New York State  Climate Action Council

Report of the Cross-Sector Electric-Grid-Powered Vehicle Sub-group of the Climate Action Plan

Issues and Strategies Rev.8

7/28/2010

This report was developed by representatives from the Climate Action Council's Transportation and Land Use (TLU), Power Supply and Delivery (PSD), and Residential Commercial and Industrial (RCI) Technical Working Groups (TWGs). The report describes cross–sector issues and policies associated with a transition to electric-grid–powered vehicles.

Report of the cross-sector electric vehicle subgroup

Members: Richard Drake (NYSERDA), Eleanor Stein (NYS DPS), Matt Fronk (RIT), Jamie Van Nostrand (Pace University), Joe Oats (Consolidated Edison), Steve Corneli (NRG Energy), Kerry-Jane King (NYPA), Carol Murphy (ACE NY), John D'Aloia (NYS DPS), Steven Tobias (National Grid), Matt Nielsen (General Electric), Dave Coup (NYSERDA), John Zamurs (NYS DOT), David Gardner (NYS DEC)

Background

In 2006, the transportation sector produced 39.5% of the State's combustion-based inventory of GHG with the gasoline-fueled light-duty vehicle sector being responsible for the vast majority of those emissions. Plug-in electric vehicles (EV), plug-in hybrid electric vehicles (PHEV), and fuel cell vehicles (FCV) powered by hydrogen derived from electrolysis offer the potential to displace a significant portion of this petroleum consumption by using electricity for all or portions of vehicle trips. If this electricity has a low or near zero carbon intensity, the carbon footprint from this segment could be nearly eliminated.

The New York Climate Action Council established four Technical Working Groups (TWGs) representing key sectors of the economy each tasked with providing technical analysis and developing policy options for greenhouse gas reductions in their sector. The GHG reduction potential of electrically powered vehicles will be influenced by the policies developed in three TWG sectors: Transportation and Land Use; Power Supply and Delivery; and Residential, Commercial, Industrial Buildings and Infrastructure. The cross-sector electric vehicle subgroup was established to identify the impact to multiple economic sectors of a transition to a high penetration of grid-powered vehicles, and to, where possible, establish a consensus on strategy encompassing all sectors.

The Approach:

The Cross –Sector sub-group consists of TWG members from the Transportation and Land Use, Power Supply and Delivery, and Residential, Commercial and Industrial TWGs. The approach used was, first: segment the flow of electricity from source to vehicle into five categories; second, identify the questions and issues in each segment that needed to be addressed in order to achieve significant market penetration of plug-in vehicles with maximized reductions in GHG; third, to research the issues, establish findings and describe strategies or approaches that addressed the issues. Where appropriate there was an attempt to identify mid and long term issues.

In addition to the individual sector perspective and expertise of the TWG members, the group invited participation and presentations from several outside sources. These included vehicle manufacturers Ford and Tesla, and a manufacturer/supplier of charging station infrastructure.

Report of the cross-sector electric vehicle subgroup

Summary:

General: A top priority should be an in depth analysis of the coincidental overlays of: EV-charging load profiles; future intermittent and non-dispatchable generation growth in NYS; projected residential, commercial and industrial electrical load growth in the State. The findings below are based on available analysis as referenced in the report.

