive sources like Canada's tar sands are now economic, which will push greenhouse gas emissions even higher when they are fully developed. Finally, PHEVs and ultimately electric vehicles will permit the greater use of renewable energy in transportation. This includes wind and solar that is stored in those car batteries, as well as biofuels, which now can make a greater contribution on the liquid fuel side as the need for petroleum declines.

Slide 2: Outline

I'm going to speak to six points:

- Background on Toronto's climate plan.
- What is a plug-in hybrid electric vehicle (PHEV)?
- What are the benefits of PHEVs and caveats?
- What are results from Toronto's pilot testing of PHEVs?
- Why aren't the car companies embracing PHEVs?
- Market transformation for PHEVs—the municipal role.

Slide 3: City of Toronto's Climate Plan

Toronto City Council made its first commitment to reduce greenhouse gas emissions in 1990. Toronto adopted a CO_2 reduction target of 20%, which it hoped to reach by 2005. The City didn't achieve that target, but it was able to stabilize emissions at the 1990 level of 24 million tonnes. Meanwhile, since 1990 Canada's emissions have risen 25%, and Ontario's emissions have risen about 18%, the province where Toronto is located. In 1991, City Council established the Toronto Atmospheric Fund, a $26 million revolving fund that finances projects that reduce green-house gas emissions. Over the last 15 years, TAF has in-cubated numerous climate mitigation initiatives. And since 1990, the City itself has reduced GHG emissions in its own facilities by 30%.

The City with provincial support is currently engaged in a massive electricity conservation program costing $100 mil-lion that aims to reduce peak use by 300 MW or about 7%. In addition, under Mayor David Miller's leadership, the City is setting up two more revolving funds, one to pro-mote energy efficiency, the other to promote renewable energy, totaling $60 million. Along with $100 million budg-eted, but not yet authorized, to implement the new Climate Plan, Toronto will hopefully devote $260 million to climate mitigation over the next three years.

Slide 4: Breakdown of Toronto's Emissions

Toronto completed a comprehensive greenhouse gas in-ventory this year. Cars and light trucks account for 27% of the City's GHG emissions. Emissions in this sector are ris-ing while emissions in the other sectors are declining. Looking beyond 2012, Toronto will not be able to achieve its very ambitious emissions reduction targets without a major transformation of the transportation sector. Canada's new emission regulations will stabilize emissions from light duty vehicles, merely offsetting the growth in travel demand.

While the City plans to significantly expand its public transit system, and a major bicycle network is under construction, these infrastructure investments will not reduce emissions to the extent needed. Clearly we have to do something about cars.

Slide 5: What is a PHEV?

There are 2.6 million hybrid vehicles on the road worldwide, about 1.2 million of them Toyota Priuses, mostly in North America and Japan. Their batteries are charged by the combustion engine and regenerative braking, The battery then powers electric motors at lower speeds and in stop and go urban driving. Hybrids improve fuel economy by 20% - 40% over conventional cars, and they don't need to plug into an external source.

Plug-in hybrids boost fuel economy even further by expanding the car's battery system so that it can be charged externally. In a Prius, for example, the battery remains only half discharged most of the time, serving as a buffer that evens out the transitions between combustion drive and electric drive. In a PHEV, the normal hybrid drive system remains in place and operates normally, but the auxiliary battery system provides an extra boost for the electric drive train by providing a full discharge cycle.

Slide 6: Why Lithium-ion (Li-ion)?

Lithium-ion is the battery of choice for PHEV conversions, because the chemistry has advanced to the point that it stores a good deal more energy for the same weight than alternatives. It can be designed for applications ranging from high power output in short periods to high-energy storage. Lithium-ion can be charged and discharged flexibly, and 3,000 - 5,000 charge discharge cycles are feasible with minimal degradation. A 10-year lifetime is expected.

Slide 7: Key Li-ion Battery Concern—Safety

Lithium-ion's main problem in the past has been the safety of older chemistries, those primarily based on cobalt. You will recall that last year Sony lithium-ion batteries in some laptops overheated and caught fire. These batteries caused Dell to initiate the largest recall in the history of consumer electronics, affecting 4.1 million laptop batteries. It is no wonder that Toyota testified in the U.S Congress this summer that lithium batteries were not ready for deployment in vehicles.

However, recent advances in lithium battery chemistry made by researchers at MIT, as well as in other locales, have resulted in commercial lithium-ion cells that are more suitable for automotive use. The electrodes in these lithium batteries are made from phosphate, manganese, or lithium titanate and are engineered with nanotechnology that creates higher capacity anodes and cathodes that do not react with the electrolyte and are thus safer.

