



Electric Vehicles and the Tipping Point: Battery Technology, Gas Prices, and Infrastructure

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Electric Vehicles and the Tipping Point: Battery Technology, Gas Prices and Infrastructure

The coming paradigm shift toward electric transportation and its timing will depend on government policy, global politics, developing a robust supply chain – and ultimately on customer response.

Moderator: **Tony Earley**, Executive Chairman, DTE Energy Co.
Ted Craver, Chairman, President, and CEO, Edison International; **Nancy Gioia**, Director, Global Electrification, Ford Motor Co.; **Britta Gross**, Director, Global Energy Systems and Infrastructure Commercialization, General Motors; **Don Karner**, President and CEO, ECOtality North America; **Jim Piro**, President and CEO, Portland General Electric.

This discussion is an edited version of an Electric Vehicles panel discussion featured at The Edison Foundation's "Powering the People" conference, held in Washington, D.C., March 3. We thank Lisa Wood and the Institute for Electric Efficiency for the opportunity to present this valuable information and insight.

Tony Earley: Being from Detroit, I know a little bit about the automotive industry. I also know a bit about the utility industry. I've been in the utility industry for 25 years, and I have been on the board of Ford Motor Company for two years. For both industries this is one of the most exciting times that anyone can remember.

One of the interesting things about both of these industries, which you may not know, is



Moderator Tony Earley, Executive Chairman, DTE Energy

that just over 100 years ago, Henry Ford worked for my company, Detroit Edison. He was an engineer working in the power plants. My predecessor, then CEO of the company, called him in and wanted to promote him.

Lore has it that he said, “Henry, you have got to stop playing around with those new-fangled machines in the machine shop or you’ve got to quit.” So Henry Ford quit and started Ford Motor Company and the rest is history. He innovated and started a revolution in a way that made travel universal.

Today we are about to see a similar seismic change in transportation. Today electric power is at the threshold of transforming the transportation sector. Outside we have the new Nissan LEAF, Chevrolet Volt, and the Ford Transit-Connect.

[Video feed and demo of electric vehicles.]

Earley: There’s something very special about electric vehicles. It’s the near-silent ride, the immediately available torque that makes it a great car by anyone’s standards. The way it

accelerates is awesome. There’s no transmission, so the accelerator pedal feeds electricity directly to the motor. When you step on that pedal the car literally jumps ahead.

With the battery centered down the middle of the car, it has great handling. No one is going to mistake these cars for golf carts. The fact that they get great mileage and are emission-free is just a bonus. Obviously I have a bias here, being from Detroit. But you don’t need to take my word for it. In January, 50 automotive journalists in the US and Canada named the Chevy Volt “North American Car of the Year” at the 2011 Detroit Auto Show. *Motor Trend* and other magazines have given the Volt their 2011 Car of the Year award. A January cover story in *Bloomberg BusinessWeek* focused on the LEAF and the Volt and their potential impact as the first serious contenders for mass-scale electric cars.

Utilities are committed to making electric transportation a success. Electrifying transportation will create new high-quality jobs and help reduce our country’s dependence on oil imports. And it will be good for the environment. But what’s different about electric vehicles today? Will these vehicles make a real difference? Or will this just amount to another fad?

Jim Piro: I’ll start with just one thing: battery life. Lithium ion batteries have a ten-year life. They’ll give us the range we need and their cost is coming down. With economies of scale, we’ll see prices come down even more, making it much more affordable. That’s key.

Britta Gross: Right. Lithium ion battery capability has improved stunningly in the last few years, and it’s going to get better and

better. We've learned so much from previous efforts – from the EV1 for example. And times are different today. Today there's so much awareness about energy security, the environment, needing sustainable energy here in the US, solving our economic problems. Just in job-creation – so many things are so different from 10 years ago. The moment is now.



Ted Craver: We're celebrating the 125th anniversary of Edison International this year. Right behind my desk, I have a picture of our 1915 "electric wagon," as it was called then. It was for our utility crew. Actually, one-third of our vehicle fleet at that time was electric, so we're really going "back to the future." The big difference today is the cost factor. With the simpler drive train, and electricity so much cheaper in real terms than it was in 1915, the operating cost of EVs is about one-third to one-quarter of the cost for internal combustion engines. You have to get past the initial capital cost. That's going to be huge as gasoline prices continue to rise. I believe the economic proposition is the big game-changer.

