Department of Energy
Washington, DC 20585

Meeting Notes
U.S. Department of Energy
Quadrennial Energy Review
Technical Workshop on
AMR Lessons Learned on Alternative Transportation Refueling Infrastructure

Office of Energy Policy and Systems Analysis
June 20, 2014

Washington Marriott Wardman Park
2660 Woodley Rd NW Washington, D.C. 20008

This summary of meeting notes reports the discussion as it occurred. The Department of Energy (DOE) does not endorse the content summarized within.

Contents

Purpose

The purpose of this technical workshop was twofold. The first was to summarize the lessons learned from the Vehicle Technologies Office/Fuel Cell Technologies Office Annual Merit Review (AMR) with regard to alternative transportation refueling infrastructure.[1] The second was to examine implications of the AMR recommendations for long-term policy planning led by the Office of Energy Policy and Systems Analysis (EPSA) as part of the Quadrennial Energy Review (QER).

The AMR evaluates programs funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy. The process provides a comprehensive overview of research, development, and deployment trends in the transportation sector. Understanding these trends is critically important to developing forward looking policy recommendations, which is a fundamental goal of EPSA as a policy advisory body to the Secretary of Energy. The goal of this workshop was to leverage the inherent synergies between the DOE's research and policy functions and gather expert input.

Specifically, this workshop concerned the current status of deployment of alternative transportation refueling infrastructure, as well as various business models to develop infrastructure in future years. The total cost of alternative fueling infrastructure is low compared to what consumers will continue to pay in fuel costs with existing transportation infrastructure.[2] The key question is who will invest in the needed alternative fueling infrastructure using what business models. A white paper[3] examining these concepts was circulated before the workshop, discussed, and edited based on feedback.

[1] The Bioenergy Technology Office also holds an Annual Merit Review, which is not discussed here.
[2] Transportation Energy Futures Study. http://www1.eere.energy.gov/analysis/transportationenergyfutures/
[3] Quadrennial Energy Review Analysis: University of Tennessee Knoxville. "Alternative Transportation Refueling Infrastructure in the US 2014: Status and Challenges." April 2015. http://bakercenter.utk.edu/2015/04/02/alternative-transportation-refueling-infrastructure-in-the-us-2014-status-and-challenges/

Workshop Timeline and Meeting Notes

Part I: Alternative Transportation Refueling for Light Duty Vehicles: Infrastructure Physical Assets and Policy, 2014

The United States transportation system is already becoming progressively less dominated by liquid petroleum and diversifying into a broader portfolio of fuels. This shift is due to both policy and economic drivers. This morning session focused on the current geography and extent of this infrastructure as well as the economic, policy and other factors that have led to the spread of alternative fueling facilities in different regions across the United States.

8:00 Framing remarks: Lessons from the AMR
Remarks were made by Jake Ward from the Department of Energy's Vehicle Technologies Office.

8:10 Introductions

8:30 Framing remarks: QER as a path forward
Remarks were made by Carla Frisch, Karen Wayland, and Levi Tillemann from the Office of Energy Policy and Systems Analysis.

8:45 Presentation of baseline AMR/QER Framing Document
David Greene, from the University of Tennessee-Knoxville, presented a draft paper and framing document for the workshop, "Alternative Transportation Refueling Infrastructure in the US 2014: Status and Challenges."[4] He discussed the motivation for a transition to alternative fuels, four of the major alternative fuels (biofuels, electricity, natural gas and propane, and hydrogen) and steps for moving forward.

Greene began with his background on alternative fuels, which he traced to his work in the policy office in 1980. Since 1980, climate change has increased in urgency, especially as the scientific consensus and rapid acceleration of climate change have become clearer. Although the United States has recently benefited from increased domestic oil production and reduced consumption, greenhouse gas emissions remain a problem that has not fundamentally changed. Greene noted that the United States does not need to completely stop using oil, but must significantly reduce usage to avoid the serious economic costs associated with dependence on petroleum.

[4] Quadrennial Energy Review Analysis: University of Tennessee Knoxville. "Alternative Transportation Refueling Infrastructure in the US 2014: Status and Challenges." April 2015. http://bakercenter.utk.edu/2015/04/02/alternative-transportation-refueling-infrastructure-in-the-us-2014-status-and-challenges/

Unlike air emissions in the 1970s, it may be harder for the public to connect climate change to public health. Fossil carbon owners do not want to see a devaluation of their resources. Greene cited the development of reformulated gasoline by incumbent energy companies in California to prevent a switch to methanol as an example of how energy systems respond to regulation.

Greene concluded that alternative fuel technologies have progressed remarkably in the past 20 years. There are still many technological barriers, such as hydrogen storage tanks and battery costs, but there are many reasons to be optimistic about a transition.

9:30 Discussants Panel Linking DOE's Past and Future
The panel discussion heard from DOE representatives working in electric vehicles (EV), hydrogen, natural gas and propane, and biofuels. Pat Davis, Fred Joseck, Zia Haq, and Mark Smith participated.

1. Electric Vehicles (EV)
EV infrastructure is and will continue to be a balance between what supports the public good and what makes business sense. Right now, the economics of EV charging stations are focused on fleets. Pay back on light-duty, consumer vehicles is harder. However, continued maintenance of the gasoline infrastructure also requires significant resources.

There are several aspects that make EV infrastructure unique, including:
(1) electricity is everywhere, but there is limited access to charging stations;
(2) much of the population has some access to electricity at home, which could be used for charging, but this might limit public investment in EV infrastructure;
(3) if people are home-charging, there is less of a business case for charging stations;
(4) electricity is a low-cost commodity, so people are resistant to price increases to cover cost;
(5) EVs need to be plugged in for a few hours, but people are used to fueling their car in minutes.
Climate change, the shale gas boom, and technology improvements are changing the landscape of alternative fuels.

There is no single model for urban parking, which means there will be no single model for EV charging. Some car-sharing models have built out infrastructure that is also available for EVs. Another model would be to use street lights for charging, but this would be Level 1.

2. ***Hydrogen***
California is the first state making significant investments in station construction with 28 stations scheduled to be open by the end of 2015 and 23 more stations to open in 2016, working towards achieving the target of 100 by 2020. International development, particularly in Japan, Germany, Korea, and the United Kingdom, of hydrogen cars and infrastructure should lead to economies of scale. Station permitting process, the time required to acquire the permit and the elements/components of the permitting process are one of the major contributions to enabling infrastructure rollout.

DOE, industry, state governments and others have formed H_2USA, a public-private partnership to promote the commercial introduction and widespread adoption of hydrogen fueled fuel cell electric vehicles. H_2USA's mission is to address hurdles to establishing hydrogen fueling infrastructure. In support of H_2USA, DOE also started the Hydrogen Fueling Infrastructure Research and Station Technology (H_2FIRST) project, a collaborative effort between Sandia National Laboratories and the National Renewable Energy Laboratory (NREL). H_2FIRST aims to:

- Provide world-class technical facilities to demonstrate hydrogen refueling technologies and infrastructure
- Reduce the cost and time of new fueling station construction and improve the stations' availability and reliability

While California is working on hydrogen infrastructure to provide fuel for the fuel cell vehicle introduction, Hawaii is also looking into hydrogen infrastructure. After this, industry and states will be able to build off of California's example to see how to deploy Zero Emissions Vehicles (ZEVs). There are 7 ZEV states in addition to California: Connecticut, Maryland, Massachusetts, New York, Oregon, Rhode Island and Vermont. Together they account for more than one quarter of the nation's new car sales.

3. Natural Gas/Propane

Natural gas is currently more established than some of the other alternative fuels. In addition to the 700 public access stations, there are about 650 fleet-access only stations. In addition to the 150-160 stations funded through the Recovery Act, another 500 Compressed Natural Gas (CNG) stations have started without federal funding.

The Liquefied Natural Gas (LNG) infrastructure is less developed, with 53 public access stations used almost exclusively by fleets. Smith noted that an LNG highway may not be feasible or necessary because long haul trucking across the country is being replaced by a hub-and-spoke approach to trucking. To contextualize the growth of natural gas, there are about 150,000 gasoline stations nationwide. While the U.S. does not need every alternative fuel to be available in every station, alternative fuels need to have some level of convenience for fleets and consumers.

Summarizing the developments in the CNG business model, previous natural gas stations were built by utilities using a "build it and they will come" model. These stations may not have been cost-effective. Today, natural gas distributors look for an "anchor tenet" to build a gasoline station, which includes a smaller pipe for natural gas. Natural gas today favors public access stations in areas of high use.

Natural gas is in the process of changing business models. Where there used to be only a handful of players in the natural gas infrastructure game, the low price of natural gas is leading to a growth in the number of both small national and large international players. In regard to propane, the industry would like to call it "auto gas" in order to differentiate it from propane used in non-car applications.

4. ***Biofuels***

The biofuels industry is expanding to jet fuel, rail and marine markets—markets with few to no other low-carbon alternatives. In addition to the transmission and distribution of the finished product, infrastructure needs to consider feed stocks and conversion facilities. The reduction of petroleum imports continues to be a national priority, one in which biofuels can play a key role. Internationally, Brazil has a highly mature sugarcane derived ethanol market that meets a significant portion of their transportation fuel needs. In addition many countries like China, Japan, and India are actively seeking technologies that can convert waste and biomass resources into alternative fuels and bio-based chemicals.

