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PUBLIC UTILITY COMMISSION
FILING CLERK

PROJECT NO. 49125

REVIEW OF ISSUES	§	**BEFORE THE**
RELATING	§	**PUBLIC UTILITY**
TO ELECTRIC VEHICLES	§	**COMMISSION OF TEXAS**

COMMENTS from

Texas Electric Transportation Resources Alliance

TxETRA

INTRODUCTION

The Texas Electric Transportation Resources Alliance (TxETRA) is pleased to submit the answers to the following questions in Project No. 49125. TxETRA is comprised of utilities, electric vehicle manufacturers, charging companies and non-profit consumer and environmental organizations. The answers to the questions below are a result of a series of meetings held to discuss our answers that we agree to between ourselves. Further answers by individual members are being submitted. This set of answers does not necessarily reflect the diversity of our members' positions.

Electric Vehicles (EVs) are about to roll into Texas in a big wave. The decisions the Commission will be making over the next several years will be the difference between being inundated and surfing.

The EV wave is coming to Texas and the United States because EVs are cheaper and cleaner to operate. They are inherently more efficient, durable and reliable. Because they are far less polluting, China, India and European countries have adopted laws or policies to reduce emissions that can only be met with electric vehicles. Emerging countries have developed the EV manufacturing facilities believing that EVs are a key path to the economic dominance that occurred when the US began mass production of fossil fuel vehicles a century ago.

We have a long "on ramp" to the full-scale adoption of electric vehicles and that will give us plenty of opportunity to adjust our trajectory and speed as we hit various mile markers.

EVs will represent a big new load on the grid, much like air conditioning was in the 50s, or server farms were in the 2000s and fracking in the 2010s. Just as the system we have in place to analyze the need for grid updates and build the grid and distribution system effectively dealt with those problems, we expect it to do so again. But just like we saw with those waves of technological change, some policy areas will require Commission review and guidance or policy changes.

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In the answer to Question #1, we are submitting new estimates of the numbers of EVs that we can expect on the road by 2030, based on international estimates and some of the most widely cited estimates. We also look at the recent shift from sedans to SUVs, which has taken about 10 years and use that as a model for anticipated EV growth.

EVs are a big opportunity to reduce costs for businesses, residential consumers, vehicle owners and utility customers if key policies are adopted and infrastructure is developed statewide.

A number of studies[1,2,3] have found that millions of EVs, if properly managed, can be safely plugged into the grid and not overload it <u>if</u> time of use rates are in place and smart chargers are deployed enabling demand management. In fact, it was noted that "the Texas grid could theoretically charge a fully electrified vehicle fleet today if vehicles were charged during off-peak hours."[4]

Best yet, they can save billions of dollars in grid costs, thus reducing the costs to all customers by using the grid and network of existing generators more efficiently.

The estimated growth in EVs and resultant load may be accelerated or slowed by many different factors including

- The types and range of vehicles available
- battery technology
- charging technology
- storage technology
- motors
- vehicle weight
- environmental demands
- legislative action or incentives
- new technologies connecting electric vehicles to other devices (V2X)
- widespread use of autonomous vehicles

Planning for and monitoring of trends in EV adoption and usage regularly could result in lower costs for infrastructure expansions that may be needed.

There are a number of ways that the Commission can pave the way to EV adoption, including:

- The Commission should adopt projections with low-, medium- and high rates of EV adoption and update them bi-annually.
- The Commission should explore ways to reduce and/or shift charging load.

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1 F. Todd Davidson, Dave Tuttle, Joshua D. Rhodes, Kazunori Nagasawa, *Switching to Electric Vehicles Could Save Us Billions but Timing is Everything*. www.theconversation.com. https://theconversation.com/switching-to-electric-vehicles-could-save-the-us-billions-but-timing-is-everything-106227.

2 M. J. Bradley & Associates, *Electric Vehicle Cost-Benefit Analysis, Plug-in Electric Vehicle Analysis: Arizona*, 2018. https://mjbradley.com/sites/default/files/AZPEVCBAnalysisFINAL04dec18.pdf.

3 Jason Frost, Melissa Whited, Avi Allison, *Electric Vehicles are Driving Electric Rates Down*. https://www.synapse-energy.com/sites/default/files/EVs-Driving-Rates-Down-8-122.pdf.

4 F. Todd Davidson, Dave Tuttle, Joshua D. Rhodes, Kazunori Nagasawa.

- The Commission should set up a process for Transmission and Distribution Service Providers (TDSPs) for estimating load from potential hot spots.
- Policy may be needed to encourage charging infrastructure investments in underserved areas such as rural communities and low-income neighborhoods.
- The Commission should develop policies to regularly review technologies and adjust expected demand as technology changes.

We're on the road to rapid adoption of EV's. The questions the Commission has asked are a good start but will certainly raise more questions. We suggest a series of workshops be held bringing in experts from around the country.

Together, we are about to begin a new journey into the world of EVs. The good news is that like a road trip we can expect bumps, congestion and detours but since we are not the first to take this road so there are many roadmaps to learn from.

Away we zoom . . . .

QUESTION #1

The Commission requests that parties provide current data sources and projections for the expected deployment of electric vehicles in Texas over the next ten years. If available sources should attribute the projections by vehicle (i.e., personal, commercial short haul including fleets and buses, and commercial long-haul electric vehicles).

The number of electric vehicles to be deployed over the next ten years is highly dependent on numerous factors including battery prices, fuel prices, consumer model choices, auto manufacturer marketing, production scale, new technologies, and policy incentives. For this analysis, vehicles are segmented into light duty, buses, and trucks. For light duty vehicles there are three scenarios presented: International Energy Agency (IEA) New Policies Scenario (NPS),[5] Bloomberg New Energy Finance (BNEF),[6] and an SUV Analogue case. For buses and trucks, there are only two distinct scenarios: IEA NPS and BNEF. For purposes of calculating totals, the SUV Analogue scenario assumes the BNEF scenario for buses and trucks.[7]

Projected 2030 Texas EV Fleet by Scenario

	Light Duty	Bus	Truck	Total
IEA NPS	506,948	2,691	4,947	514,586
BNEF	1,670,784	34,594	8,040	1,713,418
SUV Analogue	3,725,701	34,594	8,040	3,768,335

Electric vehicle deployment projections are derived from Texas population projections, Texas resident driving and car buying behaviors, and national market share of sales forecasts.

1. Population and Fleet Growth

In 2017, the latest year for which combined data are available from both the Federal Highway Administration and the Texas Demographics Center, there were 28,525,596 residents and 20,846,859 registered vehicles in the State of Texas. Most of these vehicles were light duty vehicles (cars, pickups, SUVs, and vans) at a ratio of 0.721 registrations per capita. Bus and truck registrations per capita were 0.002 and 0.008, respectively.[8]

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[5] *Global EV Outlook - 2019*. International Energy Agency, 2019, https://www.iea.org/reports/global-ev-outlook-2019.