- **Power Supply - Generation**
  - Through the mid-term (2030) the State has adequate generation capacity to accommodate the maximum (30%) anticipated penetration of EV, PHEVs.
  - "Smart Charging" to minimize grid impacts will be necessary.
  - New York's current off-peak generation mix provides PHEVs significant GHG reductions as compared to conventional vehicles, however to maximize GHG reductions, the Grid will need to be near carbon free.
- **Transmission**
  - Through the mid-term (2030) the State's transmission grid has adequate capacity to accommodate the maximum (30%) anticipated penetration of EV, PHEVs with smart charging.
- **Distribution**
  - Near- to mid- term: local distribution (transformer) upgrades are likely to be necessary.
  - Longer term: large number of EVs requiring quick charge may require local storage.
  - Business models, policy and regulatory actions encouraging Smart Charging and allowing third-party sale of electricity may be necessary.
- **Infrastructure**
  - Building codes addressing Level II and Level III charging in new residential and commercial garage construction will significantly reduce costs.
  - Building codes that address garaging hydrogen-fueled vehicles should be part of the long-term solution.
  - Policy and regulations should encourage the development of a variety of business models for charging/re-fueling (battery swap, etc.)
- **Vehicles**
  - PHEVs and EV and fuel cell vehicles having acceptable performance are a reality.
  - Vehicles deriving their fuel from the electric grid are likely to become a cost effective means of achieving carbon-free mobility.
  - Near term: incentives will likely be necessary to induce adoption. Gas may need to reach $4/gallon and R&D will be needed to improve performance and reduce cost before EV-PHEVs are economically compelling without incentives. (Reference: Transitions to Alternative Transportation Technologies, National Academy of Science, 2010)
  - Near and mid- term battery vehicles will predominate. The advantages of fuel cell vehicles having greater range, performance and quick-fill together with lower vehicle cost may compel commercial fleets initially and later private vehicles to invest in localized hydrogen infrastructure based on electrolysis from off-peak carbon free grid power.

Electric Grid Powered Vehicle - Climate Policy Issues by Category

A **Generation**	B **Transmission**	C **Distribution**	D **Infrastructure (buildings and facilities)**	E **Vehicle +End-User**
• A1 How much generation is needed to meet the new load?	• B1 Do we have sufficient transmission capacity to meet the new load?	• C1 Do we have sufficient capacity to meet the new load?	• D1 What charging infrastructure/strategy is needed?	• E1 What charging technologies are needed (e.g., smart charge)?
• A2 What CO2e intensity is required to achieve 80X50? How do we achieve it?	• B2 Does this new load create any major reliability issues (e.g., stability, thermal, voltage)?	• C2 Does this new load create any major reliability or infrastructure cost issues (e.g., stability, thermal, voltage)?	• D2 Are changes necessary in retail electricity rate structures? If so, how should they be changed?	• E2 What battery technologies are most suitable for this application? Are they available and cost-effective?
A3 What is the desired load shape for EVs to minimize carbon intensity of required generation?	• B3 Are there transmission level investments that would reduce the carbon intensity of an EV load?	• C3 Are there legal, regulatory or policy actions that could reduce transaction obstacles and accelerate a transition to electrified transportation?	• D3 What kind of advanced metering is needed?	• E3 What vehicle platform(s) seems the most viable? Can EVs meet driver needs or will we need fuel cell or bio-PHEVs to meet range requirements?
		• C4 Who should pay for any required upgrades? The individual beneficiary or the rate base?	• D4 What land-use issues need to be addressed?	• E4 Who will service these vehicles?
		• C5 Will fast-fill fueling require distribution-scale stationary energy storage (hydrogen or electric)?	• D5 What kind of consumer education is needed?	• E5 What is the rate of advanced low carbon vehicle introduction needed to meet 80X50? How do we get more cars "in the pipeline?"
			• D6 How do we bring upfront costs down for consumers?	• E6 How do we bring upfront costs down for consumers? Are incentives required to overcome high cost of electric vehicles?
			• D7 What codes and standards need to be created/updated?	

Strategies

A Generation:

A1 How much new generation is needed?

Near term (2025) supply is not an issue in terms of meeting MW requirements. NREL study – "a 50% penetration of PHEVs would increase the per capita electricity demand by around 5-10%...while increasing total electrical energy consumption (but without requiring additional generation capacity)". However, an increased proportion of low or zero carbon generation to displace traditional fossil plants must be brought on line to meet 80 by 50. All of this assumes Smart Charging will be implemented as grid-fueled vehicle penetration grows. It may be necessary for public policy or rate structures to provide incentives and disincentives to implement adoption.