Enabling policies will be critical for any alternative fuel including biofuels. The Renewable Fuel Standard (RFS) has succeeded in incentivizing business models for biofuels. In addition, the phase-out of MTBE allowed ethanol to enter the market as a replacement oxygenate in gasoline. While corn and sugarcane ethanol are cost competitive, pioneer cellulosic biofuel facilities are beginning production at commercial scale. The cellulosic biofuels industry will continue to improve their process and reduce cost of production just as the corn ethanol industry has done.

Comments from the Audience and Panelists:

One audience member remarked how China and India will soon double their consumption of petroleum. Therefore, alternative fuel production technologies need to be replicated in developing countries so that the impact can extend beyond US borders. The audience member asked for a price comparison of installing infrastructure for EVs versus stations for other alternative fuels. Hydrogen stations compare well with natural gas stations in price, based on performance over time. Hydrogen is not focused on fleet fueling. Unlike EVs, hydrogen must make infrastructure and fueling investments upfront, rather than on a per-car basis. California's investments in this area come from an expectation of growth and sustainability of fuel cells. Regarding the critical mass of vehicles that needs to be economical, the audience member said stations can be fairly small. California is giving out $1.5-2 million rewards for 500 kg/day stations.

An audience member emphasized the planning fallacy. He stressed that we should be realistic about the advantages and disadvantages of the four options (hydrogen, electric vehicles, natural gas, and biofuels), which have significant benefits and challenges. He suggested using a robust portfolio of options so if one, or all, does not work we can leverage the lessons learned and apply them to other alternative fuels.

A commenter noted that the fuel landscape can change quickly, and unexpectedly, e.g., the US natural gas boom.

There was discussion on the number of public charging stations represented in Greene's paper. There are over 8,000 stations and over 16,000 outlets represented in the paper, but David Greene and EERE's Alternative Fuels Data Center would be interested in seeing any additional

data on public charging stations. David Greene mentioned that alternative fuels infrastructure is not just about considering externalities, but also about generating positive financial outcomes. A lesson from ethanol has been that mandates work differently than subsidies. The RFS mandate has been a driving force in the ethanol industry, generating a shadow price for RIN credits, which certify that the fuel is renewable. That credit can be sold to others looking to meet their requirements.

Greene said that ethanol can be blended incrementally up to the blend wall and that hydrocarbon biofuels can be easily integrated into the existing pipeline, storage, and delivery system infrastructure. An incremental approach can gradually turned an "alternative" fuel into alternative conventional fuel.

A discussion began about whether it be more effective to help developing countries build up alternative fuels infrastructure in order to meet GHG reduction goals.

It was also mentioned that at one time people thought infrastructure growth in China would position it as an alternative fuel leader. The US has to 'lead by doing' because our free market economy and state and local structure can provide useful examples.

Several audience members noted that sufficient and reliable data on E85 pricing is not available and it is difficult to make comparisons. E85 prices need to take into account the lower energy content of E85 compared to gasoline. Consumers may also need additional differentials to make up for the inconvenience. When the price of gasoline was high in the summer of 2008, E85 use skyrocketed. The Alternative Fuels Data Center (AFDC) is trying to separate primary stations from secondary ones to distinguish stations that provide fuel to grills and RVs from ones that are truly dispensers for cars. Retail prices in the discussion paper were not reflective of auto prices because they include grill and RV.

There was mention that Massachusetts is looking at using solar or natural gas to make hydrogen and setting up workplace EV charging.

The panelists and commenters discussed parts of the value proposition for each fuel type:

1. Electricity- Fueling is at home and inexpensive fuel
2. Hydrogen- Similar fueling experience at a lower cost
3. Natural Gas- Cost effective, no different than gasoline fueling and it is price competitive
4. Biofuel- Cost competitive and readily available

Part II: Alternative Refueling Infrastructure Business Models: Constraints and Policies

The purpose of these late morning and afternoon sessions was to leverage lessons learned from the 2014 AMR to help explore and evaluate policy aspects and implications of potential business models for refueling infrastructure for alternative transportation fuels. This effort fed

into a framing document[5] that will inform future policy research and recommendations from EPSA regarding alternative transportation refueling infrastructure.

For many alternative fuel systems, there is a "chicken and egg" issue that characterizes the deployment of fueling infrastructure. Adequate fueling infrastructure is a prerequisite for deploying certain varieties of alternative fuel vehicles. However, deploying infrastructure *en mass* in advance of reaching a certain critical mass for vehicle deployment may lead to significant under-utilization of fueling infrastructure and thus pose challenges to the viability of business models that support these facilities. Certain forms of fueling infrastructure may never be profitable on a stand-alone basis from a fuel retailer perspective – which does not in and of itself mean that they should not be promoted from a societal perspective. One goal of this workshop is to better define the challenges and possible solutions to business models for alternative fueling infrastructure.

Break-out sessions one and two addressed the same questions over different timeframes. Break-out one asked participants to discuss issues, barriers, and solutions over the next five years while break-out session two looked out over the next 5-20 years.

10:45-11:45: Break-out Session 1: AMR/QER Alternative Transportation Refueling Infrastructure Framing Document: Current Issues, Barriers and Short-term (5 years) Policy Solutions

Discussion questions for this session included: Where does the U.S. need to be in 5 years for alternative fueling infrastructure? What business models exist or might exist in the future? What federal policy levers can help?

***Break-out Session 1**: Current Issues, Barriers and Short-term (5 yrs) Policy Solutions*	
Group A) Biofuels	Ethanol, biodiesel, drop-in fuels
Group B) Electricity	Urban on-street charging, metered charging, workplace charging, multi-family dwelling charging, fast charging , battery swapping
Group C) Hydrogen	Distribution, transmission, storage and fueling
Group D) Natural Gas/Propane	LNG and heavy duty trucking, fleet CNG, home CNG, public refueling, methane leakage

[5] Quadrennial Energy Review Analysis: University of Tennessee Knoxville. "Alternative Transportation Refueling Infrastructure in the US 2014: Status and Challenges." April 2015. http://bakercenter.utk.edu/2015/04/02/alternative-transportation-refueling-infrastructure-in-the-us-2014-status-and-challenges/

Group A- Biofuels:

The key topics discussed included:

- Blend wall's political and technical problems;
- Storing ethanol and biodiesel separately; and
- Ethanol transportation by rail

Reactions to the framing paper:

The session addressed the framing paper and shared their general thoughts. The delivery and distribution of biofuels is tremendously important: if it is impossible to add it to this QER, subsequent iterations need to consider feedstock infrastructure and conversion facilities. Biofuels have 150 large terminals and 100 distribution facilities nation-wide. The infrastructure, although large, is not sufficient. Greene's paper should have expanded upon the upstream infrastructure challenges of biodiesel.

Attendees were asked 3 main questions about the future of biofuel infrastructure.

1. ***What would be the definition of success in the next 5 years?***

One commenter mentioned that an increase of flex fuel blending at the pump would be a marker of success. The United States could learn by looking abroad, and learning from successful policies in Brazil, Sweden and Thailand. The speaker added that out of approximately 150,000 gasoline retail stations, about 15,000 have to be replaced each year. An incentive could be designed such that a portion of these 15,000 stations would find it financially viable to install E15 or E85 pumps. Over time, this would generate significant demand for higher level ethanol blends.

Another measure of success would be to reduce the lack of data. This has been a major obstacle for biofuels policy. Obtaining consistent policy and better survey data would be a major success in the next five years.

One major barrier to biofuels infrastructure deployment is that negative-views of ethanol have increased. A fact-based educational campaign could spur biofuels growth over the next five years.

2. What business models exist or might exist in the near future?

A successful business model has to incorporate (i) low or no cost feedstock, (ii) relatively simple conversion technology, and (iii) a combination of credits to make the fuels cost competitive. For example, municipal solid waste, waste fats, oils, and greases could be near zero cost feedstocks.

Another business model involves giving value to the customer by creating a dedicated vehicle for ethanol to incentivize infrastructure development. Biodiesel could be sold as a green, patriotic, and pro-farmer fuel.

3. What would be some important federal policy levers?

One commenter mentioned that incentivizing retailers with subsidies and grants will help.

The group discussed that there is an opportunity to learn from and emulate international policies (e.g. Sweden, Brazil, and Thailand).

Group B- Electric Vehicles:

The electric vehicle breakouts included representatives from national laboratories, academia, auto companies, trade associations and the DOE. In the first breakout, the group discussed David Greene's framing paper and the status and development of EV infrastructure over the next five years.

The key topics discussed included:

- Consumer knowledge and acceptance of EVs;
- The importance of having a diverse portfolio of alternative fuel technologies;
- Increased availability of fast charging;
- Having uniform charging standards;
- EV charging at key public destinations such as hotels and beaches;
- Expanded workplace charging;
- Business level crowd sourcing or business alliances;
- "Peak shaving" – providing fossil fueled vehicles for long distance trips;
- Congestion Mitigation and Air Quality grants to municipalities;
- Retail/amenity charging model;
- Adopt a charge station; and
- The role of DOE as a leader and convene.r

Reactions to the framing paper

The session addressed the framing paper and shared their general thoughts. The group generally agreed with the paper. No one had major disagreements with the content or identified any errors in the paper. The discussion mainly focused on things they would like added to the paper or gaps and questions the paper brought to light. Here are some salient points from this discussion:

The group discussed the scope and scale of the goal of displacing petroleum. Increasing the deployment of alternative fuel vehicles on the road reduces the consumption of petroleum for transportation. There was some discussion about defining the goal. Several participants stated that zero petroleum consumption is not the expectation or the goal. A proposed goal could be an 80% reduction (from 2005 levels) in greenhouse gas emissions (and petroleum consumption) by 2050. EVs, like other technologies, are particularly important technology because they are both low carbon and oil displacing.