[6] *Electric Vehicle Outlook 2019*. Bloomberg New Energy Finance, 2019, https://about.bnef.com/electric-vehicle-outlook/.

[7] *Highway Statistics 2017*, Federal Highway Administration, Jan. 2018, www.fhwa.dot.gov/policyinformation/statistics/2017/.

[8] *Ibid.*

Registrations per Resident 2017

	Light Duty	Bus	Truck	Total
Registrations	20,563,651	67,143	216,055	20,846,849
Residents	28,525,596	28,525,596	28,525,596	85,576,788
Registrations Ratio	0.721	0.002	0.008	0.244

The Texas Demographics Center projects that the 2020 resident population will reach 29,677,772, and the 2030 resident population of Texas will reach 34,894,429. Assuming the registration ratios hold constant, this implies that the total size of the fleet will increase by an additional 3,812,396 vehicles between 2020 and 2030. How many of the vehicles in the 2030 fleet will be electrified is the subject of this analysis.[9, 10]

Projected Texas Fleet

	Light Duty	Bus	Truck	Total
2017	20,563,651	67,143	216,055	20,846,849
2020	21,394,236	69,855	224,782	21,688,873
2030	25,154,842	82,134	264,293	25,501,269

2. Vehicle Churn

Although only 3,812,396 vehicles will be added to the total size of the Texas fleet, the total number of vehicles cycling through the same fleet is much higher, due to replacement of existing vehicles. Altogether there will be 13,779,666 new registrations and 9,683,455 deregistrations.[11]

Projections for new registrations of light duty vehicles are based on Auto Alliance new car sales data, with new car sales as a proxy for new registrations. In 2018 there were 1,515,438 light duty auto sales in Texas when the average population was 28,702,243, implying a ratio of residents to light duty vehicle sales at 0.053.12 Deregistrations of light duty vehicles are derived as the difference between projected new car sales and fleet additions.

Projections for bus sales are based on a Federal Transit Administration estimate of a 15.1 year typical age of retirement for a bus. New bus sales are derived as the difference between projected

[9] *Estimates of the Total Populations of Counties and Places in Texas for July 1, 2017 and January 1, 2018*, The population Estimates and Projections Program at The Texas Demographic Center, Apr. 2019, demographics.texas.gov/Resources/TPEPP/Estimates/2017/2017_txpopest_cog.pdf.

[10] *Texas Population Projections 2010 to 2050*, Texas Demographics Center, Jan. 2019, demographics.texas.gov/Resources/publications/2019/20190128_PopProjectionsBrief.pdf.

[11] *Highway Statistics 2017*, Federal Highway Administration, Jan. 2018, www.fhwa.dot.gov/policyinformation/statistics/2017/.

[12] *Autos Drive Texas Forward*. Auto Alliance, 2019, autoalliance.org/in-your-state/TX/.

deregistrations and fleet additions.13 Due to a lack of specific data, truck deregistrations and new sales were modeled using the same age of retirement as used for bus modeling.

Projected Registrations/Deregistrations

	Light Duty	Bus	Truck	Total
New Registrations	13,490,978	68,445	220,243	13,779,666
Deregistrations	9,450,413	55,252	177,790	9,683,455

Vehicle Cycle Characteristics

	Light Duty	Bus	Truck
Per Capita Vehicle Sales	0.0381	0.0002	0.0006
Typical Age of Deregistration	27	15	15

3. Market Share

Projections for the future market share of sales were based on three scenarios as described above. Sources for these projections were selected based on their widespread acceptance, broad treatment of vehicle classes, and availability within the public domain.

Scenario 1: The IEA NPS is the baseline United States scenario of the IEA World Energy Outlook. The scenario incorporates the policies and measures that governments around the world have already put in place, as well as the likely effects of announced policies that are expressed in official targets or plans.

Scenario 2: The BNEF scenario is extrapolated from BNEF's 2019 EV Outlook for United States EV adoption. Although new vehicles sales in this scenario grow to the BNEF 2030 adoption target, the scenario has been modified to allow growth to begin from Texas' actual 2020 base rather than the current national average.

Scenario 3: The SUV Analogue scenario considers that EVs are a lifestyle choice analogous to SUVs, which have been the fastest growing light duty vehicle segment, growing by more than 3 million units, within the total Texas fleet, over the years 2007 to 2017. This represents a growth from 18% of total Texas fleet in 2007 to 28% in 2017. This scenario assumes that EVs, driven by consumer preferences, achieve a share of new car sales comparable to that of SUVs by 2025. This projection is made more plausible because in the future, SUV-styled vehicles will become a larger share of the EV offerings.

4. Limitations of these Projections

As with any forecasting exercise, certain assumptions and simplifications were necessary to articulate a projection model.

[13] *Useful Life of Transit Buses and Vans*. U.S. Department of Transportation Federal Transit Administration, 2007, https://www.transitwiki.org/TransitWiki/images/6/64/Useful_Life_of_Buses.pdf.

a) **Vehicle Data:** Detailed data on vehicle lifespan and new vehicle sales were sparse with respect to the bus and truck segments. Data valuable for informing these assumptions are likely available from the Texas Department of Motor Vehicles, although request times for such data were too lengthy to be timely for this analysis.

b) **Market Share Data:** Market share projections from IEA rely on national projections as opposed to Texas projections. One might argue that Texas will tend to lag the nation in EV deployment, due to the lack of an overt policy push. One might also argue that Texas will outpace the nation, given a highly urban and suburban population, a robust economy, and a best in class fund (the Texas Emissions Reduction Plan) to spur new technologies that can demonstrably improve air quality. Neither of these scenarios are certain so this analysis assumes Texas will gain market share at the national average rate.

c) **Bias:** Underestimation is typical in domains of rapid change. Electric vehicles are no different. Over the past ten years, it has generally been the case that EV deployment projections have consistently underestimated the reality.