Nancy Gioia: One of the reasons electric cars practically disappeared by 1930 is that they didn't meet customer needs. In 1915 the electric starter came out for gasoline-fueled vehicles. That made them much more convenient to use, and they were half the cost of electric vehicles. In addition to the battery

L to R: Panelists Gioia, Craver, Gross, and Piro

technology, two other big elements are the computing power we now have on board – the technology is much more than the battery – and the systems engineering. It's a complex integrated system, so now we can deliver durability, reliability, and safety. With all of that – as well as a driving experience that's fun and engaging – we have something that allows the industry to grow. We're just at the beginning of that!

Don Karner: I think the key is information technology. There's obviously not just one thing that makes a difference, but availability of information technology that can integrate the vehicle with the outside world makes a huge difference. There are a number of different value chains that information technology brings to these grid-connected vehicles that will help drive costs down. We'll be able to exceed customer expectations in ways we haven't even imagined yet.

Earley: Britta, General Motors has the Volt in the market. Is the customer's experience different buying an electric vehicle?

Britta Gross: It is a bit different, yes. The Volt comes with a cord set – a 120v cord set that plugs into any three-prong home outlet. When we did the EV1, we learned that you don't want to depend on a special infrastructure system being developed. We wanted to make this vehicle as easy as plugging in to your home outlet, so outside of your house, or a hotel, or wherever you can find a three-prong outlet, you can charge this vehicle. It charges in about 10 hours. You can also charge the vehicle at 240 volts, more like a clothes dryer experience. That shortens the charge time to about four hours.

We have contracted with SPX, a service installer, to organize for the customer all the options for these 240 volt chargers because there are many options. We are involved in a DOE grant program that we are partners in with ECOtality. We're offering Coulomb chargers, as well as our own Voltec charger. SPX provides their own hardware, so we are agnostic about what kind of 240v charger the customer wants. We just want the experience to be smooth and affordable and familiar – as automotive-like as possible. We can easily scale this effort up to millions of vehicles quite soon.

Earley: Nancy, I know [Ford CEO] Alan Mulally would kick me if I didn't give you a chance to talk about what Ford's plans are to bring electric vehicles to market.

Gioia: Well, first there's the 2011 Ford Transit Connect, a van that's been on the road since last year. At the end of this year the Focus Electric launches. We're focused not

just on the vehicle but the whole electric vehicle experience, so we have an arrangement with Best Buy. When a customer comes into a Ford dealer and wants to buy the car, the dealer will ask, "Would you like us to set up a charger appointment for you?" If the customer says yes, the Best Buy Geek Squad will come out with a certified electrician to determine if the residence needs any additional wiring. If you're getting the Focus Electric, we recommend a 240 volt charger. Just like the [Chevy] Volt, a 110 cord comes with the car. Either way, you can easily recharge your car overnight.

In addition to that, we are breaking from the paradigms of how we've done things in the past. We also offer "Value Charging by Microsoft," which gives customers the ability to have their car charged at the lowest possible rate. Let's say Value Charging monitors Southern Cal Edison's rates. It can tell the customer, "Charging cost is lower between 1 o'clock and 3 o'clock, but it's *really* low between 1:30 and 2:30." The system can charge and adjust charging within very short time periods to give the lowest electricity rate. In the future a customer may say, I only want to charge on solar, or I only want to charge on wind. Those energy management choices are put in the hands of the customer.

We also have a new app called MyFord Mobile for smart phones which links SYNC technology and the technologies in the car and it puts it on your mobile phone as an application. With that you can set your car to charge remotely, and you can tell if you can get to your next location on the charge. The app on your phone will tell you, "You are getting a little short on range, so why not charge your vehicle now?" It will also tell you, "Here are two or three charge points on



The Chevy Volt – a plug-in hybrid with range

the way” – at a Starbucks, or maybe a Wal-Mart. You can charge there while you run an errand. So it’s really taking the angst out of “range anxiety,” putting choice in the hands of the consumer in a way that they’re used to. I think going forward we’re going to see a very integrated experience, and it’s just the beginning. We’re just beginning to imagine the future. But the real key is when you hop in the car and press the start button. The drive experience is fun and engaging, but you don’t have to change how you drive.