References: EPRI/NYSERDA Study - "Grid Impact of PHEVs," 2010; NREL Study - "An Evaluation of Utility System Impacts and Benefits of Optimally Dispatched Plug-In Hybrid Electric Vehicles," Oct. 2006; PNNL Study: "Impacts Assessment Of Plug-In Hybrid Vehicles On Electric Utilities and Regional U.S. Power Grids," 2007.

- *Strategy: Near term and long term - continued support of R&D for renewable technologies as well as methods to reduce carbon from fossil sources; continued financial incentives/rate structure to encourage low/zero carbon generation and off-peak, valley filling charging .*

A2 What electric grid CO_2 intensity is required to achieve 80/50?

As a nation, there has been a significant increase in the carbon intensity of the grid over the past 20 years. Therefore, for the U.S. to achieve an 80% reduction from 1990 levels in carbon by 2050, our country must cut its current rate of 5.8 billion tons CO_2/yr to 1 billion tons/yr. This equates to approximately a 4% reduction each year for the next 40 years. The carbon intensity of the grid varies significantly as a function of grid load with off-peak power having the lowest carbon footprint. In New York the electric grid is responsible on average for approximately 800 lbs. of CO_2 for every megawatt produced. At this level of intensity an all electric car is typically responsible for approximately .3 lbs. of CO_2 per mile vs. the .77 lbs./ mile that a conventional vehicle getting 26 mpg produces. Therefore with today's generation mix an electric vehicle provides on average a 61% reduction in CO_2 and if every mile driven was electric we would still fall short. Off peak power is less carbon intense and "Smart (off –peak) Charging " has the potential to provide some benefit in the near term. However to achieve the 80 by 50 goals there not only will need to be a high percentage of grid-powered vehicles but a near zero carbon footprint from the electric grid.

References: CO_2 Emissions from Fuel Combustion - Highlights – International Energy Agency, 2009; U.S. DOE Annual Energy Review Table 12.2, 2009;
2050 Greenhouse Gas Emissions Analysis: Staff Modeling in Support of the Zero Emission Vehicle Regulation, CARB, 2009

Strategy: *Assuming no growth in vehicle miles traveled and that 90% of those miles are traveled in electric vehicles, the carbon intensity of the grid power used to charge vehicle needs to be reduced to approximately 64lbs.of CO2 per megawatt hr, a 92% reduction.*

- **A3 What is the desired load shape for EVs to minimize carbon intensity of required generation?**

*Want to move EV charging to off-peak. Conversely, generally want to avoid charging immediately upon returning home (*4-6 PM) as this could compete w/other electrical load. Furthermore, moving charging to overnight hours would correlate very well to the production profile of zero carbon wind resources in NY (as well as base-loaded hydro and nuclear power).

Reference: "Alternate Route: Electrifying the Transportation Sector" – NYISO, June 2009

- *Strategy: Electricity rate structure w/incentives for EV owners to charge during off peak hours with highest incentives during overnight hours.*

B Transmission:

B1 Do we have sufficient transmission capacity to meet the new load?

Since generation (MWs of supply) is not anticipated to be seriously impacted as a result of PHEV vehicle adoption, it follows that the transmission system will not require added capacity specifically for EV charging.

References: KEMA report for ISO/RTO Council "Assessment of Plug-in Electric Vehicle Integration with ISO/RTO Systems"; PNNL Study: "Impacts Assessment Of Plug-In Hybrid Vehicles On Electric Utilities and Regional U.S. Power Grids," 2007

- *Strategy: Assumes smart charging, etc., otherwise, no specific strategy required assuming upgrades to transmission system due to expected load growth outside of EV.*

B2 Does this new load create any major reliability issues (e.g., stability, thermal, voltage)?

