Electric Vehicles and Oil Demand
Prepared for Science, Technology & Telecommunications Committee
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July 9, 2019

Madam Chair and members of the committee: Thank you for this opportunity to speak to you about electric vehicles and the demand for oil. The views expressed are my own.

The question posed to me by staff was whether or not the increase in production and sales of Electric Vehicles (EVs) could result in New Mexico facing $40 to $45 oil prices within the next five years. Is such a scenario possible? The answer is yes but the probably correct answer to this question is that we may indeed face $40 per barrel oil within the next five years but that will not be due to the increased use of EVs. Ten years from now (somewhere around 2030) EVs and other developments may reduce oil demand enough to lower prices. As always, details matter but there are some preliminary issues that warrant attention.

Some history: There is a huge literature on technological diffusion --how and when an innovation is widely adopted[1]. An important lesson from this literature is that "There is substantial variation across technologies and countries." The electric refrigerator was invented in 1913. By 1930 only 10% of US households owned a refrigerator. It was not until after World War II that most US homes had (85%) a refrigerator[2]. It is also the case that the pace of technological diffusion has increased. In 1990, fewer than 10% of US households owned a cellphone or had access to the internet. But these technologies spread very rapidly during the 1990s[3]. There are also many mathematical models and theories of innovation diffusion. The mathematical models are often logistic or S curves showing rapid or not so rapid adoption. The mathematical models often tell us little about a particular innovation. The increasing pace of technological innovations of all sorts opens the possibility that EVs will have a meaningful impact on gasoline demand and oil demand.

Some data issues: The single best source of data on various forms of transportation and the energy used in this sector is the *Transportation and Energy Data Book* (hereafter, the Data Book) produced by Oak Ridge National Laboratories. The Data Book is now in its 37th edition and contains hundreds of pages of data and much of the data is meaningful to the current problem. There are various inconsistencies in the data presented in the Data Book and other sources as well. The inconsistencies are more than a technical issue. The conclusions we may reach about EVs and oil demand are data dependent. Some of these are worth mentioning.

The first inconsistency concerns the number of cars and light trucks in use in the US. The Data Book provides two different series. One series is from the Federal Highway Administration (FHWA) while the second series is from the Institute for Highway Safety (IHS). In 2016, the latest year for which data are reported, FHWA reports a figure of 259.1 million cars and light trucks in use while IHS reports 270.6 million. The difference is 11.5 million vehicles (about 4.2% of the total). The analysis below uses the simple average of the two figures (264.5 million for 2016). For subsequent years, I have added slightly more than 5 million per year to the 2016 average. The 5 million figure came from the average increase from 2014 to 2016. This produces a figure of 274.6 million at the end of 2018 –a figure slightly less than the 276 million used by others.

The data story gets worse, not better. Adding five million cars and trucks per year to the stock is inconsistent with the nearly 17 million new cars and trucks sold each year minus roughly 9 percent of the stock each year based on the reported average life of such vehicles at 11.5 years. The sad story is that we really don't know how many light vehicles are in use in the US and the story is worse regarding world estimates. In contrast, the annual (and monthly) new car sales data are very good. The National Automobile Dealers Association (NADA) compiles such data and you can look at it for yourself.

EV Sales: EV sales in the US are reported by Argonne National Laboratories (ANL) and InsideEVs.com on a monthly basis.[4]" InsideEVs also reports World sales. The ANL and InsideEVs data are very consistent over time.

As of June 2019, 1.228 million EVs had been sold in the U.S. This figure is for light vehicles (cars, small trucks, and SUVs) and includes both All Electric Vehicles (AEVs) and Plug-in Hybrid Electric Vehicles (PHEVs) which accounted for about a third of total EVs. At the same time, there were about 275 million light vehicles in use (Figure 1). Approximately 1 in 250 light vehicles (0.4%) were EVs, a figure very close to World EV use (5 million out of 1.25 billion light vehicles). Monthly EV sales in the US and the world are displayed in Figure 2.

In 2018, EV Sales in the US increased by 80.6 percent over sales in 2017. Most of this increase occurred in the second half of 2018. This is an anomaly brought about in part because of reduction of a Federal tax credit from $7,500 to $3,750. In the first six months of 2019, US EV sales increased by 20 percent over the first six months of 2018. Do not expect an 80 percent increase in EV sales for 2019 over 2018. EV sales face many obstacles including high cost, low maximum distance between charges, and production issues.