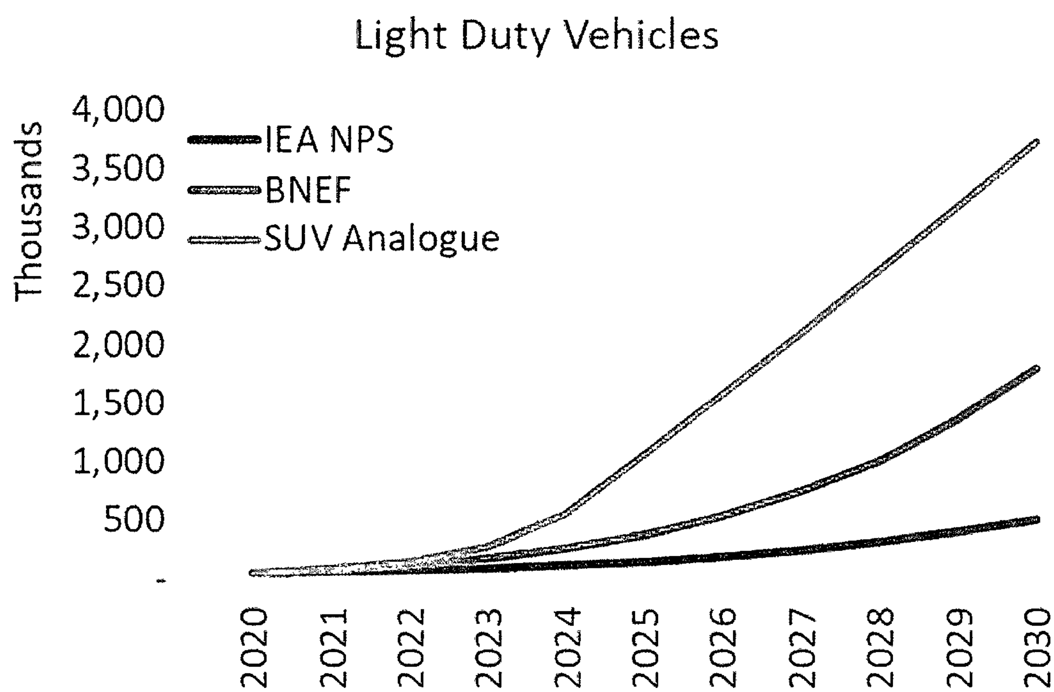
d) **Scenarios:** The included scenarios were selected to represent projections relying on current policies and expectations of market trends. There is no scenario included which contemplates a significant policy change, despite the fact that climate change mitigation policies at all levels have increasingly moved to incentivize a switch from fossil-fuel vehicles to EVs. A motivated policy scenario, such as a target of meeting the Intergovernmental Panel on Climate Change (IPCC) 1.5 degree Celsius target, would require nearly 100% of new vehicle sales to be EV within the next year.

5. Background Materials

Charts and tables below provide more granular articulation of projections as well as reference materials used to create projections.

Projections for Electric Vehicle Deployment 2020 - 2030

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
FLEET SIZE											
IEA NPS											
Light Duty Vehicles	47,691	60,552	75,421	95,514	121,646	154,806	196,418	249,331	316,040	400,697	506,948
Buses	35	110	223	377	572	810	1,092	1,420	1,794	2,218	2,691
Trucks	65	202	410	692	1,051	1,489	2,008	2,610	3,299	4,078	4,947
BNEF											
Light Duty Vehicles	55,606	82,467	117,940	176,627	262,230	379,236	534,100	739,770	1,007,574	1,356,368	1,802,720
Buses	212	658	1,338	2,259	3,430	4,858	6,551	8,518	10,766	13,306	16,144
Trucks	49	151	307	519	788	1,117	1,506	1,958	2,475	3,058	3,711
SUV Analogue											
Light Duty Vehicles	53,714	87,307	153,595	284,397	542,497	1,051,788	1,569,393	2,095,448	2,630,090	3,173,460	3,725,701
Buses	212	658	1,338	2,259	3,430	4,858	6,551	8,518	10,766	13,306	16,144
Trucks	49	151	307	519	788	1,117	1,506	1,958	2,475	3,058	3,711
% OF FLEET											
IEA NPS											
Light Duty Vehicles	0.2%	0.3%	0.3%	0.4%	0.5%	0.7%	0.8%	1.0%	1.3%	1.6%	2.0%
Buses	0.1%	0.2%	0.3%	0.5%	0.8%	1.1%	1.4%	1.8%	2.3%	2.7%	3.3%
Trucks	0.0%	0.1%	0.2%	0.3%	0.4%	0.6%	0.8%	1.0%	1.3%	1.6%	1.9%
BNEF											
Light Duty Vehicles	0.3%	0.4%	0.5%	0.8%	1.1%	1.6%	2.3%	3.1%	4.1%	5.5%	7.2%
Buses	0.3%	0.9%	1.9%	3.1%	4.6%	6.4%	8.5%	10.9%	13.5%	16.5%	19.7%
Trucks	0.0%	0.1%	0.1%	0.2%	0.3%	0.5%	0.6%	0.8%	1.0%	1.2%	1.4%
SUV Analogue											
Light Duty Vehicles	0.3%	0.4%	0.7%	1.3%	2.4%	4.5%	6.7%	8.7%	10.8%	12.8%	14.8%
Buses	0.3%	0.9%	1.9%	3.1%	4.6%	6.4%	8.5%	10.9%	13.5%	16.5%	19.7%
Trucks	0.0%	0.1%	0.1%	0.2%	0.3%	0.5%	0.6%	0.8%	1.0%	1.2%	1.4%