The group noted that the expectation that a single technology could dominate the market is unrealistic. According to one participant, companies like Tesla and Nissan do not expect 80%

market share and would consider 10-20% EV penetration in the transportation market a success over the next 5 years.

The group believed that the goal should not be to pick a winning business model. Many business models should be employed so if one fails, there are others that can continue to support the industry. Relying heavily on a particular business model can be just as bad as relying heavily on a particular fuel.

In terms of gaps in the paper, the group expressed concern about consumer knowledge and acceptance of alternative fuels. Over the next five years, there needs to be policy solutions and funding to address the gap in consumer education. Infrastructure is a problem, but it is not the only or biggest problem from the industry's perspective. Consumer education and acceptance may be a bigger barrier than infrastructure.

The group mentioned that there needs to be more discussion in the paper on leveraging public investment. The paper could examine how other clean technology sectors, such as the solar industry, leveraged funding. Lessons learned from other clean tech sectors could be applied to funding alternative refueling infrastructure.

Attendees were asked 3 main questions about the future of electric vehicle infrastructure.

1. ***What would be the definition of success in the next 5 years?***

The group discussed that the proliferation and availability of EV chargers are key issues that must be addressed. Having EV chargers in all new buildings was suggested, or at least mandating that new buildings be "EV ready." A state or city could require that all new buildings or parking facilities have EV ducting installed, without having to install the actual charger. Installing EV chargers in the future would be much easier and less expensive, lowering barriers to expanding EV infrastructure (see NYC as an example). Over the last few years, chargers have become congested (there are few chargers and many customers making it difficult to find chargers at convenient times). The group agreed that information about charger availability is needed, but is not the only hurdle. In Chicago, data is available, but consumers still have problems finding chargers when they needed them.

One commenter noted that a reservation system for chargers has been tried, but still proved challenging because people would not show up for their reserved time or would stay longer than their reservation.

Another commenter identified two goals for the next 5 years: uniform charging standards and government pulling out of certain markets, like California. Uniform charging standards are needed to eliminate confusion among charging standards. The idea around government leaving certain markets is that a more mature market (like California) would be able to stand alone without government intervention.

A commenter mentioned that success could be characterized by four metrics:

1. Widespread knowledge of Level 1 charging
2. Resolving building code issues (new building mandates for EV chargers)
3. Workplace charging funded by companies for employee attraction and retention (5% of parking at every company)
4. EV charging at key public destinations such as hotels and beaches.

Not every problem with EV infrastructure can be solved in the next five years. The idea behind key destination charging is that it is a focused approach that would raise driver awareness in a concentrated way. It also has the benefit of allowing drivers to charge after longer distance travel and would be located in places that drivers are likely to stay for extended periods of time.

The group also mentioned that the availability of fast charging is a key to success. For cars such as the Nissan Leaf, fast charging is important (at least Level 2). Fast charging can reduce range anxiety, the fear of many consumers that their electric car would run out of battery before they reached their destination. A Tokyo Electric Power Company (TEPCO) study was referenced to support the need for fast chargers. In the study, a Tokyo utility company let their employees drive EVs and return the cars whenever they needed. At first, employees returned the cars with more than 50% battery life remaining. After installing Level 3 fast chargers around the city, the drivers returned the cars with less than 50% battery life remaining. The study indicated that range anxiety was reduced by increased availability of fast chargers. However, a number of compounding factors could have contributed to reduced range anxiety, such as increased driver education/awareness. A takeaway from the discussion was that even though fast chargers might not make money at this time, they may need to be viewed as a public good to promote EV deployment.

The discussion shifted to the importance of having a diverse portfolio of alternative fuel technologies. In the next five years, every problem cannot be solved and perhaps the hardest problems should not be solved first. Easier questions can be addressed first that could help in EV deployment. Perception was identified by the group as a big problem. People need to know that infrastructure is available before they would be willing to buy EVs. EVs will not reach a level of success until urban dwellers perceive a certain level of comfort and convenience about availability and reliability of infrastructure.

2. What business models exist or might exist in the near future?

Profitable business models for EV infrastructure are very difficult to achieve in today's market conditions. Currently, there might not be a profitable, successful and sustainable model, but progress must be demonstrated towards a cost competitive model. Creating a profitable business model will involve a transition and will likely take several iterations.

Another suggestion from the discussion was that the Greene paper could benefit from a cost comparison of capital costs between all alternative fuels compared to petroleum.

Another business model idea discussed was about business level crowd sourcing or business alliances. This model aims to capture indirect benefits for businesses that provide EV

infrastructure to customers for free. Rather than making money on electricity, businesses would benefit from employee retention and customer attraction/satisfaction. A business would pay to install EV chargers, which could attract customers and lead them to remain in the store longer to shop while their EVs are charging. The return on investment a business gets from having EV chargers needs to be quantified. This model could work on an individual business level, but perhaps works better at the "alliance level" where multiple businesses, such as a shopping center, could all share in the cost of EV chargers and benefit from customers who stop to charge and shop among their stores. The idea of an alliance "charging card" for customers was proposed.

A retail/amenity charging model was the next business model discussed (*similar to the business alliance model).* Retailers, like Kohl's and Target, would install charging stations to entice customers to spend more time in their stores and to distinguish themselves as supporting EVs. A question around retail/amenity charging model is whether this would be viable 10 years from now. It was noted that different markets need different business models and you need to consider each market individually to develop a solution.

Another idea was a business transport model for "peak shaving." EVs can work in an urban environment, but can be problematic during long distance travel where charging is less available or completely unavailable. BMW recognized this challenge and provides its EV customers with access to SUVs during certain times a year (for long trips). It was proposed that the government or others could provide EV owners with Zipcars or traditional gasoline vehicles 2 to 3 times a year for long distance travel needs.

A utility business model was also discussed. In this model, the utility would fund some level of infrastructure and get paid by increased sales of electricity. For example, San Diego Gas and Electric has a proposal for a special rate where they would make money off credits and electricity sales and pool the money to fund downstream infrastructure. They would fund all infrastructure down to the charger installation. The discussion identified utilities' need for better data. Utilities do not have good data about projected demand or about what is currently in the market in terms of infrastructure. They need these tools and information resources for investment purposes. There is room for more investment, but better coordination with the utility sector is needed. Load growth is a concern for utilities so they have an interest in EV charging, but information hurdles remain. It was also mentioned that there is always regulatory uncertainty and the current regulatory structure is not going to remain the same.

Another idea for funding EV charging is to provide neighborhood or city block grants through Congestion Mitigation and Air Quality Improvement grants to municipalities. As an example, Colorado received $2 million to install EV chargers through these grants. It is important for the government to partner with municipalities and cities to make progress toward increased EV infrastructure.

Alternatively, through the tax code the government could rebate household charging or provide some sort of benefit for reducing carbon through EV use.

The discussion identified the need for the federal government to fill in gaps and act as a leader and convener. DOE should expand workplace charging and charging in key areas. There was some feeling that DOE has not put in enough resources in these areas. There was a call for better coordination between DOT and DOE on the role of corridors. The group felt this could help overcome issues of perception with a relatively small investment. The government needs to put money in infrastructure where private sector will not.

A unique idea was proposed in which a business or group could sponsor a charging station at a key location like a park or beach (adopt a charge station).

The group compared the EV charging model to the traditional gas station model, which relies on associated retail goods for a majority of its profit. A participant noted the need for a digital equivalent to Cheetos (e.g. weather, news, sports, traffic, flight status, train status, bus schedules, stock, ATM, electronic fund transfer). There has to be another revenue stream beyond selling electricity.

There was a brief discussion about vehicle-to-grid (V2G), and how EVs can provide benefit to the grid.

The final business model idea discussed was providing EPA credits to workplaces for installing charging stations.

3. ***What would be some important federal policy levers?***

It was suggested that the federal government might not want to subsidize all forms of charging.

Another suggestion was to look at the lessons learned from Wi-Fi adoption. Supplying Wi-Fi in a plane was not obvious ten years ago, but today it is. It could be useful to examine how that technology was adopted and deployed.

Other policy levers mentioned include: an EV tariff, EV as efficiency or decoupling for utilities, carbon based rebates (for example, in California the public utility commission (PUC) has decided to give rebates to utilities), and DOT/DOE coordination and intervention where private business models are not sustainable.

Group C- Hydrogen:

The key topics discussed included:

- Structuring permitting and regulations to facilitate the building of hydrogen infrastructure;
- Prioritizing safety;
- Appropriate station size and pressure ratings;
- Business models: selling higher-value goods along with the fuel and learning from the telecommunications approach;

- Financing through state incentives and private funding;
- Updating RFS to include solar and wind that is transmitted through the grid and then used to make hydrogen;
- Adding hydrogen to the Climate Action Plan; and
- Restructuring federal subsidies for increased flexibility.