Maximum driving distances for EVs remain a major obstacle to increased sales. Table 1 contains a list of ten 2019 model EVs ranked by estimated maximum distance between charges. The top three models are all Tesla vehicles. The Tesla S was the highest ranked model with a maximum distance of 335 miles, an estimated 11 hour charge time, and a starting price of $86,200. Five of the top ten models have starting prices between $35,000 and $40,000 but in most cases, the sales price is 50 percent higher than a comparable vehicle from the same manufacturer with an Internal Combustion Engine (ICE). None of the five have a maximum distance of more than 258 miles.

While limited choice of EV models has constrained the growth of EV sales, almost all major auto and truck manufacturers either have or will soon have an EV. There are also numerous startup companies around the world and there will be many new models of EVs in the next few years.

Ford plans to have 14 EV models by 2022. General Motors plans to have 20 EV models by 2023 that "won't cause sticker shock.[5]" Lucid Motors, located just outside Palo Verde, CA, is one of the more likely U.S. based startups to bring an EV to market soon. The Lucid Air is a very sleek luxury EV. Test models have already been produced. The base model starts at $60,000 but fully loaded can reach $100,000. The vehicle has 1,000 horsepower and can go from 0 to 60 mph in 2.5 seconds. The range of the base model is reported to be 240 miles but an optional battery pack may extend the range to 400 miles, which would make it the longest range EV on the market. The company currently claims it will begin selling the Air in 2020, but its proposed factory in

Casa Grande (AZ) is not complete. Lucid Motors recently received $1 billion from the Saudi Public Investment Fund. Many of the top executives are former Tesla employees[6].

Another US based startup is Rivian which introduced a small pickup truck (R1T) and a similar SUV at auto shows in 2018. The R1T has four electric motors and four battery packs --one on each wheel. Rivian claims a 400 mile range and a 0 to 60 mph time of three seconds. The base model starts at $69,000 but with various battery combinations could be as high as $100,000. Rivian is now taking orders and has a manufacturing facility in Illinois. The factory is a former Mitsubishi factory. Production and delivery are scheduled for early 2020. Amazon and Ford have both invested heavily in Rivian[7].

Lucid and Rivian appear to be well-financed with actual production starting soon. Other EV startups in the US have not been able to produce. And, there are many startups in other nations, particularly China.

Battery costs and performance: Battery cost and performance has also been a constraint on EV sales. Battery costs are decreasing and energy densities are increasing. In 2010, typical lithium ion battery packs for EVs cost $1,000 per kWh. In 2019, that figure is about $200. Tesla's Model 3 battery pack costs about $190 per kWh. Future reductions in price are widely predicted[8].

Researchers at MIT are convinced they are on the verge of a major breakthrough in battery technology that could double the range of EVs. This lithium metal (not lithium ion) technology may be on the market in a few years. MIT researcher Qichao Hu has formed a company to produce these batteries called Solid Energy Solutions. The factory is due to open in China later this year[9]. Others are also working on solid state batteries, which could dramatically increase performance and safety.[10]

Innolith, a Swiss firm claims to have a lithium ion battery that will power an EV for 600 miles. This firm replaces the electrolytes with an inorganic electrolyte. The firm plans a factory in Germany[11].

Charging times, however, remain a problem. As Argonne National Laboratory researcher Ron Walli stated in late 2017, "Widespread demand for electric vehicles could hinge on batteries that can be charged in minutes instead of hours.[12]" Typical charging times for Level 1 (120 volts) chargers are 20 plus hours. Level 2 (240 volts) reduce that to 8 to 10 hours. The so-called supercharger (480 volts) can give an 80 % charge in about 30 minutes. The superchargers are currently available only for Tesla vehicles.

Electric Vehicles and Peak Oil Demand: Little more than a decade ago, the phrase "peak oil" was commonly used to describe peak oil supply. It was alleged that the world was consuming oil faster than it could be discovered and produced. The World was, according to this story, running out of oil. How times have changed. The phrase peak oil now refers to peak oil demand. Will EVs contribute to peak oil demand? Absolutely. When will peak oil demand occur? Probably not until 2035 or 2040, if then.

The US Energy Information Administration (EIA) in its 2017 International Energy Outlook, suggests that peak oil demand for transportation could occur as early as 2025. EIA is quick to point out that 2025 will not likely be the peak of total oil demand. Oil has many other uses than motor gasoline, diesel fuel, and jet fuel.