Light Duty Vehicles
Thousands
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
IEA NPS
BNEF
SUV Analogue
2020
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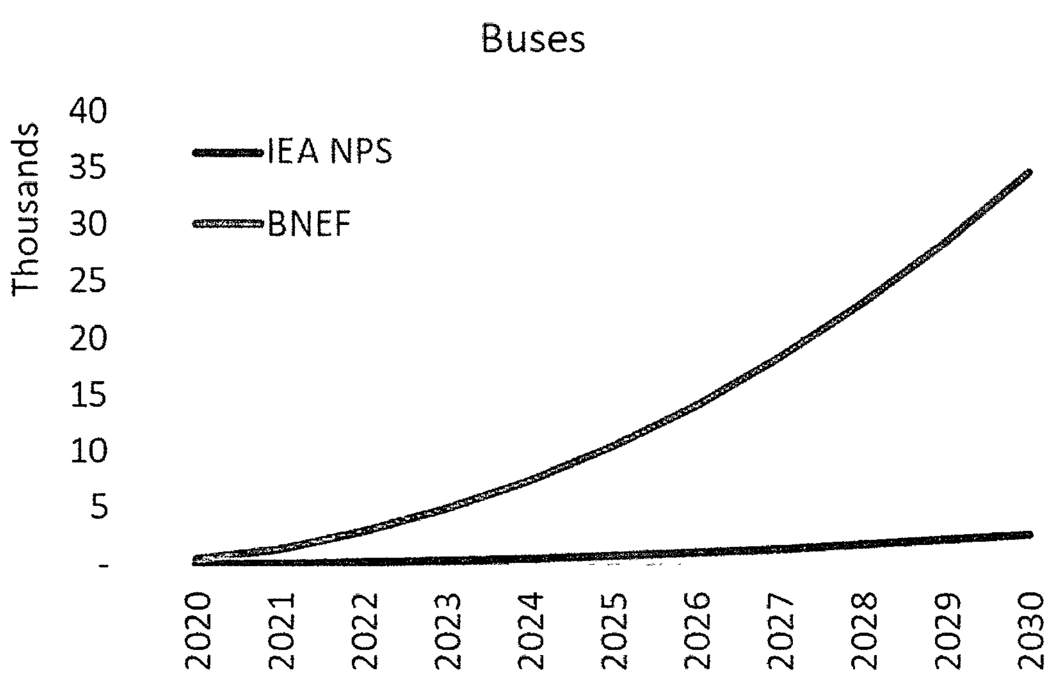
Buses
Thousands
40
35
30
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5
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IEA NPS
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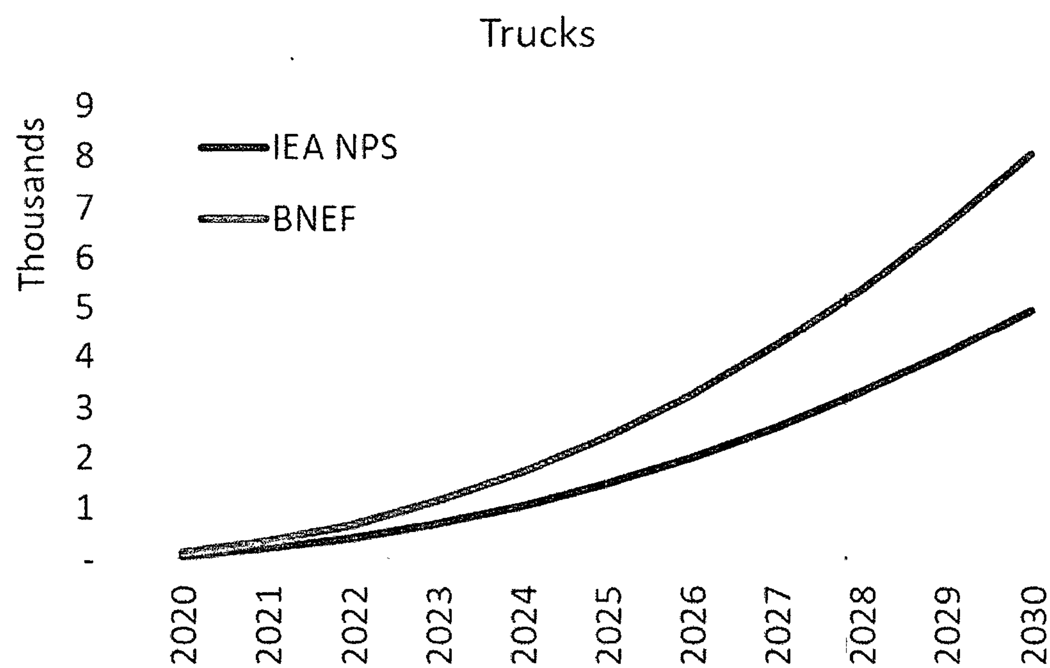
Trucks
Thousands
9
8
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IEA NPS
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IEA NPS Scenario Models

Light Duty Vehicles

Year	Resident Population	Registrations	Sales	Deregistrations	PEV % of Sales	PEV Sales	PEV Fleet	% of Fleet
2020	29,677,772	21,394,236	1,129,586	(849,627)	1.0%	11,002	47,691	0.2%
2021	30,162,253	21,743,491	1,148,026	(798,771)	1.1%	12,861	60,552	0.3%
2022	30,654,642	22,098,447	1,166,767	(811,811)	1.3%	14,870	75,421	0.3%
2023	31,155,070	22,459,197	1,185,814	(825,064)	1.7%	20,092	95,514	0.4%
2024	31,663,667	22,825,837	1,205,172	(838,532)	2.2%	26,132	121,646	0.5%
2025	32,180,567	23,198,462	1,224,846	(852,221)	2.7%	33,160	154,806	0.7%
2026	32,705,905	23,577,170	1,244,841	(866,133)	3.3%	41,612	196,418	0.8%
2027	33,239,819	23,962,060	1,265,163	(880,273)	4.2%	52,913	249,331	1.0%
2028	33,782,449	24,353,234	1,285,816	(894,642)	5.2%	66,710	316,040	1.3%
2029	34,333,938	24,750,793	1,306,807	(909,248)	6.5%	84,656	400,697	1.6%
2030	34,894,429	25,154,842	1,328,140	(924,091)	8.0%	106,251	506,948	2.0%

Buses

Year	Resident Population	Registrations	Sales	Deregistrations	PEV % of Sales	PEV Sales	PEV Fleet	% of Fleet
2020	29,677,772	69,855	5,540	(4,626)	0.6%	35	35	0.1%
2021	30,162,253	70,995	5,842	(4,702)	1.3%	74	110	0.2%
2022	30,654,642	72,154	5,937	(4,778)	1.9%	113	223	0.3%
2023	31,155,070	73,332	6,034	(4,856)	2.5%	154	377	0.5%
2024	31,663,667	74,529	6,133	(4,936)	3.2%	195	572	0.8%
2025	32,180,567	75,746	6,233	(5,016)	3.8%	238	810	1.1%
2026	32,705,905	76,983	6,335	(5,098)	4.5%	282	1,092	1.4%
2027	33,239,819	78,239	6,437	(5,181)	5.1%	328	1,420	1.8%
2028	33,782,449	79,516	6,543	(5,266)	5.7%	375	1,794	2.3%
2029	34,333,938	80,815	6,651	(5,352)	6.4%	423	2,218	2.7%
2030	34,894,429	82,134	6,758	(5,439)	7.0%	473	2,691	3.3%

Trucks

Year	Resident Population	Registrations	Sales	Deregistrations	PEV % of Sales	PEV Sales	PEV Fleet	% of Fleet
2020	29,677,772	224,782	17,828	(14,886)	0.4%	65	65	0.0%
2021	30,162,253	228,451	18,798	(15,129)	0.7%	137	202	0.1%
2022	30,654,642	232,181	19,106	(15,376)	1.1%	208	410	0.2%
2023	31,155,070	235,971	19,417	(15,627)	1.5%	282	692	0.3%
2024	31,663,667	239,823	19,734	(15,882)	1.8%	359	1,051	0.4%
2025	32,180,567	243,738	20,057	(16,142)	2.2%	438	1,489	0.6%
2026	32,705,905	247,717	20,384	(16,405)	2.5%	519	2,008	0.8%
2027	33,239,819	251,761	20,717	(16,673)	2.9%	603	2,610	1.0%
2028	33,782,449	255,871	21,055	(16,945)	3.3%	689	3,299	1.3%
2029	34,333,938	260,048	21,399	(17,222)	3.6%	778	4,078	1.6%
2030	34,894,429	264,293	21,748	(17,503)	4.0%	870	4,947	1.9%