A123 Systems has commercialized its chemistry, and its batteries are used in millions of commercial Black & Decker portable power tools worldwide. Altairnano, also a U.S company, has developed batteries engineered with lithium titanate material. Both A123 and Altairnano have agreements with GM to test their batteries for the upcoming GM Volt, a PHEV. That company that wins the contract for the Volt will become the largest lithium battery manufacturer in the world. So we are approaching a tipping point on lithium battery chemistry for automotive applications!

Slide 8: Strategic Benefits of PHEVs

Apart from enabling a significant increase in fuel economy, PHEVs will allow us to leapfrog into electric mobility on a larger scale and much sooner than previously thought. This is because after the PHEV battery fully discharges, the vehicle can still operate in conventional hybrid mode without recharging from an external source. So one of the primary barriers to electric vehicles—their range—is no longer a problem.

When viewed on a collective societal scale, however, the benefits of PHEVs are even greater. PHEVs will create electricity storage capacity that will enable utilities to reduce peak load, incorporate more intermittent renewable power on the grid, utilize their capital assets more fully, and create revenue streams for customers that help finance the higher costs of PHEVs. With less gasoline or diesel being used, biofuels can then make more of a difference in a plug-in.

Slide 9: PHEV Loops

PHEVs also make great strategic sense when you compare the production loops for the alternatives. Gasoline and diesel fuels take 500 million years for Nature to produce, and earth's supplies are in decline in most regions of the world. Biofuels can take 1 - 50 years to produce, depending on the feedstock. As promising as biofuels are, they currently compete with food production. Fuel for PHEVs, however, can be produced in one day or less, and can be customized to your local rooftop. What is more, the distribution system for electric mobility is mostly in place and is as near as a conventional electrical outlet.

Slide 10: Why is V2G Important?

A related technology called “vehicle to grid” or V2G will enable utilities to make the most of PHEVS and, eventually, electric vehicles. V2G is simply a communications protocol that enables vehicles and utilities to talk to each other over remote distances. It gives the vehicle an IP address that can reached by a central computer over a wide area network. It enables the utility to control the vehicle’s time and rate of charging, no matter where the vehicle is plugged in.

In addition, the utility can take electricity from the vehicle when it needs it during peak periods of the day, and further use the collective battery storage locally for other ancillary grid services. In essence, V2G will enable utilities to more fully utilize the generation capacity they already have—increasing off peak use and reducing peak use—while creating new revenues streams for themselves, as well as their customers.

Finally—and most importantly—V2G will enable the utilities to bring more intermittent renewable sources onto the grid, by using vehicle storage capacity to flatten the ups and downs of wind and solar. This will increase the value of renewable energy to utilities, who typically add a hefty risk premium to these sources because they can’t depend on them for firm and reliable power.

Slide 11: PHEV Constraints and Caveats

While PHEVs offer the most practical pathway towards electric vehicle mobility and battery storage on the grid, their environmental benefits are subject to many variables. Smaller vehicles such as the Prius will benefit more than larger vehicles such as the Highlander or the Lexus. The larger the vehicle, the larger the battery pack, and the higher the cost.

The fuel economy benefits of PHEVs will depend a lot on how the car is driven. Factors such as trip length, mean speed, and driver aggressiveness all affect fuel economy. In addition, we expect winter driving will reduce fuel economy, since the gasoline motor has to operate to supply space heating for passengers.

Finally, once a lot of vehicles are being charged in one locale, there may be local impacts on power quality and other technical aspects of distribution. Initial tests and simulations in Canada and U.S., however, are showing that these potentially negative effects would be too minor to affect utility performance.

Slide 12: Toronto Plug-in Hybrid Electric Vehicle Project

In order to find out how PHEV conversions would perform under actual fleet driving conditions on the road, TAF created the Toronto Plug-in Hybrid Pilot Project. TAF assembled a consortium of private and public fleets to do the testing, including the City's Fleets Division, local utilities, universities, two provincial ministries, and a local car sharing company. We are testing 8 converted Priuses and 2 Ford Escapes, all outfitted with A123/Hymotion prototype conversion kits.

Each vehicle is equipped with a sophisticated data logger that collects information on about 30 different performance variables. The SD cards are mailed monthly to a team at the University of Toronto, who download and analyze the data.

Slide 13: Initial Toronto PHEV Prototype Results

The project was launched last May, and the vehicles have been on the road since August. A year from now, we will know a great deal about how PHEV conversions perform under actual on road conditions in a variety of different fleet applications. Today, I'm able to report some limited findings from two vehicles being operated by the City of Toronto Fleets Division (COT) and the provincial Ministry of Transportation (MTO).

The fleet applications of these two agencies are quite different. CFO operates its vehicles primarily downtown in stop and go driving along short routes. The MTO is located in Toronto's suburbs, and the routes being driven by the vehicle are longer and tend to be on local highways and suburban arterials. The MTO's Prius is also older than the City's Prius, so this is likely affecting performance.