Earley: So the economics are a key driver. Ted and Jim, can you comment on what you’re going to charge for electric vehicles.

Ted Craver: We’re just beginning to sort through those kinds of plans. Right now our utility subsidiary, Southern California Edison, has three rate plans, two of which are basically time-of-use plans. A key point is that we want to get the charging to take place largely at home, and largely off-peak. That’s where

you get the real efficiency from the grid. There’s a lot of excess capacity in the system during off-peak hours, roughly speaking, from 10 at night to 6 in the morning. That’s prime time for the EVs to be charging. All of this is very early, but the work we have done thus far suggests that about 80 percent of the charging will probably take place at the home. That’s great for integrating with the grid.

One final point: In California we have quite a bit of renewable power in our system and that’s growing. It is mandated to grow to 33 percent of the total power delivered by 2020. Much of that is wind power, and it operates mostly off-peak, so there can be a perfect marriage between the renewable generating source and off-peak charging of the vehicles. We want to incent that through our pricing.

Piro: It’s very similar at Portland General. Our off-peak rates are about 30 percent below our average rates, so there’s an opportunity for customers to charge off-peak at a lower rate. Like SCE, we have a significant amount of renewables. We’re at about 10 percent renewables today, so the ability to communicate through our smart meter system to the vehicles – to charge them at the optimum time – will allow us to give them an even better discount on price. That’s the real excitement about this technology. We want more off-peak load as we add variable resources, so the opportunity to have a battery to charge at night will be tremendous.

Earley: When you talk about electric vehicles, the battery is the key. Don Karner, what kind of progress can we expect in battery technology?

Karner: There’s certainly a lot of work going on that’s driving costs down. Senator Levin talked about the investment in battery

production facilities that were part of the stimulus package. That's an important step in getting production up and bringing costs down. I would rather see an investment made in charging than in bigger batteries.

Infrastructure lasts much longer, and the cost per kilowatt or kilowatt-hour is much less. I think a combination of infrastructure, so that people can extend the range of their vehicles, and a lower battery cost is ultimately what will drive electric transportation.

Earley: I notice that Delta Airlines has now set up charging stations at all of the airport gates where you can plug in your BlackBerry, your iPad, devices like that. When do you think we're going to see charging stations sprouting up by malls and other locations?

Karner: We have a private/public partnership with the Department of Energy that we call the EV Partnership. It will deploy about 13,000 chargers in 17 different cities across the US. We have also partnered with General Motors and Nissan to install residential chargers for about 8,300 electric vehicle purchasers. Our plan is to build out a mature charging infrastructure in commercial spaces, and to study that to understand whether, in fact, 80 percent of charging will happen at home, how the impact of different on-peak versus off-peak rates affects that estimate, where the best places are to put in charging stations and where are the really bad places. I'm sure we will make some mistakes along the way.

That rollout is beginning. Last week we did the first residential installations, and we'll be doing the first commercial installations soon. They will be down the West Coast, through Arizona and Texas, and through Tennessee to Washington, D.C. You

will begin to see that commercial infrastructure appear – both Level 2 infrastructure and fast chargers – as vehicles begin to roll out and we get a concentration of vehicles to utilize it.

Earley: Britta, how important are charging stations to your rollout plans? Clearly they are not around in many places. Is that important to you, or can you go ahead without commercial charging stations.

Gross: We can. The Volt was designed to not need the parallel infrastructure. It has a 40 mile battery range, which is within what three-quarters of Americans drive to travel to and from work. After the 40 miles – actually, the range on the batteries can vary between 25 and 50 miles on a charge, depending on the terrain, driving habits of the operator, the weather, etc. – the Volt can go another 330 miles on one tank of gas. The Volt doesn't *need* the infrastructure.

But when we have a large number of vehicles out there, commercial infrastructure will allow us to extend the market to people who don't have a place at home to charge the car safely, conveniently, and reliably every night. Perhaps they live in a townhome, or they park curbside. It would be great to have workplace charging. That kind of targeted infrastructure, places where cars are parked for four or more hours at a time – that's a great place for chargers. It would open the market for us beyond home owners with dedicated parking and charging spots.

Earley: Jim Piro, when you think of all these cars plugging in, what concerns do you have?