Attendees were asked 3 main questions about the future of hydrogen infrastructure.

1. ***What would be the definition of success in the next 5 years?***

One definition includes multiple automakers producing vehicles, multiple states adopting policy, multiple markets, multiple investors funding stations, and a sound profit model for station development. In California, the goal is to be ready for 1 million fuel cell and plug-ins by 2020 with 100 stations. Current renewable fuels credits do not apply to infrastructure construction, and expanding this definition to cover infrastructure would incentivize development.

The group reiterated that independently funded station development would be an important definition of success for the industry. So far, independent funding has only come in material handling stations. There was some discussion that the permitting and regulatory environment should be structured to facilitate consideration of hydrogen infrastructure building. For example, South Carolina uses state-wide permitting for hydrogen distribution, instead of municipality-based permitting. Another example was to change set back distances to allow more hydrogen stations.

The group touched on the prioritization of safety (including increasing consumer understanding about safety) and introduction of technologies that will support integration with the grid.

One major obstacle to success is determining appropriate station sizes and pressure ratings, especially with regard to the time it take to fill a hydrogen car. Stations need to be built with consumers in mind, who demand long-range, fast-fill vehicles. Auto companies could make a lower-cost vehicle with only one tank, but most consumers would not be interested in purchasing that model as it restricts range. 700 bar fast-fill stations could be cost prohibitive for independent investors. The group also noted that consumers who wish to spend less on fuel may still choose to fill a 700 bar-approved engine with 350 bar fuel the same way that gas cars can be filled only halfway. Most of the group agreed that the 700 bar standard was necessary in order to attract customers to H2 cars over other alternative fuels.

2. ***What business models exist or might exist in the near future?***

The United States has been focused on putting in large numbers of stations from the beginning, even before hydrogen vehicles have been brought to market in large numbers. One member pointed out that in Oslo, a low-capacity station was built in the city center for a few cars and then moved out and expanded as more demand came in.

Another point was that fuel providers today have a small margin on fuel and that their large margins come from their convenience stores. Potentially, H2 car owners may be higher-end consumers so convenience stores at H2 stations may be able to sell higher-value goods. However, margins for liquid fuel may be small but large volumes of sales make up for it. The key will be increasing utilization of H2 fuel cell cars because the infrastructure will be more expensive the less frequently it is used.

Another potential model would be to use a telecom approach where one investor or company would be given a station license for a particular area. That way, investors could build out capacity as the demand grows.

The breakout summarized the likely growth path for H2 stations as follows: financed primarily through state incentives and private funding, industrial gas providers install stations for a small number of cars. As demand grows, new groups will come in to replace industrial providers and deploy stations over a wider footprint. Finally, new groups will become 'first-movers' themselves, instead of solely taking over industrial stations. For example, Hygen, Hydrogen Frontier, United Hydrogen, First Element are some of the first movers in the business.

3. What federal and state policies could help development?

Investors would want to see reasonable utilization rates for new hydrogen stations and therefore coordinated deployment of fuel cell electric vehicles and fueling infrastructure is highly desirable. This is why governments (e.g., California, Japan, etc.) are enabling an initial infrastructure framework sufficient for future private investment levels to support market growth. Absent this initial public investment, a higher rate of return would be needed (~20%). There is a need to fill in the gap, which will occur between the depletion of government financing and the up-take by private investors. The discussion noted that risk would need to be quantified for investors. Some risk could be mitigated by mandating Zero Emission Vehicles in different states in addition to the 8 that already have some provision for ZEVs.

The group discussed moving from grants to tax credits would grow the market. State-focused policies could be leveraged to provide infrastructure investment.

It was mentioned that under current standards, solar and wind used to directly produce hydrogen qualifies for the renewable fuel standard (RFS), but solar and wind that is transmitted through the grid and then used to make hydrogen does not qualify.

The group spoke about how by addressing resilience and flexibility of the grid, hydrogen can be integrated with other systems in order to act as a storage system. In grid blackouts, like those caused by Hurricane Sandy, hydrogen could allow vital services to continue. In light of the importance for grid security, fuel security and climate change mitigation, the group suggested adding hydrogen to the Climate Action Plan.

A commenter mentioned that restructuring federal subsidies to allow more flexibility in business plans for municipalities. For example, municipalities looking to buy a new fleet of

hydrogen buses are eligible for an 80% federal subsidy. However, a private company that is buying a fleet of buses for use by the municipality would not be able to tap into that subsidy. This limits how municipalities can contract work out to private companies.

The group discussed that subsidizing not just hydrogen production but also infrastructure as well as the potential for foreign countries to test out technologies where traditional infrastructures are not yet developed.

The group spoke about how a national hydrogen pipeline system similar to the national highway system. If H2 pipelines could use the right-of-way for railroads, it would save a lot of regulatory time and expense. New fiberplastic, reinforced pipe could also increase the speed with which the pipeline system could be built.

The group felt that the best-use of federal money would be to facilitate the build-out of stations in a managed way. A participant from California pointed out that initial stations built today will look very different from ones built five years from now.

The group spoke about how the legal profession should be educated. It takes 2-3 years to get station approvals through legal system, which can lead to risk aversion. However, there are (or will be) insurance companies that will create products to protect against risk. This could be a more effective way to manage risk than educating the legal profession.

It would beneficial to map out the hidden and apparent incentive structures currently available for hydrogen in order to make sure there are not incentives working against one another. Mapping incentives will allow players to assess impediments to integration across multiple sectors**.**

Another proposal would stimulate initial demand through government mandates that a certain percentage of new federal vehicles purchased are fuel cells.

Finally, the group spoke about how consistency and durability of policy over time would be ideal.

Group D- Natural Gas and Propane:

The key topics discussed included:

- Discuss natural gas and propane separately;
- Incorporate Recovery Act “lessons learned;”
- Discuss potential across transportation modes (especially rail and marine);
- Mention bio-methane;
- Add an integration section to the QER across all fuel pathways to provide a holistic view of alternative fuels;
- Expand vehicle markets in heavy truck, medium truck, rail and marine;

- Expand infrastructure;
- Resilience and emergency preparedness;
- Innovative utilities;
- Communicate advantages to light-duty market;
- Consistency of policies and data;
- Technology neutrality; and
- Incentives.

Reactions to the framing paper

The session addressed the framing paper and shared their general thoughts. The group mentioned that they would have liked to see more examples for natural gas throughout the paper. In particular, they felt the paper would have benefited from incentive-based success stories and lessons learned, such as UPS using propane trucks.

References could be made to other transportation modes besides fleets and a discussion of situations where LNG would make more sense than CNG and vice-versa.
Participants mentioned that more discussion on bio-methane should have occurred in the paper. One participant from a nonprofit organization argued that bio-methane has a bigger market than solar. For example, Fair Oak's dairy farm in Indiana successfully uses the methane gas from manure from the farm's cows to power their fleet of milk trucks.

The discussion then shifted to thinking holistically about how the different modes of transport (rail, trucks, marine, long haul and short haul) function together and how to create a road map for alternative fuels in the different modes of transportation. The QER does not need to contain the answers to all of these questions, but it does need to present questions for consideration and create a blueprint for others to follow.

Attendees were asked 3 main questions about the future of natural gas and propane infrastructure.

1. ***What are your key issues and ideas for the QER?***

Many of the ideas from the discussion revolved around various ways that natural gas could be used in the future including measures for resiliency for both LNG and CNG.

Discussion began about how methane emissions and methods for storing LNG should be covered in the QER. LNG storage methods in particular could be of interest, as LNG must be stored at a very low constant temperature, which could prove difficult for transport.

A commentator mentioned that more focus could be placed on consumer behavior and acceptance of alternative fuels. A great deal of research is going into business models for heavy duty natural gas vehicles, but consumers are more concerned with light duty vehicle so more emphasis should be placed on light duty vehicles. The QER should also include alternative fuels success stories to which the public can relate.

Focusing on all of these ideas not only individually, but also as a whole is particularly important. There could be a broader conversation on the opportunity for use of natural gas vehicles for fleets and linking natural gas vehicles to issues involving resilience.

There was discussion about how there is a great opportunity for natural gas vehicles to be used in the long haul trucking industry, citing that this industry accounts for 20% of all fuel use. Federal dollars and policies could promote the use of alternative fuels in this industry.

A participant noted that a user-friendly measuring system for comparing the costs of diesel, LNG, and CNG could be implemented. The current system, measurements are done in kgs, GGEs and gallons and there is no consistent, standard system for all three fuels.
A broader discussion could be had of the potential for CNG in the light-duty market on both the regional and local level. CNG is often discussed for fleet applications but could be capable of having a broader impact.

It makes sense for commercial fleets to adopt alternative fuels, but there should also be a discussion of the barriers for natural gas for light duty vehicles. What can be done from a policy standpoint for the implementation of alternative fuels to be successful?

The QER could also mention examples of successful deployment and adoption of alternative fuels and the social incentives that have helped influence the public to switch to alternative fuels (use of HOV lanes, special parking spaces were mentioned as examples of incentives).

It does not make sense to include propane and natural gas together in one section. While issues discussed could have some relevance to propane, the two fuels should be more separate, giving propane "its own two legs to stand on."