A recent report by BloomblergNEF suggests that peak oil demand for light vehicles may occur by 2030. This report does not suggest that (total) oil demand will peak that soon.

Wood-Mackenzie, a major industry consulting firm, forecasts a peak in World oil demand by 2036[13].
BP, formerly British Petroleum, take a different perspective. "The point at which oil demand will peak has long been a focus of debate. BP chief economist Spencer Dale and Bassam Fattouh, director of The Oxford Institute for Energy Studies, argue that this focus seems misplaced. The significance of peak oil is that it signals a shift from an age of perceived scarcity to an age of abundance – and with it, a likely shift to a more competitive market environment.[14]" They also point out that small changes in assumptions lead to large differences in the projected date of peak oil.

There are other forecasts predicting that peak oil demand will occur as early as 2023 (Carbon Tracker Initiative, London), DNV GL (Norway), for example. The CEO of Shell oil recently stated that peak oil could occur as early as 2025 –if all nations complied with the Paris accord.

A 2018 study by Argonne National Laboratory indicated that the cumulative effects of EVs may have reduced US gasoline consumption by 0.1% in 2017 from what it would have been without the EVs[15]. An important lesson from this study is that the process of producing such an estimate is long, tedious, and complex.

Some arithmetic may be useful. Until EV vehicle sales exceed sales of Internal Combustion Engine (ICE) vehicles, a decrease in demand for gasoline is unlikely. At least that is the case unless there are improvements in ICE miles per gallon or the number of miles driven per vehicle declines. Shortly after EV sales equal ICE sales, a reduction in gasoline demand is possible. Since oil has many uses and a 42 gallon barrel of oil produces only 19 or 20 gallons of gasoline, peak oil demand due to EVs would occur sometime after the peak in gasoline demand.

Scenarios for the US will be considered first. In 2018, 361,000 EVs were sold and at the end of 2018, the total EVs sold since 2010 were 1.228 million. From 2016 to 2018, The US sold an average of 17 million light vehicles per year. While there are various projections of future light vehicle sales, using the 17 million figure with no increase for many years is a rather cautious assumption. If US EV sales increased 20 percent per year, through 2025, 1.294 million EVs would be sold. Total EVs in use would be about 6.8 million. Assuming US consumers continue to purchase about 17 million light vehicles per year, EV sales in 2025 would be about 6 percent of total light vehicle sales and about 2.2 percent of total US vehicles in use. If a 20 percent growth rate continued for US EV sales, it would be 2036 before EV sales surpass ICE sales. At a 40 percent per year growth rate, US EV sales exceed ICE sales in 2028.

Are such growth rates possible for an extended time? Perhaps. From 2015 to 2017, the annual increase in US EV sales was 19.0 percent. 2018 was an extraordinary year (80.6 percent increase) that few expect will be repeated. Including 2018 brings the 2015 to 2018 average to 34.6 percent. Take your pick of assumptions but neither of these scenarios reaches the critical point before 2028 with peak oil occurring sometime later.

In 2018, world EV sales were 2.02 million or about 2.5 percent of total light vehicle sales. Using a 20 percent annual growth rate for EV sales and no increase in other light vehicle sales, the world reaches the critical point of parity between EV and ICE vehicles in 2030. Using a 40 percent annual growth rate moves this date to 2025.

Peak gasoline and oil demand would occur sometime after those dates. The forty percent scenario implies that there might be as many as 200 million EVs in use worldwide by 2030.

Several assumptions were used in the above scenarios. Most importantly, it was assumed that the US and world economies would continue growing through 2025 without a recession. Also assumed was that there would be no major policy changes such as a massive subsidy for EVs by the federal or state governments. Also assumed is that there are no large spikes in either the retail price of gasoline or the retail price of electricity. It was also assumed that EV manufacturers continue to expand capacity and there are no major production problems.

Policy implications: EVs are not a passing fad. No matter what the date at which EV sales exceed ICE sales, New Mexico, like other governmental units, will need new policies to address the new technology.

Many states (17 by the latest reports) have implemented some sort of tax or user fee on EVs to offset the decrease in gasoline tax revenue resulting from EV use. Georgia has the highest tax at $300 per EV per year. California, which also subsidizes EVs through tax rebates also has an EV user fee. An obvious alternative to an EV tax is to increase the per gallon gasoline tax. This year, 16 states have increased the gasoline tax which had not been increased in most states in more than two decades. New Mexico will need to confront this issue and has begun to do so with a task force.