Piro: For the electric grid, we have to ensure that a neighborhood with EVs has good

reliability. That means that the transformers that serve that neighborhood must be sized to meet the needs of that area. So we're going to watch very carefully how these vehicles are deployed. If necessary, we will have to upgrade the network. But I think that our system has enough capability to meet the charging requirements of EVs, especially if they're charging off-peak. We have a lot of latent capacity in our system, so if they do charge off-peak, we see very little cost impact on our system. If we see a high penetration in a neighborhood, we may need to upgrade transformers in that neighborhood to serve the load.

I think we are well prepared for it. We are working closely with vehicle sales forces so that we can understand where those vehicles are being deployed. We are also training our customer service reps, as they talk to consumers who have electric vehicles and want to move to off-peak pricing, so that we can locate where these vehicles are on the map. We are trying to be very proactive to provide our customers with the reliable product they depend on.

Earley: Ted Craver, are you worried about generation infrastructure? Have we got enough generation to supply millions of vehicles?

Craver: I'm not worried about the generation side of it at all – and actually not really worried about the transmission side of it either. It's the distribution piece that Jim was referring to that we need to be mindful of. In the early days, the flow of new vehicles will probably be at a pace that's easily digested.

One thing we haven't talked about yet that's worth noting is having the automobile manufacturers and dealers at the showroom

level in kind of a partnership with the utility. Because what will help this become a good customer experience, particularly early on, is timely identification of where these new vehicles are going to be. We believe that, as with gasoline hybrids, you are going to have clusters of early adopters of these vehicles. A typical neighborhood circuit in our system has about 12 homes on it. We want to make sure, if it's one of those neighborhood clusters like mine where you might have three homes that want an electric vehicle, that we have all of the capacity needed upstream. Early communication from the showroom to the utility will be important to accommodate that demand.

Earley: Nancy, is your dealer network prepared to share that kind of information with utilities?

Gioia: It's going to be a real transition for our dealers. We've selected 19 cities for our first Focus Electric deployment. Working with those dealers, gaining experience with the relationship with Best Buy and the Geek Squad – that's an additional interface. So it's more than the dealer, it's making sure that group is also a part of this interface.

We are putting a great deal of effort into educating our dealers, not only on repair, parts and service, but also the communication link with the customer. How do we make it a one-stop shop for the customer? Are interfaces all clearly known and laid out? We have many dealers who may only sell a handful of electrified vehicles in the first year or two. But their training, and engaging them in that process with partners and contact points at utilities, is going to be important. It's a huge transition.

The Focus is a full-battery electric vehicle. It's one type of electrified transportation. We will also have hybrids, our Fusion and our Escape, as well as full battery electrics like the Focus and Transit Connect.

We are also introducing a plug-in hybrid similar to the Volt, but different in architecture. It will recharge overnight on a 110 outlet, does not require additional infrastructure, and has a 500-plus mile range on a tank of gas. We recognize that some people won't have access to infrastructure or can afford only so much; others may have home plug-in connections but not the 240 volt charger. The challenge for our dealers will be helping customers with different demands, different needs, and different access to charging.

Earley: You probably remember the TV show "Candid Camera." There was one skit where they had a car come into a gas station. The driver gets out and tells the mechanic there's something wrong. The mechanic opens the hood and there's no engine in there! I can see a mechanic opening up one of these vehicles and having that same surprised reaction. Anyone want to comment on how you deal with that? When these cars are on the road and they have a minor glitch, what happens?

Gross: We have dealers in seven states selling the Volt – I think 765 dealers in all. But we also have a network of service-certified dealers in other, non-launch states. By the end of the year, as we deploy the Volt nationally, that service will be available across all 50 states. You have to be aware that you could have vehicles in states without dealers. In fact, even though they are only for sale in seven states, Volts have already migrated to 35

states. We have been working our tails off for four years getting ready for this so that there's no hitch.

Gioia: That's another area where technology has really helped us. If a vehicle comes in and a service technician isn't certified to work on it, there could be a problem. But now we have "hotlines" – streaming video with a camera and an expert online -- to walk the technician through the problem.

Earley: Don Karner, you're in the infrastructure business. Is there anything you see that could help here?