2. What would be the definition of success in the next 5 years?

The group discussed about how some of the "low hanging fruit" of the fueling industry include long haul trucks, which account for 20% of all fuel use. Success for this case would be defined as getting 10% of that market within 5 years. Other low hanging fruit discussed included the market for refuse trucks and transit buses.

Another definition for success would be shifting the focus to both fleets and consumers and having available, cost-competitive home refueling for natural gas vehicles for consumers. A target that was discussed was having 140,000 natural gas vehicles in 5 years in a variety of makes and models. An argument was made that it is difficult to create a business model for consumers, so that is one area for improvement.

Rail and marine LNG in the next 5 years could also be a measure of success. While it was discussed that this would be a reach goal, there is considerable interest in the marine community to explore LNG as a compliance option to meet low sulfur fuel requirements. Clear

communication and education of both policy makers and the public on natural gas was seen as a major area to focus on.

3. **What federal and state policies could help development?**

The group discussed how the government should create consistent policies across the various fuels and markets. It was mentioned that in terms of policy, vehicles should be incentivized in addition to infrastructure. For example, in Indiana tax credits are used to incentivize trucks to use natural gas. This system has rapidly expanded the use of natural gas in Indiana. Someone else commented that this idea could work at the regional level if the federal government strongly encouraged states to support these ideas.

Another participant mentioned that the EIA may be re-characterizing natural gas liquids into hydrogen gas liquids. While this is a new process, the goal is for the system to be more coherent in the long term.

1:15-1:30- Summary of Breakout 1

<u>Biofuels</u>

Reactions to the framing paper:

The biofuels group thought the discussion on fuel distribution was very good, but would like to see subsequent QERs focus on feedstock and conversion facility infrastructure.

Definition of success (in the next 5 years):

The group's definition of success includes having better survey data and an increased usage of flex-fuel at pumps. A key objective should be reducing the cost of production such that multiple biofuels are cost competitive in the marketplace without subsidies.

Business models:

There are a limited number of privately funded business models that are successful today. Support for enabling policies is needed. The private sector should have more involvement. It appears that financial backers are waiting to see what technologies will work. Once there is a proof of concept about certain technologies, then capital will flow to replicate those technologies. One business model is to market biodiesel as "green, patriotic, and pro-farmer fuel."

Federal policy levers:

Existing policy levers include: Renewable Fuel Standard, tax incentives, grants, loan guarantees, crop insurance programs, and financial help with defraying the cost of establishing crops. There is an opportunity to learn from and emulate international policies (e.g. Sweden and Brazil).

<u>Electricity</u>

Reactions to the framing paper:

When it comes to EV charging models, there currently is not a perfect model to pursue or emulate. There are many options, and the group touched on a lot of ideas in the discussion.

First, it is necessary to have a portfolio of options. No one knows what the answer is, so it is important to explore many models (and fuels). The policies put in place now depend on future goals; the goal of an 80% reduction in GHGs is important to keep in mind as policy is developed. There is a lack of consumer knowledge about EVs and education is a way to fill that gap. Finally, there are multiple steps along the way in the transition to EVs. This will require stepping stones and incremental progress as opposed to a single, all-encompassing solution.

Definition of success (in the next 5 years):
More charging options are needed, especially in places where EVs are currently being deployed. New structures should be able to easily retrofit EV technology. This could be accomplished by requiring new structures to have the ducting for EV charging (be EV ready). There should be a reliable number of stations to support the growing EV fleet, and anything being done today has to lead to something sustainable. One definition of success is the government leaving certain markets so those markets can grow and develop on their own. Success also involves widespread education and knowledge of Level 1 EV charging.

Business models:
EV charging can be an amenity or return on investment (e.g. Starbucks with charging stations). Another option is the utility business model. Since utilities are one of the prime players in EV fueling, they should be involved in the infrastructure process. EV charging could also be shared among multiple people, e.g. neighborhood charging or urban charging network. Providing loaner vehicles to EV owners a few times a year for long distance travel is one way to encourage EV ownership. The OEM model Tesla uses is another option. Tesla has put in hundreds of charging stations across the country and provides their customers that amenity for no additional charge (included in the price of the car).

Federal policy levers:
Grants and carbon-based rebates can help incentivize EVs. To encourage businesses and groups to distinguish themselves as supporting EVs, there could be an "Adopt-a-Charge-Station" model, similar to "Adopt-a-highway." Providing EPA credits for workplace charging was also proposed. In addition, there is a need for increased DOE/DOT coordination in certain areas.

<u>Hydrogen</u>
Reactions to the framing paper:
There is a gap between government financing and sustainable business models. There are also some numbers in the paper about station commitments in California that need to be corrected.

Definition of success (in the next 5 years):
It is important to identify the right station size and continue to build infrastructure across America. By 2020, success would involve multiple automakers with hydrogen cars and deploying more stations. In California, they are preparing for 1 million hydrogen vehicles on the road by 2020, with community readiness for 100 fueling stations. Other important considerations include safety and consumer awareness, profitable stations without subsidies, and permitting and regulatory reform.

Business models:
Two business models discussed in the breakout session were a variation on the traditional gas station model and a telecom approach. In the gas station model, the station makes a majority of its profits from selling associated higher margin goods along with fuel. Hydrogen stations could develop a variation of this model with their customer base in mind. The telecom approach would give a license to a particular financer to develop in a particular area, allowing that group to take advantage of growing markets.

Federal policy levers:
Tax credits are an important policy lever for developing hydrogen infrastructure, perhaps more effective at moving the market forward than grant-based subsidies. It is also important to have state focused policy. A mechanism that needs to be modified is the Renewable Fuel Standard (RFS). Currently solar and wind that that are transmitted through the grid then used to produce hydrogen are not counted toward RFS targets. This should be updated to incentivize renewable hydrogen. Hydrogen infrastructure must continue to be subsidized, but in a way that allows for greater flexibility of business plans for municipalities. Finally, another policy option is for government to mandate a certain number of hydrogen vehicles.

Natural gas
Reactions to the framing paper:
The natural gas/propane group would have liked separate treatment for natural gas and propane as well as a discussion about the potential across different transportation modes, especially rail and marine. Vehicles have continued to drive the infrastructure in this space: e.g. UPS fleet and LNG stations. Additionally, bio-methane and renewable natural gas should be included into the discussion to provide a holistic view.

Definition of success (in the next 5 years):
Infrastructure development over the next 5 years should focus on trucks and fleets. The market is maturing to a certain extent, and it is important to go after low hanging fruit. Success also includes low-cost home refueling for convenience, as well as the expansion of retail operators with CNG. The stations need to be robust to handle the market and also resilient in order to handle emergency events like Sandy.

Business models:
One option is innovative rate-based pricing, e.g. Oklahoma's 25 cent rebate model. Other business models would be to focus on rail and marine LNG and create a successful business model for consumers to complement the commercial fleet model.

Federal policy levers:
Policy must be consistent across-the-board and technology neutral. Companies can determine what works best for them. Incentives such as point-of-purchase vouchers are more effective than credits.

1:30-2:45- Break-out Session 2: The AMR/QER Alternative Transportation Refueling Infrastructure Framing Document: Long-term (5-20 years) Issues, Policies and Blue Sky Thinking

There are a wide variety of possible business models and government policies that may be used to promote alternative transportation refueling infrastructure. Some of these are led by government and others by the private sector. For instance, on the private sector side, original equipment manufacturers (OEMs) have taken on the responsibility of providing fueling infrastructure (e.g. Tesla fast charging, Toyota fuel cells, Nissan fast chargers). On the government side, a wide variety of models exist to promote the viability of such infrastructure:

- **Over the hump**: Infrastructure may be subsidized or encouraged through various forms of public financing (e.g. loan guarantees) to promote early deployment to drive down prices, with the expectation that it will eventually become self-sufficient and profitable (e.g. semiconductors).
- **Subsidized**: Fueling infrastructure may be subsidized by government because it provides a compelling public benefit, but may not be profitable for private entities to manage (e.g. highways, internet, etc.).
- **Regulated**: A competitive market may not achieve the economies of scale or penetration to transition to a sustainable business because of externalities not included in market pricing. Regulation or regulated markets can help provide public benefit (e.g. synthetic markets, regulatory mandates, etc.).

This session explored potential business models, government policy, or combinations of both that can facilitate alternative fueling infrastructure development over a longer time period. Discussion questions for this session included: What are the characteristics that define where a specific business model is optimally applicable over the long term? Where are such business models already in use? What variations might be useful? What public policy levers can help?

This break-out session paralleled session one by examining issues, barriers, and policies, while expanding the time frame to 5-20 years. It also encouraged blue sky thinking by asking participants to imagine broad definitions of success that are not limited by today's barriers.

Break-out Session 2*: Long-term (5-20 yrs) Issues, Policies and Blue Sky Thinking*
Group A) Biofuels
Group B) Electricity
Group C) Hydrogen
Group D) Natural Gas/Propane

Group A- Biofuels:
The "blue-sky" discussion focused on business models for the next 15 to 30 years, and those currently under development.

In biofuels, one business model that has generated interest is federally backed loan guarantees. Both USDA and DOE have loan guarantee programs that can be utilized by industry to support investments made by the private sector. Additional policy levers could be incentives and grants that reduce the cost of the infrastructure such as blender pumps, E85 pumps, and flex-fuel vehicles (FFVs).