New Mexico is an oil and gas producing state and, of course, state revenue depends heavily on that industry. Creating revenue stability with less reliance on the oil and gas industry is a high priority and more than one legislative committee is working on that issue. An increasing number of EVs worldwide contributes to the pressure to find a solution but with or without EVs, this needs to be done.

The Land of Enchantment is also a tourism state. The tourism industry, broadly defined, is responsible for more New Mexico jobs than the oil and gas industry. Because of the importance of tourism to the state economy, New Mexico should facilitate EV use. There are many ways to do this. All state parks, museums, and roadside rest areas could be equipped with charging stations for EVs. State government could also work cooperatively with federal government agencies to ensure that national parks and monuments have EV charging stations. None of this would be an expensive project and it would provide another tourism advertising theme.

In the private sector, new hotels (and perhaps old ones) as well as other private sector tourist destinations could be required to install EV charging stations.

State and local government agencies will soon be buying EVs as part of their fleet of vehicles. While the initial cost of EVs is currently more expensive than comparable ICE vehicles, economies of scale and technological change will narrow this gap. EVs are also predicted to last longer than ICE vehicles and the cost per mile is probably lower. State employees will also be driving more EVs. So, the state could put charging stations in all parking lots of state offices and buildings.

Fees could be charged for all of these charging stations and it is possible that the state could generate some revenue in this fashion.

Certainly, the policies described above only scratch the surface. Thank you for your time and I am happy to answer questions.

[1] See for example, Diego A. Comin Bart Hobijn "An Exploration of Technology Diffusion " https://www.hbs.edu/faculty/Publication%20Files/08-093_097fb722-e6dd-466d-aa1a-29733fa92757.pdf , April 2008. I will be happy to provide as many references to technology diffusion as you might like.

[2] https://thekitchenadvisor.com/refrigerator-history/) Accessed July 2, 2019.

[3] See for example, https://www.theatlantic.com/technology/archive/2012/04/the-100-year-march-of-technology-in-1-graph/255573/

[4] Argonne National Laboratory, . https://www.anl.gov/es/light-duty-electric-drive-vehicles-monthly-sales-updates

[5] https://fortune.com/2019/06/05/gm-electric-cars/

[6] https://lucidmotors.com/

[7] https://www.theverge.com/2018/11/26/18111782/rivian-r1t-electric-pickup-price-specs-la-auto-show-2018.

[8] https://www.ucsusa.org/clean-vehicles/electric-vehicles/electric-cars-battery-life-materials-cost

[9] https://www.technologyreview.com/lists/innovators-under-35/2019/entrepreneur/qichao-hu/

[10] https://www.sciencedaily.com/releases/2019/06/190628182314.htm

[11] https://www.theverge.com/2019/4/4/18293989/innolith-ev-battery-breakthrough-lithium-ion

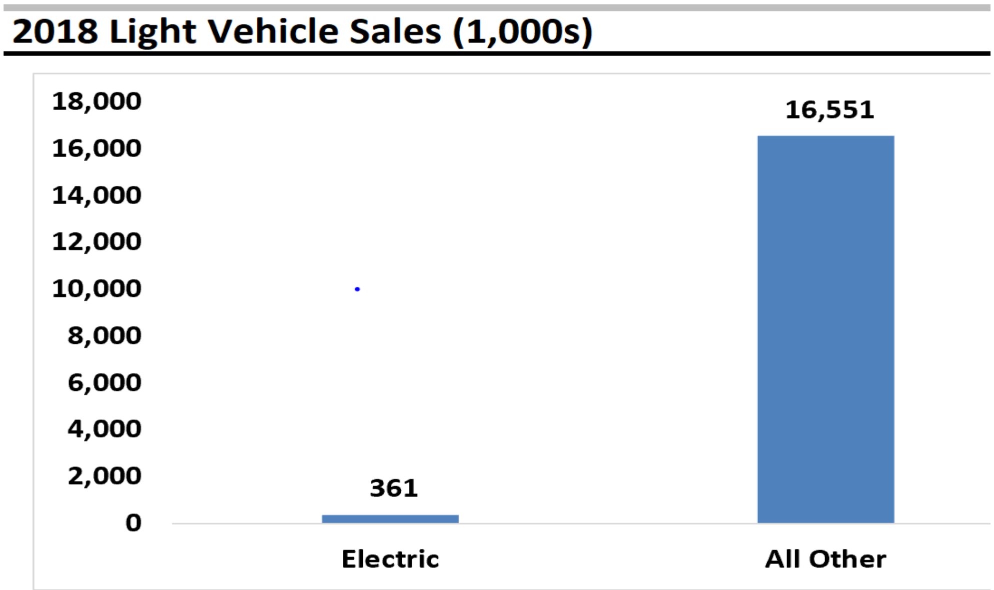
[12] https://www.anl.gov/article/closing-the-gap-argonne-partners-putting-charge-into-ev-battery-technology