Karner: I think Nancy hit the nail on the head. The capabilities in the dealerships and the training work that's been going on pretty much assure that these vehicles are going to be taken care of. A lot of planning and hard work has gone into these rollouts and they are very well planned and supported, so I think we are in pretty good shape there.

Earley: I'll ask each of you to comment: From a policy perspective, what's on your wish list?

Karner: I think there is a great deal that has to happen in determining how these vehicles are going to interface with the grid. We've heard [FERC Chairman Jon] Wellinghoff speak about this relationship. How are responsibilities going to be split between vehicle owner, the utility, and the infrastructure provider? How will utility rate design encourage electric transportation? How do we really make electric transportation an asset to the grid and not a liability, as some people fear? From a policy standpoint there's a lot of work that has to be done.

That work is beginning to get underway. We are really encouraged by what is happening

both at FERC and at the California PUC – a lot of discussion and debate, and progress is being made. But this is an area where a lot more work will be required.

Gross: We are in the “hot and heavy” right now with this rollout. I would say to policy makers that the next few years – not days or weeks or months, but the next few *years* – will be a huge learning curve. We don’t know everything about the technology of these vehicles, so we over-designed them. That’s why [the Volt] has liquid heating and cooling systems – to keep the battery more temperate. It doesn’t like hot; it doesn’t like cold. We’ve done a lot of bootstrapping on the vehicle because we also want to learn where we can save next time, where we can back off some engineering; where we can eliminate so many lines of software code. It’s the same thing for the grid interface. It is a big learning space. AMI or non-AMI? What about the PLC [power line communication] or ZigBee, or through OnStar, or other telecommunication systems in our vehicles? What’s the right way to do it? Are time-of-use rates really worth it, because they may be very complicated for buyers of these vehicles. All that learning is really important, so I strongly suggest that we focus on walking before we run, because I think a lot of the answers aren’t yet known.

How much infrastructure, how little infrastructure? What is the real variability of home charging installations? There’s a lot of variability in the cost of home chargers that are going in, so extending and making sure that we have incentives for people doing the home installations would be fantastic because variability will kill you in the viral webspace of people talking and comparing – even though

it is only because their homes are very different.

The long term vision – the government’s investment in battery development, etc., – is important because we don’t have the deep pockets to hang in there for ten or 15 or 20 years. That stimulus investment was far-sighted and it’s something that’s really going to help us out. It was a collaboration. So I’d say: Collaborate. Keep things simple. And let’s walk before we run. That’s all very important.

Piro: Just two things. One is clarity on the incentives to buyers. That’s what’s really going to help this industry, because if we can build scale, then we can get the prices down. Then the EV will be an affordable, great vehicle. Secondly, from a public policy standpoint, government and businesses need to commit to buying the vehicles. Because we are going to be the first early adopters, we can demonstrate how these are going to work.

Our commitment to buying these vehicles early on and getting them out in the public’s view is going to be really helpful.

Gioia: The constancy of purpose of an energy policy and a strategic approach nationally are really important. It can’t be an administration-to-administration debate. I see other nations around the world taking a long-term view, with constancy of purpose. It’s about diversifying transportation fuel to include electricity. We need to take that view and realize that it’s a long-term journey that we’re on – a marathon – to build on what Britta said.

The stimulus package was necessary to jump-start this journey. The question is: What are the building blocks beyond manufacturing to

put battery cells together? We need knowledge, technology, and equipment in this country. We need to have the assembly equipment for battery cells, nearly 100 percent of which still come out of Asia. We have a long way to go to encourage all of these things. That's what I think we will need to be globally competitive.

Craver: I like that the states are beginning to engage in this. California is a good way down the road, but not all of the rules and regulations are set at this point. I think what you are going to find is that each state is going to have a slightly different twist on certain policy-making elements. I believe that in fairly short order we will have a sense of what really works and what doesn't work. Getting a chance to learn from others' experience and make adjustments along the way – I think that will really help the innovation process.

Earley: Questions are starting to come from texters and Tweeters. One of them is, "How will manufacturers solve the limited range problem?"

Gioia: We will offer a variety of "range" solutions for customer so they can pick the product that meets their needs. Gas hybrids can get as much as 700-800 miles on a tank of gas. A plug-in hybrid will run like a regular hybrid – going over 500 miles after the battery charge is used up. Until battery technology makes a quantum leap, I think it's better to help customers select the vehicle they need for their particular driving needs. We can help them manage their range and energy consumption through the smart apps and tools we offer.