BNEF Scenario Models

Light Duty Vehicles

Year	Resident Population	Registrations	Sales	Deregistrations	PEV % of Sales	PEV Sales	PEV Fleet	% of Fleet
2020	29,677,772	21,394,236	1,129,586	(849,627)	1.7%	18,917	55,606	0.3%
2021	30,162,253	21,743,491	1,148,026	(798,771)	2.3%	26,862	82,467	0.4%
2022	30,654,642	22,098,447	1,166,767	(811,811)	3.0%	35,473	117,940	0.5%
2023	31,155,070	22,459,197	1,185,814	(825,064)	4.9%	58,686	176,627	0.8%
2024	31,663,667	22,825,837	1,205,172	(838,532)	7.1%	85,604	262,230	1.1%
2025	32,180,567	23,198,462	1,224,846	(852,221)	9.6%	117,005	379,236	1.6%
2026	32,705,905	23,577,170	1,244,841	(866,133)	12.4%	154,864	534,100	2.3%
2027	33,239,819	23,962,060	1,265,163	(880,273)	16.3%	205,670	739,770	3.1%
2028	33,782,449	24,353,234	1,285,816	(894,642)	20.8%	267,805	1,007,574	4.1%
2029	34,333,938	24,750,793	1,306,807	(909,248)	26.7%	348,793	1,356,368	5 5%
2030	34,894,429	25,154,842	1,328,140	(924,091)	33.6%	446,353	1,802,720	7.2%

Buses

Year	Resident Population	Registrations	Sales	Deregistrations	PEV % of Sales	PEV Sales	PEV Fleet	% of Fleet
2020	29,677,772	69,855	5,540	(4,626)	8.2%	453	453	0 6%
2021	30,162,253	70,995	5,842	(4,702)	16.4%	956	1,409	2.0%
2022	30,654,642	72,154	5,937	(4,778)	24.5%	1,457	2,867	4.0%
2023	31,155,070	73,332	6,034	(4,856)	32.7%	1,975	4,841	6.6%
2024	31,663,667	74,529	6,133	(4,936)	40.9%	2,509	7,350	9 9%
2025	32,180,567	75,746	6,233	(5,016)	49.1%	3,060	10,410	13 7%
2026	32,705,905	76,983	6,335	(5,098)	57.3%	3,628	14,039	18 2%
2027	33,239,819	78,239	6,437	(5,181)	65.5%	4,214	18,252	23.3%
2028	33,782,449	79,516	6,543	(5,266)	73.6%	4,818	23,070	29.0%
2029	34,333,938	80,815	6,651	(5,352)	81.8%	5,442	28,512	35.3%
2030	34,894,429	82,134	6,758	(5,439)	90.0%	6,083	34,594	42.1%

Trucks

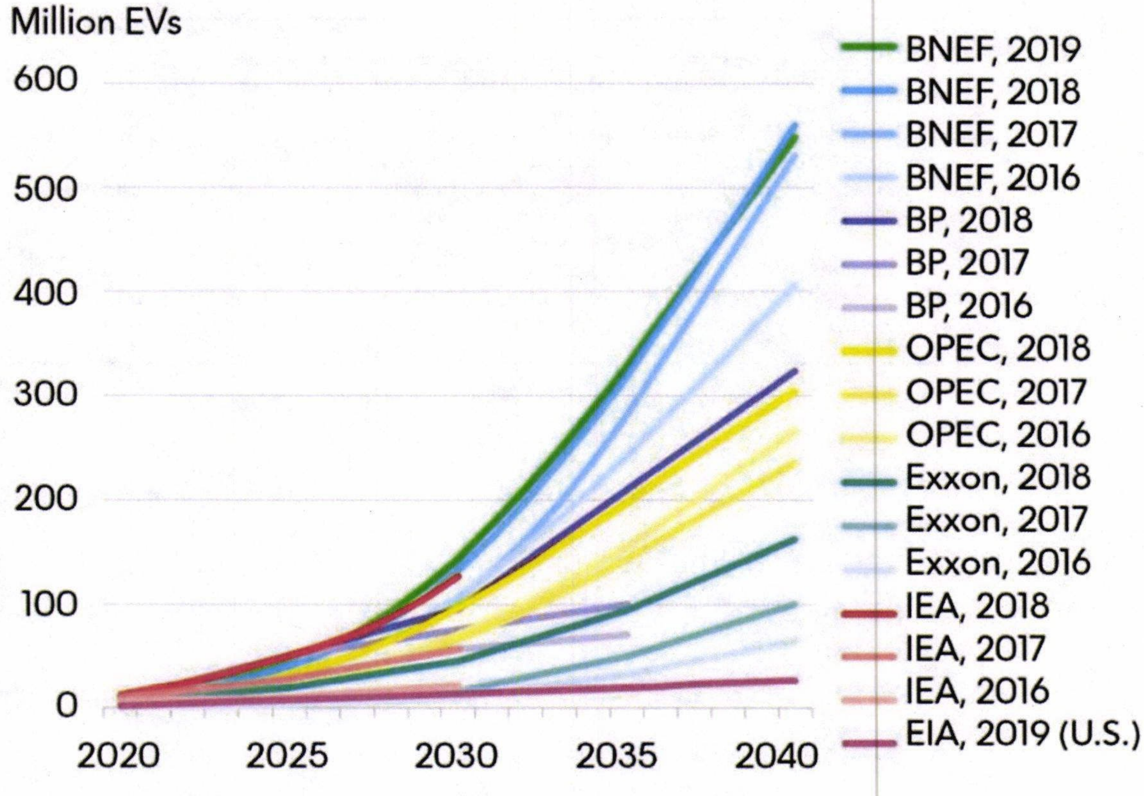
Year	Resident Population	Registrations	Sales	Deregistrations	PEV % of Sales	PEV Sales	PEV Fleet	% of Fleet
2020	29,677,772	224,782	17,828	(14,886)	0.6%	105	105	0.0%
2021	30,162,253	228,451	18,798	(15,129)	1.2%	222	328	0.1%
2022	30,654,642	232,181	19,106	(15,376)	1.8%	339	666	0.3%
2023	31,155,070	235,971	19,417	(15,627)	2.4%	459	1,125	0.5%
2024	31,663,667	239,823	19,734	(15,882)	3.0%	583	1,708	0.7%
2025	32,180,567	243,738	20,057	(16,142)	3.5%	711	2,419	1.0%
2026	32,705,905	247,717	20,384	(16,405)	4.1%	843	3,262	1.3%
2027	33,239,819	251,761	20,717	(16,673)	4.7%	979	4,242	1 7%
2028	33,782,449	255,871	21,055	(16,945)	5.3%	1,120	5,362	2.1%
2029	34,333,938	260,048	21,399	(17,222)	5.9%	1,264	6,626	2.5%
2030	34,894,429	264,293	21,748	(17,503)	6.5%	1,414	8,040	3.0%