We find that the fuel economy improvement ranges from 30 - 55%. CO2 emission reductions, when both fuel and electricity are taken into account, is about 20%, reflecting a 25% mix of coal in Ontario's electricity grid. If the vehicles were charging in Vancouver, Winnipeg, or Montreal with 100% renewable energy, the CO2 emissions reduction would be in the 35% range.

Please keep in mind that these are very early returns, based on only two vehicles using prototype conversion kits tested over a period of two months. But they do point towards potentially significant benefits, subject to how and where the vehicles are driven.

Slide 14: PHEV Emissions vs. National Averages

This graph puts PHEV performance into the context of national policies promoting lower carbon vehicles. It shows that PHEVs can, indeed, play an important role in achieving aggressive CO2 emission rate targets set by the EU and by California. The Toronto prototypes are performing in the range of 100 grams of CO2/kilometre, along with the Google PHEV fleet. This performance will improve as the commercial A123/Hymotion conversion kits become available next year, and other conversion companies with competing conversion kits enter the market.

Slide 15: PHEV Fuel Economy Varies

This graph shows the variability of fuel economy of A123/Hymotion Priuses now being tested in the U.S. Again, trip length is an important influence on fuel economy. For trip distances solely in the 1 - 10 kilometre range, fuel economy improves by almost 100%. Fuel economy improves only 20% or more for trips longer than 40 kilometres. So these vehicles appear to be a perfect match for congested, stop and go urban traffic.

Slide 16: C40 and PHEVs

The City of Seattle recently announced a 13-vehicle fleet consortium pilot similar to Toronto's. The Province of Manitoba will announce a similar project soon. These pilot projects are laying the foundation for commercialization of PHEV conversions next year.

There should be enough performance data available by the end of 2008 from a variety of sources, including crash data, to give us a lot of comfort that PHEVs work, are safe, and offer substantial fuel economy and environment benefits in many locales.

C40 cities could play a substantial role in facilitating the commercialization of PHEVs, and Toronto would welcome cooperative efforts with other cities. We are already reach-ing out to Seattle, as well as other U.S. municipalities that are testing just one or two vehicles in their fleets.

Slide 17: Car Companies and PHEVs

If PHEVs are so great, why aren't the car companies embracing the technology? At this moment, 4 - 5 car companies, but it is difficult to gauge how serious they are. Daimler-Chrysler is pilot testing its Sprinter PHEV Van. GM has included production of its PHEV Volt in its recent labor contract with the U.S. auto unions, with production scheduled to begin in 2010. I've read that Volvo is developing its C30 concept, a PHEV with a powertrain design similar to the Volt. Toyota may produce a limited, "mild" PHEV. This vehicle is now being pilot tested in France, Japan, and California. But this may be more of a PR effort to beat GM to the market and to discourage future after market conversions of the Prius.

The main reason that the car companies haven't embraced PHEVs is that they are managed by very large, conservative bureaucracies that change very slowly and avoid risk. After all, the internal combustion engine has been perfected over almost 100 years. Car executives remember the failures of the Ford Edsel and the GM Corvair with its aluminum rear engine, and they don't want a repeat. In my opinion, car companies are much like Hollywood film companies, where sequels to successful films are the norm!

Slide 18: PHEV Market Transformation

The California Air Resources Board or CARB recently released a report evaluating the commercial potential of the various alternative auto technologies. Here is a graphical representation of their evaluation. PHEVs show the shortest pathway towards commercial status, with vehicles being mass-produced in numbers greater than 100,000 annually by 2015. Fuel cell vehicles don't reach full commercialization until 2025, and hydrogen vehicles by 2030.

The PHEV pathway could accelerate, however, if PHEV conversion kits reach market next year and are popular, and if GM actually follows through on its Volt production and generates consumer enthusiasm. We could reach full commercialization of PHEVs, then, within 3 - 5 years, which would help drive the other technologies requiring charging facilities and facilitate the broader public acceptance of electric mobility necessary for the car companies to take notice.

Slide 19: Conclusions

In summary, plug-in hybrid electric vehicles offer substantial fuel economy, emissions reductions, and petroleum displacement benefits. Their environmental benefits, however, are subject to local conditions, such as how the vehicle is driven and how much coal is burned to generate local electricity.

Strategically on a broader scale, PHEVs—and ultimately electric vehicles—offer a pathway to significant petroleum displacement. Their full commercialization will increase the relative amount of renewable energy sources in transportation—both green electricity and biofuels. And because utilities will earn new revenue streams and be able to maximize return on their sunken investments in generation, a compelling business model will emerge that makes the deployment of higher cost lithium batteries feasible.

PHEVs and ultimately electric vehicles will enable us to transform the energy and transportation sectors in tandem, so that governments are able to reach the ambitious greenhouse gas reduction targets they have set.

Thanks very much for the opportunity to share this vision with you.