System reliability could be reduced as a result of a high utilization scenario as less reserve capacity is available. With smart sharging, reliability issues are not expected – with further advancements in vehicle-to-grid (V2G) technology, it is possible that vehicle storage may provide benefits to transmission system reliability. While it appears that PHEVs are much better suited to support short-term ancillary services such as regulation and spinning reserve, a large fleet of PHEVs could possibly replace a moderate percentage (perhaps up to 25%) of conventional low-capacity factor (rarely used) generation used for periods of extreme demand or system emergencies. Overall, the ability to schedule both charging and very limited discharging of PHEVs could significantly increase power system utilization.

References: PNNL Study: "Impacts Assessment of Plug-In Hybrid Vehicles on Electric Utilities and Regional U.S. Power Grids," 2007; NREL Study - "An Evaluation of Utility System Impacts and Benefits of Optimally Dispatched Plug-In Hybrid Electric Vehicles," Oct. 2006

- *Strategy: Adoption of "Smart Charging" systems that recognize grid emergencies could mitigate the extent and severity of these events; continued R&D into the V2G technology; explore financial incentives for providing grid support.*

B3 Are there transmission level investments that would reduce the carbon intensity of an EV load?

The issues of vehicle range, fueling infrastructure, and cost will be challenging. Quick charge (level III) electric charging may require stationary storage or other upgrades. Range issues can be overcome with fuel cell vehicles however quick fill public hydrogen infrastructure would require a major investment. A third option, hybrid bio-PHEV, may be the easiest pathway on the vehicle side however low carbon cellulosic ethanol is not yet a proven option.

- *Strategy: All of the above options should be maintained; all may be needed to meet the variety of duty cycles, first cost vs. operating cost constraints and user needs. In all cases, continuous improvements in vehicle technology will be needed together with significant long-term infrastructure investment. Public policy should be technology neutral and, in the near term, focus on low carbon vehicle incentives such as fee-bates for low carbon vehicles and tax credits and buy-downs for fueling infrastructure.*

C Distribution

C1 Do we have sufficient distribution capacity to meet the new load?

To achieve the penetration rates required by the 80X50 target, some distribution system upgrades will undoubtedly be needed. Because of clustering and a slower penetration rate of pure battery vs. PHEV, current analysis indicates upgrades will be needed at a local level involving distribution transformers and customer service; not primary feeders or transformers. Impacts can vary greatly from system to system. Some distribution systems have a low ratio of customers to service transformers; ranging from as low at 2 to 1 and will see very different impacts compared to Rochester Gas and Electric's ratio of 9 to 1. In systems that are largely underground, there is some potential for underground cables and transformers to have inadequate cool down periods at night should significant load be shifted to off-peak nighttime periods on feeders that are highly loaded during the day. So, although load growth rate is generally expected to be within the normal bounds of planning activities and load growth, there will be situations requiring special consideration and study.

References: EPRI/NYSERDA report: "Analysis of Grid Impact of PHEVs in New York State," 2010; "Thoughts and Opinions on the Impact of Plug-in Hybrid Electric Vehicles" Quanta Technology, 2008

- *Strategies: Smart charging, load shifting, stationary storage all have the potential to mitigate most of the anticipated problems for the next decade.*

C2 Does this new load create any major reliability or infrastructure cost issues (e.g., stability, thermal, voltage)?

As noted in B2, (transmission), with Smart Charging, distribution reliability issues are not expected – with further advancements in V2G technology, it is possible that vehicle storage may actually provide benefits to distribution system reliability.

- *Strategies: Financial incentives for desired market transformation and disincentives for unwanted behavior will be necessary to accelerate low carbon vehicle market penetration. Infrastructure investment will also be a necessary element and may require adjustments in public policy and public investment.*

C3 Are there legal, regulatory or policy actions that could reduce transaction obstacles and accelerate a transition to electrified transportation?

- *Strategy: consider revised tariffs in NY that would allow charging infrastructure providers to resell electricity they purchase from utilities.*

C4 Who should pay for any required upgrades? The individual beneficiary or the rate base?