SUV Analogue Scenario Models

Light Duty Vehicles

Year	Resident Population	Registrations	Sales	Deregistrations	PEV % of Sales	PEV Sales	PEV Fleet	% of Fleet
2020	29,677,772	21,394,236	1,129,586	(849,627)	1.5%	17,025	53,714	0.3%
2021	30,162,253	21,743,491	1,148,026	(798,771)	2.9%	33,594	87,307	0.4%
2022	30,654,642	22,098,447	1,166,767	(811,811)	5.7%	66,288	153,595	0.7%
2023	31,155,070	22,459,197	1,185,814	(825,064)	11.0%	130,801	284,397	1.3%
2024	31,663,667	22,825,837	1,205,172	(838,532)	21.4%	258,101	542,497	2.4%
2025	32,180,567	23,198,462	1,224,846	(852,221)	41.6%	509,291	1,051,788	4.5%
2026	32,705,905	23,577,170	1,244,841	(866,133)	41.6%	517,605	1,569,393	6.7%
2027	33,239,819	23,962,060	1,265,163	(880,273)	41.6%	526,055	2,095,448	8.7%
2028	33,782,449	24,353,234	1,285,816	(894,642)	41.6%	534,642	2,630,090	10.8%
2029	34,333,938	24,750,793	1,306,807	(909,248)	41.6%	543,370	3,173,460	12.8%
2030	34,894,429	25,154,842	1,328,140	(924,091)	41.6%	552,241	3,725,701	14.8%

EV Outlooks then and now



Source: BloombergNEF, organization websites. Note: BNEF's 2019 outlook includes passenger and commercial EVs. Some values for other outlooks are BNEF estimates based on organization charts, reports and/or data (estimates assume linear growth between known data points). Outlook assumptions and methodologies vary. See organization publications for more.

QUESTION #2

Please provide any current data sources and information on the expected amount of new load attributable to electric vehicles over the next ten years. If available, the data sources should attribute this load by vehicle (i.e., personal, commercial short-haul including fleets and buses, and commercial long-haul electric vehicles).

Electric vehicles (EVs) will have different load characteristics depending on the number of vehicles in each class, the respective consumption of each class, and operator charging behaviors. Scenarios for the number of vehicles are already defined in the answer to Question #1.

Peak EV Charging Demand in 2030 (MW)

Class	Light Duty	Bus	Truck	Total
IEA NPS	1,004	94	252	1,350
BNEF	3,569	1,211	410	5,190
SUV Analogue	7,377	1,211	410	8,998

Aggregate EV Annual Consumption in 2030 (MWh)

Class	Light Duty	Bus	Truck	Total
IEA NPS	1,645,128	101,370	305,417	2,051,916
BNEF	5,850,117	1,303,161	496,373	7,649,650
SUV Analogue	12,090,500	1,303,161	496,373	13,890,033

1. Energy Consumption

Estimates of energy consumption can be drawn from vehicle watt hour per mile ratings[14,15] and statistical data about annual vehicle miles traveled reported by the Federal Highway Administration.[16]

Annual EV Consumption

Class	Wh/Mi	VMT	MWh
Light Duty Vehicle	283	11,467	3.2
Bus	2,150	17,521	37.7
Truck	2,537	24,335	61.7

2. Peak Charging Demand

While sparse data is available to inform estimates of EV charging impact on peak demand, one estimate that has been made is provided in ERCOT's 2018 Long-Term System Assessment (LTSA).[17]

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14 Kane, Mark. *All-Electric Car Energy Consumption (EPA) Compared – May 2019.* InsideEVs, 7 May 2019, insideevs.com/news/348093/energy-consumption-epa-compared-may-2019/.

15 Eudy, Leslie, et al. *Foothill Transit Battery Electric Bus Demonstration Results.* National Renewable Energy Laboratory, 2016, https://www.nrel.gov/docs/fy16osti/65274.pdf.

16 *Annual Vehicle Distance Traveled in Miles and Related Data - 2017.* Federal Highway Administration, 2017, https://www.fhwa.dot.gov/policyinformation/statistics/2017/pdf/vm1.pdf.

17 *2018 Long-Term System Assessment for the ERCOT Region.* ERCOT System Planning, 2018, http://www.ercot.com/content/wcm/lists/144927/2018_LTSA_Report.pdf.

Peak EV Charging Demand in 2033 (MW)			
Class	Number of EVs	Aggregate Demand	Demand per EV
Light Duty Vehicle	3,000,000	5,940	0.002
Bus	80,000	2,800	0.035
Truck	200,000	10,200	0.051

3. Limitations of this Projection

- Peak charging demand assumptions are drawn from an ERCOT scenario that has not been empirically validated. More data is necessary to understand how EV charging will impact peak in practice.
- Peak charging is based on assumptions about customer behavior that do not account for the potential impact of incentives that might motivate greater off-peak charging behavior. Some recent analyses have shown this potential to be significant[18] with considerable economic value.[19]
- Annual consumption estimates are based on national averages that do not account for regional differences in driving behaviors, climate, and topography.
- Annual consumption estimates do not include the impact of charging losses due to resistance, which can be upwards of 10% for AC level 2 charging.[20]

4. Background Materials

The chart below provides more granular articulation of projections.

[18] Allison, Avi, and Melissa Whited. "Electric Vehicles Still Not Crashing the Grid." https://www.synapse-energy.com/sites/default/files/EV-Not-Crashing-Grid-17-025.pdf.
[19] *Charging Ahead: Deriving Value from Electric Vehicles for All Electricity Customer*. Illinois Citizens Utility Board, https://www.citizensutilityboard.org/wp-content/uploads/2019/03/Charging-Ahead-Deriving-Value-from-Electric-Vehicles-for-All-Electricity-Customers-v6-031419.pdf.
[20] *An Assessment of Level 1 and Level 2 Electric Vehicle Charging Efficiency*. Vermont Energy Investment Corporation Transportation Efficiency Group, 2013, https://www.veic.org/documents/default-source/resources/reports/an-assessment-of-level-1-and-level-2-electric-vehicle-charging-efficiency.pdf.