Another innovative business model involves the manufacture of bio-based chemicals and products in parallel with the production of fuels. This business model is currently being used by the petro-chemical industry to produce a wide variety of chemicals, polymers, intermediate products, and fuels from petroleum refineries. A wide variety of high value chemicals and products can be made from biomass. They have a global market since they meet specifications for existing products and have some valuable attributes such as reduced greenhouse gas emissions. For example, 1,3-butadiene (used as an intermediate to manufacture tires) is a priority chemical that could be produced using biomass resources. Bio-derived butadiene could replace fossil-based butadiene without any reduction in performance.

Demand for ethanol in the United States can be increased by greater consumption of E15 and E85 both of which require modified storage tanks and pumps. Increased FFV sales and greater use of E85 by existing owners of FFVs will also result in additional ethanol demand. Technology development activities have focused on converting lingo-cellulosic biomass and algae into hydrocarbon fuels such as renewable diesel, jet, and gasoline. There are several promising pathways that are being tested at pilot and demonstration scale facilities. Scale-up to commercial scale facilities will begin in the near term. For example, three projects being jointly funded by Department of Defense, Department of Agriculture, and DOE, will begin commercial scale production of renewable jet and diesel beginning in 2017. In comparison to their conventional diesel and jet, renewable diesel and jet have nearly identical properties including energy content. Renewable diesel and jet will not require any changes to existing fuel distribution and end use infrastructure.

Group B- Electric Vehicles

The second breakout session was on longer term business models and policy levers for increasing EV infrastructure. The group divided the discussion into Level 1 and 2 business models versus Level 3 options. They began by discussing business already under development. They also discussed potential public policy levers.

Level 1 and 2 business models

The group discussed that the list of L1/L2 business models currently being deployed includes: home charging, amenity business model/associated retail, street light charging, urban charging network membership (up-charge for being a member of a club), pay for use, workplace charging, and the OEM model (e.g. Tesla).

Travel and destination charging was discussed. Some models already exist (e.g. airports), but there is a potential to expand the availability of chargers at destination locations like hotels, beaches, parks, etc.

Rescue and distressed charging models are potential near- and long- term business models. Such options include being able to charge on a tow truck or being able to rent an extra battery/have a battery delivered.

One participant mentioned that funding for EV charging could be obtained through a continuing grant program like the Highway Trust Fund. The government could charge a highway or sales and use tax (road user fee) and use those funds to pay for public chargers. There could be a federal/state partnership where the federal government provides the initial capital and the state provides maintenance costs. There is a continuum between government and private models, with a hybrid model lying in between. It is difficult but important to decide what mix of public and private funds should be used. The highway trust fund is an example of government paying for infrastructure. Government has the advantage of being able to maintain infrastructure without going bankrupt.

As a long-term option, it was mentioned that DOE is working on in-street inductive charging.

Level 3 business models

The group discussed the DOE study with INL input that examined the level of throughput needed to make L3 charging profitable. The study found that a station that charged about 15-20 vehicles a day can become profitable after 2 years. Having demand is a big issue with DC fast charging. If demand does not materialize, L3 charging is not profitable.

A participant mentioned that L2 charging is underutilized and L3 charging is more used compared to L2 charging. Information is needed about where to place L3 charging. One potential solution is putting out a lot of charging in a test market and seeing where people use it in order to learn what is most useful for consumers.

Distressed charging and co-location options were both discussed. For distressed charging, there might be a business model in having EV charging on tow trucks. Other options include co-locating L3 EV chargers with gas stations or places where people stop for longer periods of time like a grocery store or coffee shop. However, it would probably not be profitable to have a large network of co-located L3 EV chargers because a lot of stations would not be used. It is important to locate L3 chargers in prime locations. Siting is a big concern because people do not want to stop at a gas station for 30 minutes.

One idea is to have fast chargers at highway rest stops. This is currently not allowed because of laws prohibiting the sale of fuel at rest stops. The commercialization of rest stops was identified as a policy opportunity.

It was brought up that utilities need to have a role in L3 charging deployment. There is a need for studies on power needs and cross-state opportunities. Massachusetts is in the process of installing 20 L3 chargers, which could be a potential source of data on charging locations. Additionally, Washington State conducted a large study about Level 3 charging.

A participant mentioned that DC fast charging is expensive, but there could be big advancements over the 20 years to make it cheaper. However, the real problem is the installation cost, not the technology. Siting is another big hurdle that would need to be overcome to make L3 charging profitable.

In line with the amenity model where chargers are provided as free services at businesses looking to attract and retain customers, tax incentives can be provided to add extra incentive for businesses to provide this amenity. There could be a tax credit provided to new businesses who install pads for L3 chargers during construction. Having pads installed during construction will allow for less expensive development of charging infrastructure down the road.

A government driven model could be to require infrastructure on certain municipal or federal lands. On land where DOT manages parking rights, the government could require a certain number of EV chargers.

There was significant discussion about eliminating demand charges. If utilization of EV chargers is not at a sufficient level, demand charges can make EV infrastructure cost prohibitive. One option to address this barrier is to have a specific, lower rate for EV charging facilities. There was some concern that treating different electric loads differently would be slippery slope. The more supported option appeared to be prohibiting demand charges for a limited number of charging stations. The state could either mandate that a certain number of EV chargers would be exempt from demand charges or provide a limited subsidy or rebate, reimbursing the demand charges. There was some feedback from the group that this was a reasonable and doable option. Battery recycling was mentioned as another way to get around the problem of demand charges. The final idea surrounding demand charges was to aggregate EV charging facilities into a single network demand charge. That way, you could control the load of multiple sites which could be managed to alleviate demand peaks.

Public policy levers

The topics discussed include RPS credits for EV charging, an autonomous and connected vehicle model for EV charging, utility regulations that do not penalize utilities for increased EV demand, various climate policies, and PUCs as a policy barrier.

One policy lever discussed for states with an RPS is to provide credits for EV charging. It could incentivize states that are bumping up against their RPS targets to invest in EV infrastructure.

It was brought up that connected and autonomous vehicles (AVs) were also mentioned as an area of opportunity for EV policy. There will need to be a business model for connected and

autonomous vehicles using EV charging. Business models that use V2G and V2I communications were noted as currently under development, but 5 to 10 years down the road.

One idea was that regulations around the electricity sector need to be developed as to not penalize utilities for increased demand from EVs. Current regulations incentivize utilities to lower demand through efficiency measures. Demand from EVs should not be treated as a penalty for utilities in the context of the Clean Power Plan. There was a comment about not getting credit for vehicles or cross sector credits under the Clean Power Plan.

The group discussed that regarding climate policy as a mechanism to fund EV infrastructure, if there was a price on carbon, some of that revenue could be diverted to EV infrastructure development. It is unclear how effective it would be. The Low Carbon Fuel Standard in California and the Regional Greenhouse Gas Initiative in the Northeast were both mentioned as potential funding mechanisms, but more information is needed about what is possible.

Participants mentioned that PUCs can be a barrier to desirable EV policy. There is a need to generate national scale PUC attention on the issue of EV infrastructure and EVs in general. It was suggested that the DOE could act as a convener in this space (where they are legally permitted to act - there may be some legal restrictions).

Group C- Hydrogen

The Hydrogen infrastructure breakout session spoke about long-term business models and public policy levers.

Long-term business models currently under development

Similar to the first session, the group reiterated that integration with renewable energy by using hydrogen to store electricity is crucial. This approach could allow the United States to reach longer-term GHG goals by allowing more renewable generation to be brought on line. More research needs to be done to minimize energy losses incurred from moving in to and out of hydrogen.

The group then debated the creation of a “sin tax” on gasoline. Some believed that a goal to reduce dependence on foreign oil should be coupled with a “sin tax” on things that use foreign oil. In this way, hydrogen would be more competitive. Others argued that a “sin tax” may not be nationally feasible or applicable. One member mentioned that even without a tax on gasoline, government programs are financed with “hidden taxes.” In other words, the money spent on subsidies ultimately comes from consumer taxes, so it may make more sense to directly tax people that are heavy users of gasoline than spread the tax more evenly across the public.

Currently, hydrogen advocates favor a cluster business model. Stations are built in communities with fuel cell vehicles. Similar to cellphone tower development, stations are first sourced to be convenient to first-consumers- both at their home (cluster stations) and at places they are likely

to go (connector/destination stations). Over time, these destination stations will become new clusters.

The group discussed about how business models that develop technology, meet growing demand and provide convenience for customers will be the most useful.

Public policy levers
The group analyzed how incentivizing the entire sector would get automakers to produce more fuel cell cars for sale by dealers. Continuation of a H2 tax credit for consumers would encourage more sales.

The group would also like to see modeling work that looks at the cost for moving slowly, acknowledging that smaller subsidies over an extended period of time would likely be more expensive in the long run. Ideally, the government would offer large subsidies for a short period of time and then allow the free market to step in.
Currently, cluster connectors/destinations are underused. The group wondered whether there may be new revenue streams to leverage or whether connectors/destinations will have to wait out the lull until demand picks up.

Fuel cells are likely to first be deployed in densely populated states with policy levers in place. Returning to the cluster business model, it does not make sense to pepper infrastructure, fleet use, and consumers around. Instead, vehicle investments should be made in the same geography as station investments. In this vein, federal money should have requirements that it go to places that can leverage existing infrastructures. Another area for federal government assistance would be in the creation of green banks in cluster communities.