It could be argued that the advent of PHEVs is similar to the widespread adoption of air conditioning in the 1960's. The utilities incorporated this new load as a part of their normal planning process and the cost was added to the rate base.

- *Strategy: Costs should not be borne by individual customers, a preferred alternative is to use* revenue derived from a broader base *to cover the cost of upgrades specific to the supply of electricity for plug-in vehicle charging.*

C5 Will fast fill fueling require distribution scale stationary energy storage (H2 or electric)?

- *Strategy: Since fast fill charging is likely to be required by a user at a time other than off-peak, purchase of the* stationionary electrical *storage may be necessary to minimize negative grid impacts and allow the utilization of excess renewable electricity generated in off-peak times.*

D Infrastructure (buildings and facilities)

D1 What charging infrastructure/strategy is needed?

It seems generally accepted (and reinforced with surveys, PlaNYC, EPRI) that the most important locations for charging infrastructure are those facilities where vehicles are parked routinely for extended periods, such as home garage or work. Legislative and regulatory action is required to implement third-party owned and operated public charging stations that sell electricity. New business models together with communication and transaction protocols will need to be standardized to allow smart –charging that benefits the grid and consumer.

- *Strategies: First priority - Standardization of physical interconnections (plugs, voltages, etc.) and communications protocols. Second: Public policy and regulatory action that supports the development of business models that allow sale of electricity by third parties (non-utility); aggregation of loads for business transactions; private and public investment in publicly accessible vehicle charging; development and deployment of standardized quick charge (Level III) technology.*

D2 Electric Rate Structures

California's PUC has established special rates for electric vehicle charging and off peak use. Remote-controlled charging could also occur by allowing a customer to charge their vehicle at any location and be billed for the energy at a rate determined by the location of the vehicle rather than at a residential rate.

- *Strategy: Establish EV electric rates that encourage vehicle charging load growth that is consistent with minimized negative impact on the grid and that provides positive economic incentives to consumers. PHEV-specific dynamic pricing may be one way to introduce dynamic pricing to consumers while adverse customer reaction with regard to existing retail loads.*

Reference: KEMA report for ISO/RTO Council "Assessment of Plug-in Electric Vehicle Integration with ISO/RTO Systems."

D3 What kind of advanced metering is needed?

Using advanced meters, vehicle charging would be one of several home energy uses that could be managed through automation. Even simple time-of-use residential meters could provide customers with the incentive and the ability to manage their energy usage for charging PHEVs.

- *Strategy: Advanced metering will be required to enable consumers to benefit from favorable electric rate structures. Utilities specifications and business models will determine meter specs. PSC tariffs allowing rate-base recovery of additional costs specific to EV charging as opposed to unique customer cost may be helpful.*

D4 What land use issues need to be addressed?

- *Strategy: Preferential parking, HOV lanes, lower tolls for low carbon vehicles.*

D5 Consumer Education

- *Strategy: Television, newspaper and website information for consumers similar to current NYSERDA media campaign promoting change-out of incandescent lighting to CFLs.*

D6 Bring cost down to consumers

- *Strategy: See D2 &D3*

D7 Codes and Standards

Vehicle charging communications has received some support from automakers because it could allow for a single industry standard for recharging mechanisms to meet the needs of the electric utility system. Automakers would prefer to see a single vehicle standard that could be universally implemented as opposed to a patchwork of standards and technologies across state boundaries or utility service territories.

The addition of Level II charging infrastructure to an existing building can typically cost $3,000 and this cost can be an impediment to sales. When charging infrastructure is incorporated in new construction, the cost is $300.

