

# Is There an Electric Vehicle in Your Future?

Opening Remarks

(As Prepared)

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Good morning and welcome. This is a new venture for IEEE. And as I look at the program, it seems like it's a venture with a future. My congratulations to the organizers, and my thanks to all of you who have come to share your experience.

I'm an electrical engineer, but not a power engineer and not a transportation engineer. That said, I'm convinced that some of the most important and interesting challenges for engineers in the 21<sup>st</sup> century are in energy, and in its connection to security, prosperity and the environment.

So why are we here to talk about electric vehicles?

Well, first of all, it's about carbon.

It's too late to argue that the Earth is not warming. We can see it in the Arctic and the Antarctic.

When it comes to why...and what we should do about it... I can't say much from personal expertise, but I'm prepared to go with opinions from the best atmospheric and climate scientists in the world, just like I'm prepared to go with the opinions of the best medical scientists in the world when I need to make a decision about health care.

Transportation represents more than a quarter of greenhouse gas emissions, second to, and just a bit behind, electricity generation. And assuming that, sooner or later, everybody will become serious about carbon emissions, transportation is one of the biggest opportunities to make a difference.

And let's forget any thoughts we might have about capturing carbon at the automobile. With a little bit of high school chemistry and a little bit of arithmetic, you'll discover that, every time you put 10 gallons of gas in your car, you would need to remove 200 pounds of CO<sub>2</sub>. That's if you can figure out an effective and inexpensive way to capture it.

If cars are powered by electricity, then of course you have the chance of capturing the CO<sub>2</sub> at the power plant. Perhaps more importantly, you have the chance to reduce the component of fossil fuels in electricity generation.

As you may know, California has set a target of reducing greenhouse gas emissions to 1990 levels by 2020 and then reducing them another 80% by 2050. These are consistent with projections by the Intergovernmental Panel on Climate Change, which would stabilize atmospheric greenhouse gas concentrations at around 450 parts per million of CO<sub>2</sub> equivalent.

There's a very interesting article in the January 6 issue of Science that focuses on how California can meet the 2050 target. The authors concluded that it cannot be done without widespread electrification of transportation, coupled with a substantial shift to what they call "decarbonized electricity" as the dominant form of energy supply.

More specifically, they call for reducing the gasoline consumption of light duty vehicles by 75% and generating 90% of electricity without CO<sub>2</sub> emissions, whether that be by increased use of renewables, nuclear, or carbon capture and storage.

But the importance of electric vehicles isn't just about carbon. It's also specifically about petroleum.

For both economic and security reasons, the U.S. needs to reduce its reliance on petroleum. You've noticed that the price of gasoline is back in the headlines. It's been estimated that every \$10 increase in the price of a barrel of oil has a \$75B impact on the U.S. economy. Almost all of the energy used in the transportation sector (95%, or so) is from petroleum. And transportation consumes at least two thirds of all the petroleum used in the U.S.

We're learning, or learning again, that the market for petroleum is a world market, and a complex one. We're experiencing the outsized effect of disruptions, and threatened disruptions, in the flow of oil from just one country, a country that contributes less than 5% of the world's supply, a country that provides virtually none of the oil consumed in the U.S.

Diminishing our reliance on imports will help, somewhat. And on this front, the good news is that over the past three years, U.S. net imports of petroleum have dropped from 57% of consumption to 45%. That's substantial. We need to keep that trend in place, and I'm sure we will hear a lot more about that between now and November.

But the ultimate answer is to diminish our consumption of petroleum, to shift to other fuels, and electric vehicles provide one of the best opportunities to do that.

Our interest in electric vehicles is also about efficiency.

The efficiency of an internal combustion engine is 15-20%, more or less, depending on specifics. In contrast, the efficiency of an electric motor can be 80%, again depending on specifics. For EVs, in terms of mileage, battery to wheel efficiencies of 200-300 watt-hours/mile are quoted for many vehicles, which is in the range of 100 to 150 miles/gallon, gasoline equivalency. So the potential gain in efficiency is significant.

Then, finally, we must look at the growing demand for mobility, especially in developing countries.

If car ownership continues to follow established patterns around the world and if economic growth projections, especially in places like China and India, come true, the world-wide automobile fleet could double in 20-25 years. Accommodating that with gasoline powered vehicles is difficult to imagine. In fact, accommodating it with any source of energy will be difficult.

So, then, is it realistic to project a major shift in how we fuel transportation?

Well, it's worth thinking about how different fuels have dominated in different periods of our history.

In the U.S., wood was the largest source of energy until the last half of the 19<sup>th</sup> century, when it was overtaken by coal, which stayed on top for only a half century or so, before it was displaced by petroleum.