Gross: The Volt doesn't have a limited range problem. They are crisscrossing the country as we speak, and some of the first customers

we started rolling out to in the first week of December or so still have not put gas in their tanks. The model was based on the fact that most people do not drive more than 40 miles a day, so if you charge regularly it takes you a very long time to use up a single tank of gas.

Earley: A related question: Do you think the cost of batteries will come down quickly, or just incrementally?

Gioia: We've just completed a really extensive study of the batteries and battery cells. There are the batteries, the battery cells and then there is the big package that you put them into. The battery cells represent the greatest opportunity to keep costs down. We have taken cells apart – measured them to determine how many kilograms of lithium are needed, and what's in the anodes and cathodes, and where does the material come from. We've looked at all the elements: the equipment, the manufacturing process, etc. We've looked at the entire value chain, working with suppliers, looking at where the technology is and what improvements they expect. Then we projected this out to 2020 and 2030.

What we see is that today's battery cells range from about \$500 to about \$1000 per kilowatt-hour, depending on the source and the materials used. What that requires for a full battery electric vehicle – a Focus Electric type vehicle, is a 23 kilowatt-hour battery. You can do the math, but that is somewhere between \$11,000 and \$15,000 for the battery system. In the future – in a 2020-type time frame – we see the ability potentially to get that down to \$250 dollars per kilowatt hour with the technology and scale available at that time. That's still a \$6000 cost for a 23 kilowatt hour



Ford's Transit Connect – a fleet van

battery – still a substantial amount. To get beyond that, I think it's going to take a quantum effort, a combination of technology and scale. We have more to do on technology before you ramp up the scale.

Gross: When you do first generation technology you're looking at many things. There are many parts that are sourced on the Volt. For the battery there was only one supplier worldwide that was capable of doing what we asked. The stimulus money that's poured into a new supply base in the US – for example, for batteries – that adds competition; that adds capability. Now you have the ability in the next generation to really start attacking cost.

You can't do much in Generation 1 when you have only one player. Across the board – it's not just the batteries, it's also motor drive electronics, it's big fans – it's everything that's kind of new. We have a huge opportunity to cut cost, but I wouldn't want to mislead people with the thought that the electric vehicle is going to be cheaper than a gasoline vehicle one day. In reality, we are paddling so fast with these vehicles and the technology to keep the costs down and the quality in – but the capital cost of a gasoline vehicle is very

tough to beat. Gasoline is still cheap and the combustion engine is very cheap technology.

So we have to hang in there with a strategy – a comprehensive energy strategy – that allows us to stay in there until a tipping point is reached where everyone wants to buy these vehicles because they are wonderful and they are thrilled to pay what they cost. We'll get the cost down, but it will take time.

Earley: Someone in the audience is asking about competition. Is the oil industry the competition? Are they fostering or hindering the EVs?

[Laughter. No one speaks up.]

Karner: From my perspective as an infrastructure provider, we have BP as a partner and they are very interested in understanding what the infrastructure requirements are for these vehicles and trying to work that into their existing retail operations. There is a lot of curiosity out there, and a desire to understand.

Earley: Ted Craver, I'd like you to comment on the environmental benefits of EVs. We heard during the digital tour that there is no tail pipe and there are no emissions, but that electricity comes from somewhere. Give us a perspective on how much of an environmental benefit the EVs will provide. How does that work?

Craver: The starting point would be traditional pollutants. Leave greenhouse gas just on the side for a second. We serve 14 million people in southern California and there's always a big concern around emissions. That's where EVs can make a huge difference. Couple that with the fact that, in California, virtually all of the electricity comes from either nuclear – which has virtually no

emissions – or renewables, or natural gas. Those are really the principal energy sources for electricity in California. In different parts of the nation, obviously, that resource mix is different.