Projections for Electric Vehicle Impact 2020 - 2030

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
PEAK CHARGING DEMAND (MW)											
IEA NPS											
Light Duty Vehicles	94	120	149	189	241	307	389	494	626	793	1,004
Buses	1	4	8	13	20	28	38	50	63	78	94
Trucks	3	10	21	35	54	76	102	133	168	208	252
BNEF											
Light Duty Vehicles	110	163	234	350	519	751	1,058	1,465	1,995	2,686	3,569
Buses	16	49	100	169	257	364	491	639	807	998	1,211
Trucks	5	17	34	57	87	123	166	216	273	338	410
SUV Analogue											
Light Duty Vehicles	106	173	304	563	1,074	2,083	3,107	4,149	5,208	6,283	7,377
Buses	16	49	100	169	257	364	491	639	807	998	1,211
Trucks	5	17	34	57	87	123	166	216	273	338	410
Usage MWh											
IEA NPS											
Light Duty Vehicles	154,765	196,501	244,753	309,958	394,761	502,370	637,408	809,119	1,025,601	1,300,326	1,645,128
Buses	1,318	4,144	8,400	14,202	21,547	30,513	41,136	53,492	67,580	83,552	101,370
Trucks	4,013	12,471	25,313	42,723	64,887	91,928	123,970	161,136	203,673	251,767	305,417
BNEF											
Light Duty Vehicles	180,450	267,619	382,734	573,183	850,979	1,230,682	1,733,240	2,400,673	3,269,740	4,401,633	5,850,117
Buses	17,065	53,077	108,000	182,361	276,876	392,146	528,851	687,556	869,050	1,074,051	1,303,161
Trucks	6,482	20,250	41,117	69,455	105,448	149,344	201,389	261,892	331,039	409,075	496,373
SUV Analogue											
Light Duty Vehicles	174,311	283,325	498,441	922,914	1,760,490	3,413,221	5,092,933	6,800,066	8,535,065	10,298,389	12,090,500
Buses	17,065	53,077	108,000	182,361	276,876	392,146	528,851	687,556	869,050	1,074,051	1,303,161
Trucks	6,482	20,250	41,117	69,455	105,448	149,344	201,389	261,892	331,039	409,075	496,373

QUESTION #3

Please identify any anticipated load "hot spots" in the state for electric vehicle charging. Please specify whether these hot spots are expected from personal, commercial short-haul, or commercial long-haul electric vehicle deployment or charging.

A hot spot can be defined as a concentration of EV charging loads of significant coincident demand that will require a distribution upgrade and could require a transmission system upgrade.

There are many types of hot spots that could occur where a large concentration of EVs are plugged in and charging at one time and exceed the capacity of the circuits. There are thousands of potential hot spots in Texas.

Hot spots arising from commercial electric vehicle deployment include:

- Distribution centers
- Airports
- Rail yards
- Ports
- Bus hubs
- Trucks stops
- Highway rest areas
- Commercial centers with multiple "load in" and charging facilities E.g. big box stores, large grocery stores and super centers

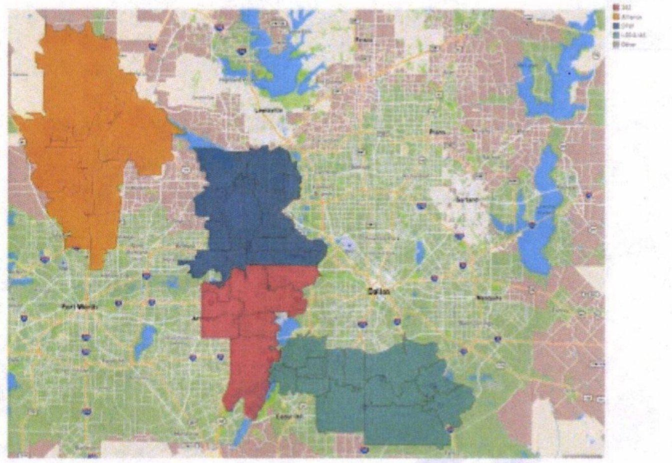
Hot spots arising from personal vehicles could arise in four types of locations:

- Parking garages
- Large multifamily residential development
- Commercial centers drawing large numbers of customers
- Large highway fueling stations

Specifically, for the Dallas/Fort Worth area, Oncor obtained information on the concentration of distribution centers and truck depots from FleetSeek.com. They obtained information on school bus barn locations from the Texas Department of Education. The following slides were provided by Oncor at the Texas Energy Summit. They have chosen to submit their own comments in this docket and are not participating in the development of TxETRA's comments.

Logistics Clusters in DFW Area

D/FW has four pockets of high concentrations of logistics and distribution centers, all proximate to the interstates and/ or DFW or Alliance airports.



ONCOR

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Co-location of Logistics and Distribution Centers

These pockets are very dense and could impact substations if multiple customers electrify only a few vehicles each simultaneously.

ONCOR

9

Fleet Charging Requirements

Depot overnight

- Delivery Vans: Possibly level 2 – 240 volt 48 amp service
- Short Haul/Municipal: DC Fast Charge – 150 kW to 1 MW

Continuous Use:

- Regional / Long Haul: DC Fast Charge: 250 kW to 1 MW

Impact: A large depot could require between 5 – 40 MW additional load at a facility currently likely running less than 300 kW (unless A/C or Refrigerated warehouse)

ONCOR

11

Our members feel that this is not an issue that requires any regulatory action at this time. If a company asks for a service upgrade, the Transmission and Distribution Service Provider (TDSP) will analyze the adequacy of the service and upgrade it as needed. The TDSP will take the growth in anticipated load from charging clusters into consideration as they do their 5-year transmission and distribution capital plan and will adjust as they see hot spots emerging. In addition, our members agreed that having time of use pricing is a critical tool to shift demand.

QUESTION #4:

Describe the observed or anticipated load profiles and impacts of various types of electric vehicle charging stations (e.g., residential Level 1, Level 2, and Level 3 DC Fast charging) and the class of the vehicle charging (i.e., personal, commercial short-haul including fleets and buses, and commercial long-haul electric vehicles).

Load profiles vary with vehicle type and duty cycles. For example, residential charging load profiles will differ from those for charging commercial or heavy duty trucks used 24 hours a day. It may also vary with commuter vehicles that are plugged in and charge at work. Our review of the literature demonstrates that the key to mitigating increased peaks from charging is demand management and time of use rates.

ERCOT developed an EV scenario for inclusion its 2018 LTSA and suggested the following charging patterns might occur.[21]

The charging patterns and demand flexibility will likely vary among different types of EVs. For this study, most cars were assumed to charge overnight so that they would be fully charged before hour ending 0500, trucks and buses were assumed to charge around noon and again overnight. Figure 6 shows the assumed normalized average hourly charging pattern of EVs by type.

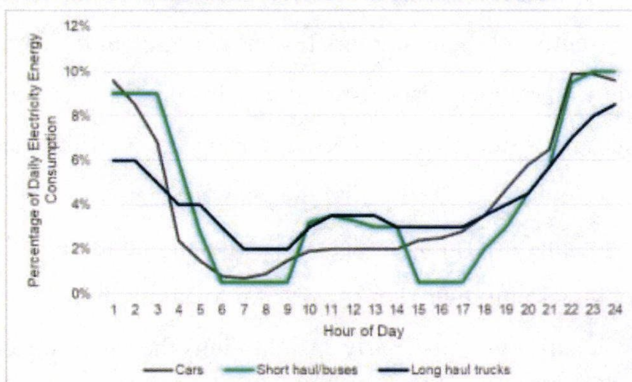

Figure 9: Assumed Hourly Charging Patterns by Vehicle Type

For 2033, the total peak charging demand is estimated to be over 18,500 MW at midnight. Approximately 5,000 to 6,000 MW of charging demand was expected during hours ending 1600-1800. In this scenario, the system-wide summer peak would occur around hour ending 2200. Figure 7 shows the aggregated charging demand by vehicle type.