- *Strategy: Developing standards that are compatible smart-grid/smart-charging Level III and Building Codes that requireboth residential and commercial new garage construction, to provide circuitry that conforms will enable lower cost market penetration and safer/more reliable service. Policy and regulations should encourage standardization of vehicle charging interfaces at the regulated utility level and with vehicle manufacturers.*

E Vehicle (end user) Strategies:

References: Transitions to Alternative Transportation Technologies--Plug-in Hybrid Electric Vehicles, National Academy of Sciences, 2009; Electrification Roadmap, the Electrification Coalition, 2009 (200 million EVs by 2050); 2050 Greenhouse Gas Emissions Analysis: Staff Modeling in Support of the Zero Emission Vehicle Regulation, CARB, 2009; Reducing Greenhouse Gas Emissions from the US Transportation: Pew Center, Oak Ridge National Laboratory, MIT, 2003

E1 Vehicle charging

Smart charging will be needed as grid-fueled vehicle penetration grows. Shifting the vehicle charging load to off-peak time may be the biggest long term issue. It may be necessary for public policy or rate structures to provide incentives and disincentives to implement adoption. SAE and IEEE standards are under development and there are several technical approaches which will enable vehicle-gird-building communication and smart charging. Energy storage technology will likely be necessary to mitigate large quantities of on-peak or fast –charge charging in the future.

- *Strategy: Near term: encourage demonstrations of technical options and monitor performance, explore behavioral influences of rate structures and public policy. Long term: enact appropriate rate adjustments and incentives to mitigate grid problems, research and development of energy storage technologies that can utilize large quantities of excess power generated from renewable sources and base load nuclear power (which are difficult to turn down) for on-demand and Level III quick-charge vehicle charging.*

E2 Battery technology

Continued advances are required in battery technology and manufacturing. Significant cost reductions will be required to allow grid charged vehicles to compete with petroleum at anything less than $4/gal. This may be difficult with lithium-ion technology because of the current low labor cost and as of yet undetermined sources of cheaper materials.

- *Strategy: continued R&D into the next generation of battery chemistry; explore innovative business models (battery leasing, battery change out, etc.).*

E3 What platforms?

The issues of vehicle range, fueling infrastructure, and cost will be challenging. Quick charge (level III) electric charging may require stationary storage or other upgrades. Range issues can be overcome with fuel cell vehicles however quick fill public H2 infrastructure would require a major investment. H2 only provides significant GHG benefits over conventional hybrids when the hydrogen is produced through electrolysis or via thermo-nuclear means, therefore H2 is a long-term option that can provides benefits if and when there is adequate (or an excess) of zero carbon electricity. A third option, hybrid bio-PHEV, may be the easiest pathway on the vehicle side however low carbon cellulosic ethanol is not yet proven to be competitive.

- *Strategies: None of the above options should be abandoned, all may be needed to meet the variety of duty cycles, first cost vs operating cost constraints and user needs. In all cases, continuous improvements in vehicle technology will be needed together with significant long-term infrastructure investment. Public policy should be technology neutral and in the near term focus on low-carbon vehicle incentives such as fee-bates for low carbon vehicles a low carbon fuel standard and tax credits, and buy-downs for fueling infrastructure.*

E4 Who will service?

Strategies: Public policy and financial support for educational and workforce development programs at community Colleges; BOCES and other publicly supported schools; tuition assistance.

E5 What rate of low carbon vehicle introduction is necessary?

Over 90% of the vehicle miles traveled are made with vehicles than 15 years old. Therefore to achieve a near total transition to low-carbon travel by 2050 nearly all vehicles sold after 2030 would need to be low carbon.

- *Strategies:* *Financial incentives for desired market transformation and disincentives for unwanted behavior will be necessary to accelerate low carbon vehicle market penetration. Infrastructure investment will also be a necessary element and may require adjustments in public policy and public investment.*

E6 How to bring costs down:

- *Strategy: Manufacturer competition may be the most cost effective way to reduce vehicle cost with battery manufacturing capacity and, supply-demand being a dominant factor. A robust market can be encouraged through incentives, adequate charging infrastructure, and education. A low-carbon fuel standard, vehicle purchase fee-bate or other carbon pricing mechanism will be need for EVs/PHEVs to be economically competitive in the near term.*