We've seen industry move from water to steam to electricity, to power heavy manufacturing. Once they were introduced, it took only about 40 years for electric motors to capture about 80% of the manufacturing market.

It took diesel locomotives about 30 years to replace steam locomotives. In fact, most of that happened during just one decade, the 1930s.

These were very substantial technological and economic shifts that occurred over decades, not centuries. And it does seem possible that transportation can be the next example.

But we do recognize that there are challenges.

Initial costs are still high, and this deters some potential customers, even those who recognize that lifetime costs may favor electric vehicles, when you include operating expenses, maintenance, and repair costs.

Limited range, limited access to charging stations, and significant recharging times, all create “range anxiety,” the fear of being stranded, and that’s a further deterrent.

Safety issues have been raised, and perhaps not resolved in the minds of the public.

And while there may be adequate generating capacity, rapid adoption could strain the electric grid, particularly at the distribution end.

These are just some of the topics that I hope we’ll learn more about over the next few days, and I’m optimistic that we will. The program is impressive, as I expected it would be, because organizing conferences like this is what IEEE volunteers and staff do, and do well.

IEEE, as an organization, is about knowledge, nurturing its creation and dissemination, while promoting its application. We are about helping innovators innovate. We are about, as our motto says, “advancing technology for humanity” through the work of our 400,000 members in 160 countries.

We do this by sponsoring conferences like this one, about 1300 of them, last year, altogether. We do it by publishing journals and magazines – there are currently about 150 titles in our portfolio. And we do it by facilitating the development of standards, about 900 of which have been adopted. I just checked our electronic library and found more than 12,500 documents related to electric vehicles, most of them written within the past decade or so, but a handful of them more than a century old. That is your knowledge base, the most substantial knowledge base in the field.

Within IEEE you will find a number of communities, or networks, that focus on areas related to electric vehicles. We call them technical societies. You will have noted that eight of them are among the sponsors of this conference, societies of members interested in

- Vehicular Technology
- Intelligent Transportation Systems
- Power Electronics
- Power and Energy

- Computational Intelligence
- Instrumentation & Measurement
- Reliability, and
- Industry Applications

Also, IEEE has Councils, groups of Societies, that focus on

- Sensors, and on
- Systems.

They're here, too.

You will have also noted the sponsorship of the

- IEEE Standards Association,

and of

- IEEE-USA

which focuses on technology policy and helps our members make their views known to policy makers.

And because we believe that electric vehicles are important, we're building internal structures that will help these pieces of our organization work together more easily and serve the EV community better.

Among our 400,000 members, you can find more expertise, in more areas of electrical, electronics, and computer technology, than anywhere else. And I would add that we increasingly support the professional interests of applied technologists in other disciplines, including mechanical engineering, civil engineering, physics, and materials science. No matter what your interests in electric vehicles may be, there's a place for you to plug in to IEEE.

And after that shameless pun, I'd like to close by telling you about the very first of those 12,500 articles about electric vehicles.

It was published in the Transactions of the American Institute of Electrical Engineers, one of our predecessor organizations, in 1899. It starts as follows:

“During the last three years many descriptive articles relating to the automobile have appeared in the technical press but up to the present time, there has been published no definite data which might be used to indicate whether or not electric operation possessed any advantages. Hence both the general, as well as the technical public, could form no definite opinion as to the benefits to be derived from the use, in any particular class of service, of either an electric or a horse system. The purpose of this paper is to present the results of an investigation, carried on during the past year in the city of New York, of the operating costs of the horse and electric delivery service, as at present instituted by the large department stores.”

It concludes by saying:

“In light delivery service in large cities, when a number of units are employed by individual firms, the adoption of the automobile would seem to be merely a question of time. For this kind of service it seems pre-eminently the best solution. It is cheaper to operate than horse service, and the mechanical problems have been so far solved as to

make the vehicles commercially successful. Though, as stated before, it is not the intention to discuss depreciation, it may be noted that the comparison of the costs of operation as regards food, cost of power, etc., would show a saving in favor of the electric delivery wagon, in one year, of 15%, which, under more favorable conditions as to the price of power, might easily be increased.”

And it goes on about major benefits....

- The hygienic condition of large cities will be improved.
- The cost of street cleaning will be decreased.
- The wear and tear on pavements and streets will be reduced
- The traffic in cities will not be as congested, owing to the saving in space now occupied by the horse. (there were apparently 200,000 horses in NYC at the time)
- The cost of operation will be reduced, as automobiles become more common.
- [And] The danger of accident from runaways will be eliminated.

Thank you for being here and participating. I hope you find the conference stimulating. I'll be around until tomorrow afternoon and look forward to talking with many of you.