But the Natural Resources Defense Council and the Electric Power Research Institute did a very good study a couple of years back that looked at this issue on a national basis. So if you look at the mix of fuels we have for producing electricity, the first thing to recognize is that virtually all the fuel sources that go into the plants that make electricity are domestic. Petroleum accounts for less than 1 percent of what's used to make electricity in this country, so that's a huge advantage in energy security in terms of fuel sources. In general, the fuel mix is 50 percent coal, 20 percent natural gas and 20 percent nuclear, and 10 percent hydro and other renewables, such as wind and solar. NRDC and EPRI looked at plug-in hybrid electric vehicles and they found that a plug-in hybrid fueled by the nation's electricity system was more environmentally benign even than a gasoline-powered internal combustion engine vehicle. That's the promise that we're looking for. It's simply a lot more efficient to transmit electricity to a battery and to wheels than a gas tank to wheels. That's where the environmental benefit comes in.

Earley: In addition to the environmental benefits, a lot of people are talking about energy security values. Senator Levin talked about that, and the fact that all of our fuel for electricity is domestic.

Piro: I'll just put in a plug. For those who are really interested in this topic, there is a group called the Electrification Coalition. You can go on their website. They have two great

documents that get into the economics and benefits of EVs and fleet vehicles. They are probably the two best publications on the topic, so I would really encourage you to look at that. They have a lot of the details behind the data that we're talking about.

Earley: We just have a couple of minutes left and I want to put the panelists on the spot. I'll start with Don Karner. Tell me what year there will be one million EVs on the road, and why.

Karner: Okay, I'll flip that around. If you can tell me what is going to happen in the Middle East, I'll have an answer for you. It's a market-driven situation. There has to be value for the customer to want to buy these vehicles. The price of gas at the pump is certainly part of that. You can produce all the vehicles you want, but if nobody buys them it doesn't do any good. We are making progress and we would like to see it be two or three years down the road, but there are a lot of variables. We need to continue to work at it, to create value in the vehicles, to create convenience from a regulatory standpoint, and to encourage their adoption. The more we can do, the faster it will go. So I completely avoided your question.

Earley: Nancy, what is Ford's thinking?

Gioia: It has to be a customer driven solution. At Ford we stand for affordable transportation for people and solutions that meet their needs. I can tell you what we are planning. Today about 1 percent of the Ford global fleet is electrified, primarily hybrids. By 2020, we expect 10-25 percent of our global fleet to be electrified or hybrids. That's a very big range. That includes hybrids, plug-in hybrids, and full battery electrics. Of the 10-25 percent, we still expect around 70 percent

to be hybrids, 20-25 percent plug-in hybrids, and the remainder full battery electric vehicles. This is driven by meeting customer needs with affordable solutions.

The reality is that we don't know. I wish that I were that good! Instead of doing a vehicle for one single technology, we have said that we don't know what the growth will be. We want it to be robust so we have electrified our highest volume platforms— which means that a C-sized platform like the Focus will come as a hybrid, a plug-in hybrid, a battery electric, and an efficient petrol or diesel, all of them built down the same assembly line at five assembly plants around the world. We produce up to 10 different vehicles and over 2 million units from this C-sized platform. This gives us the scale and component sharing. We have the ability to support an ambitious goal, and what we want to see are affordable customer solutions. So I also avoided your question.

Earley: Ted Craver, are you going to give me an answer?

Craver: 1.1 million in our service area by 2020. Now I get to give you a caveat. That's our high case. We've done the best we can at this early stage. Our medium case is 450,000 vehicles by 2020 in our service territory – and we have a 50,000 square mile service territory in California. Quite frankly, I am an unabashed, unashamed EV booster. I believe the customer demand is going to be there, but it's going to depend on the production side. I think that is going to be key.

Gross: I think the production side is going to be great! It's the demand side that we have got to watch. I think if we can just stay flexible and on our toes, and watch what is happening with the market, and watch that

consumers are still seeing the incentives that they need, because you have to move from early adopters who are more able to pay, then to fast-followers, then to the mainstream, and finally the laggards. As we move along we have to pay attention to whether the incentives are actually doing the trick. So I think we have to keep our eye on that demand. I think President Obama's goal of 1 million vehicles in 2015 is a great stretch goal. I think we are going to miss it by maybe a year or two, but there is reason to think that this industry could put up those kinds of numbers in the 2017-2018 period. I think we can do it, but we have to watch demand on those vehicles.

Earley: Jim, your time frame?

Piro: Gas prices are going up and the economics are going to look even better for EVs, so my view is 2017.

Earley: Well, this has been a terrific panel. Thank you all so much. ■

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