13 https://www.ft.com/content/a12af4be-85cf-11e8-96dd-fa565ec55929

[14] https://www.bp.com/en/global/corporate/energy-economics/spencer-dale-group-chief-economist/peak-oil-demand-and-long-run-oil-prices.html

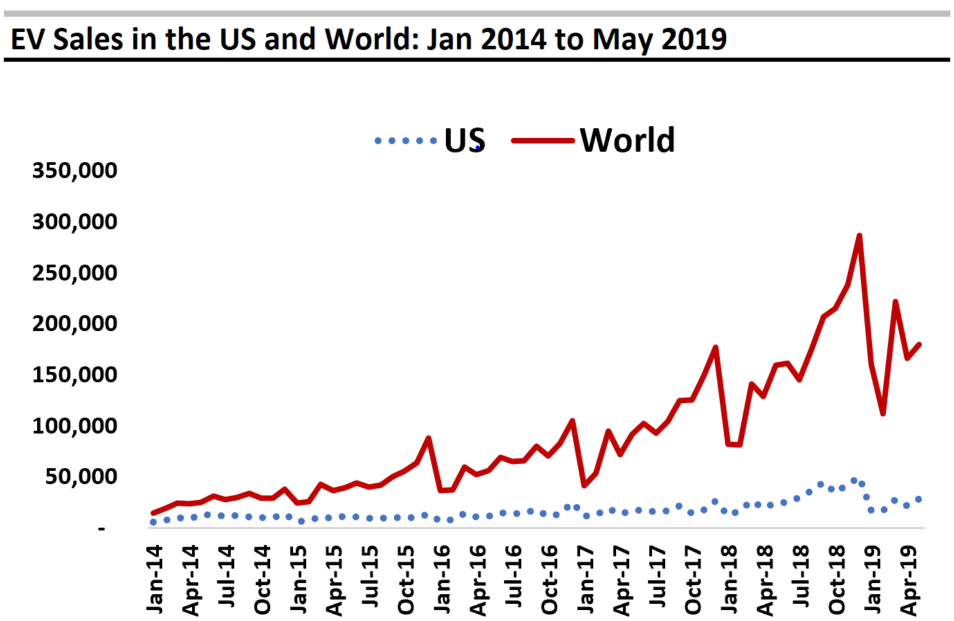
[15] D. Gohlke and Y. Zhou, "Impacts of Electrification of Light-Duty Vehicles in the United States, 2010 – 2017," Argonne National Laboratory, Lemont, IL USA, ANL/ESD-18/1, 2018.

Figure 1



Source: Oak Ridge National Laboratory, Transportation Energy Data Book, Vol 37, Table 6.2 , 2019 and InsideEvs.com

Figure 2



Source: InsideEvs.com

Table 1

Maximum Range and other information for Evs

Rank	Vehicle	Max Range on Full Charge	Estimated Charge Time	Starting Price	EPA Fuel Economy MPG
1	Tesla Model S	335	11	$86,200	102
2	Tesla Model 3	310	10	$52,200	130
3	Tesla Model X	295	10	$90,700	87
4	Hyundai Kona Electr	258	9.5	$36,450	120
5	Kia Soul EV	243	9.5	$35,000	114
6	Kia Nero EV	239	9.5	$37,500	112
7	Chevrolet Bolt	238	9.5	$37,495	119
8	Jaguar I Pace	234	12.9	$70,495	76
9	Nissan Leaf Plus	226	11.5	$37,445	108
10	Audi E-tron	204	8	$74,480	74

Source: Kelly Blue Book, "Ten Longest Range Electric Cars of 2019", https://www.kbb.com/car-reviews-and-news/top-10/longest-range-electric-