There is also the possibility for development of a franchise system. Free fuel could be another incentive, citing Hyundai's decision to provide free hydrogen for fuel cell vehicle consumers. Regarding consumer outreach, Nissan's program in Europe allows electric car rental. A similar program with fuel cell cars could introduce them to a wider consumer base.

The group touched on V2V as an enabler and the need for laws on the books to be non-restrictive or counter to goals.

One idea was that there is also a need for technological solutions to deal with emergency refueling. Potentially, consumers would want plug-in capabilities to get enough charge to reach a fueling station.

In addition, training in fuel cell servicing is needed.

Group D- Natural Gas and Propane
This breakout session spoke about current future business models and financial mechanisms and policy levers.

Current and future business models

One current business model is the "CNG in a box," a fully integrated CNG fueling supply system from GE. There was agreement that it was a revolutionary turnkey solution and that other packaged systems like it could be successful.

In addition, there are also mother-daughter stations, popular through Europe and South America. They function on the idea that if you do not have access to a natural gas station, a mobile refueling unit can come to fill up your vehicle.

Several other examples of successful NGVs include:

a. Schwan's Food Company uses all propane vehicles for their deliveries,
b. Shell's work with LNG bunkering facilities in northern Europe and the Gulf area is tied to marine and rail. Shell has the benefit of not only selling the LNG, but also of being involved in setting up the infrastructure. Energy vendors that are involved with creating the infrastructure are able to profit even more.

Another recommendation was capturing flare gas and using CNG to power truck fleets (dual purposing stations).

The group spoke about the challenge for natural gas to get past fleets. Though natural gas penetration is highest for fleets, do not presuppose the success or limits for fleets.

Value propositions were seen as a good characteristic for business models. Including a value proposition allows a company to enter the light duty consumer market across multiple modes.

Infrastructure design flexibility is also an important feature for a business plan. Vertical integration and collaboration were also discussed as ideas to allow companies to be involved across the value chain. Utility/producer engagement in gas and electricity pricing as functions of time-of-use rates was also seen as a generally positive characteristic.

Financial mechanism and public policy levers

The idea of bundling was also discussed, as bundling is not effective if average gas prices go down but the customer is still locked into paying the original fuel price. However, many municipalities shy away from bundling because of this possibility.

Educating fleets on their purchasing options, differentiating between the short- and long-term options, was also brought up.

The group discussed that states should have similar regulations to allow for consistency across the markets.

It was also mentioned that the federal government could cite codes on vehicles, but the regulations would need to be enforced (e.g., NFPA-52 and vehicle installations).

They spoke about how there is also a need for standards and regulations on refueling and other infrastructure for rail and marine, and also for storage and rail transport. In addition, there is also a need to fix tender car codes to allow for LNG use for rail.

Regarding CAFE standards, unless there are major incentives for them or any real reason why they should switch, most auto manufacturers will continue to choose flex fuels over natural gas. Using CAFE standards for both light duty and heavy duty vehicles could provide an incentive to vehicle manufacturers.

The importance of stable emissions standards and looking to past policies that have proved effective was also noted.

Another idea was that of an "energy check-up:" a mandatory assessment of energy needs that would occur each year. With the check-up, consumers would be provided with recommendations and advice for what would be most economically feasible and cost effective for them, which would promote informed decision making for the future. It was mentioned that the Clean Cities Coalition currently has a similar concept in place.

Non-financial incentives could be a major motivator for consumers, especially in urban centers. Examples included HOV lanes, parking spaces and not having to pay for tolls.

Bi-fuel vehicles, such as E85 vehicles, can still play a critical role and bridge the infrastructure and that policy should not discriminate against them.

Summary of Breakout Session 2

Biofuels

In the biofuels area, the emphasis has been on developing technologies that can convert lignocellulosic biomass and algae into ethanol, renewable gasoline, diesel, and jet fuel. The historical focus has been on ethanol for use in light duty vehicles as either E10, E15, or E85. For ethanol, the focus has shifted to optimizing engines and fuels to enable higher blends (higher than E10) of ethanol. The ultimate goal is to use ethanol blends such as E30 or E50 in highly optimized engines that take advantage of ethanol's high octane value and thus can deliver high performance from smaller engines.

New areas of focus include production of renewable diesel, jet, and gasoline for military, heavy duty vehicles, aviation, marine, and rail sectors. Biomass-derived renewable hydrocarbons have the advantage of being nearly identical to existing fossil-based diesel, jet, and gasoline. Thus, renewable hydrocarbons are expected to utilize existing distribution and end-use infrastructure.

There is continuing and growing interest in bio-derived chemicals and products that are of high value. It is envisioned that integrated bio-refineries (like petroleum refineries) will produce a

variety of products including fuel. A near-term possibility could be a bolt-on option whereby an existing corn dry mill produces ethanol and then converts that into jet fuel in a catalytic reactor co-located at the same facility. Similarly, an existing bio-diesel facility could add hydro-treatment and upgrading units to convert bio-diesel into renewable diesel.

Policy support is critical for continued use of alternative fuels. Important policy instruments include the Renewable Fuel Standard, tax credits, payments to farmers. Support for biofuels, electric vehicles, and demand management (CAFE standards) needs to continue in order to provide a suite of options that in totality can achieve significant greenhouse gas reductions, lead to oil import reductions, and create jobs in rural areas. One technology option alone will not be sufficient to provide all transportation sector needs.

Electric Vehicles

The EV breakout sessions separated the challenges of Level 1 and 2 charging from those of Level 3 charging. One business model for Level 1 and 2 charging would be to provide them as amenity charging, for example in a mall or coffee shop in order to keep customers inside the store for longer. Level 3 charging (80% charge in 15-20 minutes) could be used as a distressed charging mechanism and in rescue or mobile EV charging. It would be beneficial to co-locate Level 3 charging stations with gas stations or places with large electricity draws so that the electricity infrastructure is not additionally burdened by EV charging expansion. A final summary point addressed the benefit of putting Level 3 chargers in highway rest areas, but noted that there are some regulatory issues with citing them there.

Some challenges and solutions going forward, particularly for Level 3 charging, include demand charge, a billing mechanism that applies to consumers who draw electricity at a fast rate. These consumers are charged for their periods of large consumption, but pay a lower price on the electricity drawn. Level 3 charging stations could be good candidates for demand charge billing, but currently can't develop a successful business model for it because of the low number of EVs on the road. Changes to how demand charges are applied to charging station could allow a network of EV Level 3 chargers to operate under one demand charge. Another policy issue will revolve around how 111(d) changes the incentives around electrical generators. Finally, parking structures are preparing for Level 1 and Level 2 chargers, but the breakout session suggested having certain facilities install the pads/electric for Level 3 points that could be cost-effectively built into a full charging station.

Hydrogen

In the interest of time, the hydrogen group only addressed the key points from the discussion on long-term business models. Development needs to look at a whole energy solution; hydrogen can be integrated with renewables for use as an energy carrier, frequency stabilizer, voltage stabilizer, and more for stationary power generation. Hydrogen can be used as energy storage and renewable hydrogen for light duty vehicle transportation. RFS credits for hydrogen could be generated from excess solar and wind electricity, if the RFS policy were updated. In general, there needs to be more integration across all modes. Finally, hydrogen investments for

fueling infrastructure should be location/region-specific to have the most impact since fuel cell vehicles most likely will be introduced on a regional basis.

Natural Gas

There may be a turnkey solution, in which a company puts in a station and people pay for what was provided. GE looked into an "in-a-box" refueling station that came as one unit; future work could move this to development scale. Private users may decide to sell natural gas for public use as well, which could greatly expand the number of available filling stations. Other solutions may come from retail stations, mobile/roaming refueling units, and bundling of performance-service contracts. A benefit of natural gas is the ability to use dual-purpose stations that both sell NG as a product and use it as the station's power source. Finally, the industry is looking into applications for marine, rail bunkering and intermodal use at ports.

To summarize the characteristics that define a specific model, consumers are already seeing the value proposition of natural gas, including scalable and expandable stations, infrastructure design flexibility, utility and producer engagement, and vertical integration and collaboration across the value chain.

The industry would benefit from performance contracting. In addition, education/awareness about long-term contracting would help fleet vehicles, many of whom are currently unaware of the long-term contracts available for alternative fuels. The industry would benefit from a third party standards enforcer to make sure conversions are done correctly. Finally, utility rate design can play role.

There should be stable emissions standards that are consistent across fuels as well as technology forcing in order to remain as neutral as possible. Another suggestion from the breakout was services that would provide a consumer driving needs assessment—modeled after energy efficiency retrofit assessments—that would advise consumers on which fuel best fit their needs. In terms of non-financial incentives, there is also the benefit from HOV access and no tolls. Finally, this breakout session cautioned natural gas and propane providers not to overlook fleets as they are critical in developing infrastructure and providing lessons for small consumer vehicles.

Conclusion

In brief, the workshop was to inform the QER, which is an outward-facing document. It began with a review of the size and cost of infrastructure development and key issues between gaps in development and sustainability. The breakouts discussed subsidies, financing, best practices, and business plans. Alternative fuels are in a different arena than they were twenty years ago from a climate change standpoint, in their ability to address issues like petroleum dependency, and in their sensitivity to price. Several themes from the workshop emphasized the need for 1) infrastructure rollout for all fuels; 2) consistent, reliable policy across different fuels; 3) education and awareness; and 4) codes and standards.

Technical Workshop Agenda

More information on the QER can be found at: http://energy.gov/epsa/initiatives/quadrennial-energy-review-qer

AMR Lessons Learned on Alternative Transportation Refueling Infrastructure: Implications for the Quadrennial Energy Review (QER) June 20, 2014

Washington Marriott Wardman Park
2660 Woodley Rd NW Washington, D.C. 20008

Overview

The purpose of this technical workshop will be twofold. The first is to summarize the lessons learned from Annual Merit Review (AMR) presentations with regard to alternative transportation refueling infrastructure. The second is to examine their implications for long-term policy planning led by the Office of Energy Policy and Systems Analysis (EPSA) as part of the Quadrennial Energy Review (QER).

The AMR evaluates programs funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy. This process provides a comprehensive view of research, development, and deployment trends in the transportation sector. Understanding these trends is critically important to developing forward looking policy recommendations, which is a fundamental goal of EPSA as a policy advisory body to the Secretary of Energy.

The goal of this meeting is to leverage the inherent synergies between the DOE's research and policy functions and gather expert input. Specifically, this workshop concerns the current status of deployment of alternative transportation refueling infrastructure, as well as various business models for such infrastructure.

Part I: Alternative Transportation Refueling for Light Duty Vehicles: Infrastructure Physical Assets and Policy, 2014

The United States transportation system is already becoming progressively less dominated by liquid petroleum and diversifying into a broader portfolio of fuels. This shift is due to both policy and economic drivers. This morning session will focus on the current geography and extent of this infrastructure as well as the economic, policy and other factors that have led to the spread of alternative fueling facilities in different regions across America.

8:00 Framing remarks: Lessons from the AMR (Jake Ward, DOE/VTO)

8:10 Introductions

8:30 Framing remarks: QER as a path forward (Carla Frisch, Levi Tillemann, DOE/EPSA)

8:45 Presentation of baseline AMR/QER Framing Document (David Greene, UT-Knoxville)

9:30 Discussants panel: Linking DOE's past (lessons from the AMR) and future (input to the QER) (DOE/EERE)

- Biofuels – Zia Haq
- Electricity – Pat Davis
- Hydrogen – Fred Joseck
- Natural Gas – Linda Bluestein (represented by Mark Smith)

10:30 Break

Part II: Alternative Refueling Infrastructure Business Models: Constraints and Policies
The purpose of these late morning and afternoon sessions is to leverage lessons learned from the 2014 AMR to help explore and evaluate policy aspects and implications of potential business models for refueling infrastructure for alternative transportation fuels. This effort will feed directly into a framing document (*the AMR/QER Alternative Transportation Refueling Infrastructure Framing Document*) that will inform future policy research and recommendations from EPSA regarding alternative transportation refueling infrastructure.

For many alternative fuel systems, there is a "chicken and egg" issue that characterizes the deployment of fueling infrastructure. Adequate fueling infrastructure is a prerequisite for deploying certain varieties of alternative fuel vehicles. However, deploying infrastructure *en mass* in advance of reaching a certain critical mass for vehicle deployment may lead to significant under-utilization of fueling infrastructure and thus pose challenges to the viability of business models that support these facilities. Certain forms of fueling infrastructure may never be profitable on a stand-alone basis from a fuel retailer perspective – which does not in and of itself mean that they should not be promoted from a societal perspective. One goal of this workshop is to better define the challenges and possible solutions to business models for alternative fueling infrastructure.

10:45—11:45 Break-out 1: AMR/QER *Alternative Transportation Refueling Infrastructure Framing Document: Current Issues, Barriers and Short-term (5 yrs) Policy Solutions*

Discussion questions for this session will include: Where does the U.S. need to be in 5 years for alternative fueling infrastructure? What business models exist or might exist in the future? What federal policy levers can help?

Break-out Session 1*: Current Issues, Barriers and Short-term (5 yrs)Policy Solutions*	
Group A) Biofuels	Ethanol, biodiesel, drop-in fuels
Group B) Electricity	Urban on-street charging, metered charging, workplace charging, multi-family dwelling charging,

	fast charging , battery swapping
Group C) Hydrogen	Distribution, transmission, storage and fueling
Group D) Natural Gas/Propane	LNG and heavy duty trucking, fleet CNG, home CNG, public refueling, methane leakage

11:45—1:15 No-host lunch

1:15—1:30 Summary of break-out session 1 findings (rapporteur from each session)

1:30—2:45 Break-out 2: *the AMR/QER Alternative Transportation Refueling Infrastructure Framing Document*

There are a wide variety of possible business models and government policies that may be used to promote alternate transportation refueling infrastructure. Some of these are led by government and others by the private sector. For instance, on the private sector side, original equipment manufacturers (OEMs) have taken on the responsibility of providing fueling infrastructure (e.g. Tesla fast charging, Toyota fuel cells, Nissan fast chargers). On the government side, there exists a wide variety of models to promote the viability of such infrastructure:

- **Over the hump**: Infrastructure may be subsidized or encouraged through various forms of public financing (e.g. loan guarantees) to promote early deployment and drive down prices, with the expectation that it will eventually become self-sufficient and profitable (e.g. semiconductors).
- **Subsidized**: Fueling infrastructure may be subsidized by government because it provides a compelling public benefit, but may not be profitable for private entities to manage (e.g. highways, internet, etc.).
- **Regulated**: A competitive market may not achieve the economies of scale or penetration to transition to a sustainable business because of externalities not included in market pricing. Regulation or regulated markets can help provide public benefit (e.g. synthetic markets, regulatory mandates, etc.).

This session will explore potential business models, government policy, or combinations of both that can facilitate alternative fueling infrastructure development over a longer time period. Discussion questions for this session will include: What are the characteristics that define where a specific business model is optimally applicable over the long term? Where are such business models already in use? What variations might be useful? What public policy levers can help?

Break-out Session 2*: Long-term (5-20 yrs) Issues, Policies and Blue Sky Thinking*
Group A) Biofuels
Group B) Electricity
Group C) Hydrogen
Group D) Natural Gas/Propane

Technical Workshop Attendees

Name	Organization
Jay Albert	GE Global Research, Oil & Gas Technology Center
Mark Alexander	EPRI
Lance Atkins	Nissan
Sam Baldwin	DOE
Ted Barnes	Institute of Gas Technology
Carol Battershell	DOE/EPSA
Sandra Birk	INL
Linda Bluestein	DOE/EERE/VTO
Steve Boyd	DOE/EERE/VTO
Eric Bunnelle	ExxonMobil
John Cabaniss	Global Automakers
Dave Catarious	DOE
Jeff Chamberlain	ANL
Kathryn Clay	AGA
Christy Cooper	DOE
Wendy Dafoe	NREL
Greg Dierkers	NGA
Mark Dowd	Global Automakers
John Dowd	Global Automakers
Catherine Dunwoody	CAFCP
Mark Elless	DOE/EERE/BETO
Steve Ellis	Honda
Mitch Ewan	Hawaii Natural Energy Institute
Mindi Farber-DeAnda	DOE/EIA
Sandy Fazeli	NASEO
Charlie Freese	GM
Carla Frisch	DOE/EPSA
John Gartner	Navigant Research
Sallie Gilbert	DOE/EPSA - Intern
Kuman Gogineni	ChargePoint, Inc.
David Greene	UT-Knoxville
Britta Gross	GM
Jill Hamilton	Sustainable Energy Solutions
Zia Haq	DOE/EERE/BETO
Marcos Harsha-Gonzales	DOE
Brian James	Strategic Analysis, Inc.
Lisa Jerram	Navigant Research

Fred Joseck	DOE/EERE/FCTO
Praveen Kedar	GM
Becky Kreutter	DOE/EPSA - Intern
Mark Kuhn	Ricardo
Klaas Kunze	BMW
Albert Lee	Navigant Research
Paul Leiby	ORNL
Zhenhong Lin	ORNL
John Lushetsky	DOE
Bill MacLeod	Hyundai
Jonathan Male	DOE/EERE/BETO
Dawn Manley	SNL
Vishakh Mantri	EIA
Andrew Martinez	CARB
Chloe Mcpherson	DOE/EPSA - Intern
Tien Nguyen	DOE/EERE/FCTO
Mike Nicholas	UC-Davis
Nick Nigro	C2ES
Sarah Olexsak	DOE/EERE/VTO
Esteban Plaza-Jennings	NADA
Steve Plotkin	ANL
Steve Russell	State of Massachusetts
Costa Samaras	Carnegie Mellon University
Erin Searcy	INL/DOE
Mark Smith	DOE/EERE/VTO
Tom Stephens	ANL
Ned Stetson	DOE/EERE/FCTO
Bryce Stokes	DOE/CNJV
Kevin Stork	DOE/EERE/VTO
Levi Tillemann	DOE/EPSA
Turnure	DOE/EIA
Laura Verduzco	Chevron
Alex Wallen	DOE/EPSA - Intern
Kelly Walsh	Indianapolis Clean Cities
Michael Wang	ANL
Jake Ward	DOE/EERE/VTO
Silvia Wessel	Ballard
Brian West	ORNL
Peter Whitman	DOE/EPSA

Bob Wimmer	Toyota
Joann Zhou	ANL
Kathryn Zyla	Georgetown Climate Center