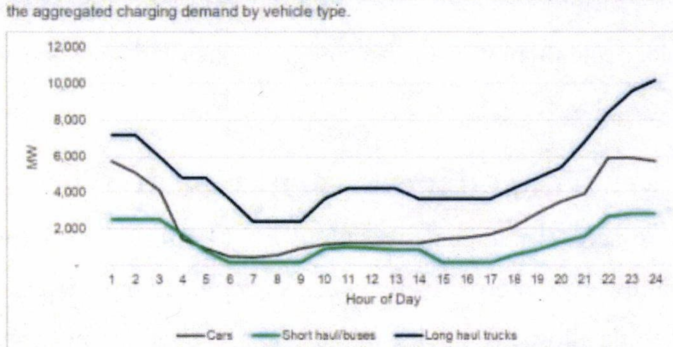

Figure 10: Estimated Total Charging Demand of EVs by Type in 2033

[21] ERCOT System Planning: 2018 Long-term System Assessment for the ERCOT Region. December 2018. http://www.ercot.com/content/wcm/lists/144927/2018_LTSA_Report.pdf.

McKinsey studied load profiles in Germany which had, as of December 2018, a total of 196,750 plug-in electric vehicles.[22] The country is the largest passenger car market in Europe, however, as of December 2016, it ranked as the eighth largest plug-in market in the world and the fifth largest in Europe. Approximately 2% of their vehicle fleet are EVs.

Using information from Germany as an example, shows EV growth is not likely to cause large increases in power demand through 2030. Instead in Germany, it potentially adds about 1 percent to the total load and requires about five extra gigawatts (GW) of generation capacity. That amount could grow to roughly 4 percent by 2050, requiring additional capacity of about 20 GW.

Based on ERCOT's interconnection queue, almost all this new-build capacity will be wind and solar power, and energy storage, with the possibility of some gas-powered generation. Energy providers have several ways to address this situation. They can influence charging behavior: for example, time-of-use electricity tariffs can give incentive to EV owners to charge after midnight instead of in the early evening. Analysis shows this could halve the increase in peak load.[23] Easy to implement and proven in trials, time-of-use rates will require oversight because their use can result in "timer peaks" which occur when many people inadvertently set their chargers to start charging at the same time.

Alternatively, energy providers can deploy more local solutions, such as co-locating an energy-storage unit with the transformer that charges the unit during times of low demand. The storage unit then discharges at times of peak demand, thus reducing the peak load.

While some investments in grid upgrades or alternative solutions will be unavoidable, companies can greatly reduce them by tackling their root causes. An example involves avoiding peak-load increases altogether by shifting EV charging loads. Early insights into the charging behavior and the driving and parking patterns of EV owners suggest that for a significant share of the time that EVs remain connected to the grid, they are not actively charging. This share can range from more than 80 percent of the time for private, residential EV charging to some 25 percent for public charging. This situation creates the potential to shift the charging load and thereby optimize charging times and speeds from a system perspective, thus making charging smart.

INTELLIGENTLY STEERING CHARGING BEHAVIOR TO CREATE VALUE

Centrally coordinated, intelligent steering of EV charging behavior could create value in several ways. First, it could allow even more effective peak shaving and thus greatly reduce the grid investments discussed. Second, it could allow a reshaping of the load curve beyond peak shaving to optimize generation

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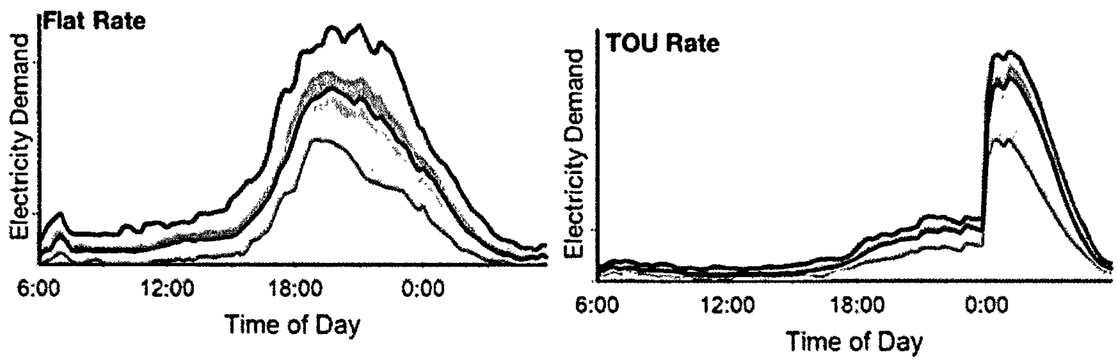
[22] McKinsey Center for Future Mobility, *The Potential Impact of Electric Vehicles on Global Energy Systems.* July 2018. https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-potential-impact-of-electric-vehicles-on-global-energy-systems.

[23] *Ibid. Exhibit 5.*

cost (shifting demand from peak to base-load generation). And, charging up at times of excess solar and wind generation or throttling it down at moments of low renewables production could help to integrate a larger share of renewable power production. Finally, by providing demand-response services, smart charging could offer valuable system-balancing (frequency-response) services.



Examples of load profiles for uncontrolled EV charging (top) and indirectly controlled charging through TOU rates with off-peak hours from midnight to 6 am (bottom). Figure modified from The EV Project (2013).[24]

Smart charging systems are internal software and networking components of Electric Vehicle Supply Equipment (EVSE), enabling internet connection to provide access to network dashboards to assist in monitoring and controlling system APIs in order to deliver custom deliverables to end users. Deliverables consist of a number of features such as driver and EV profiles, usage reports, electric load profiles/characteristics of different power levels of charging, with a strong call out regarding the ability to shape/manage EV load.

A recent UT study published by IEEE demonstrates the value of time of use rates to shift peak.[25]

[24] Steven Schey, Don Scoffield, John Smart. *A First Look at the Impact of Electrical Vehicle Charging on the Electric Grid in the EV Project.* https://www.energy.gov/sites/prod/files/2014/02/f8/evs26_charging_demand_manuscript.pdf.

[25] Anamika Dubey, Surya Santoso. *Electric Vehicle Charging on Residential Distribution Systems: Impacts and* Mitigations. *IEEE Access*, *3*, 18711893.[7264982]. https://doi.org/10.1109/ACCESS.2015.2476996.

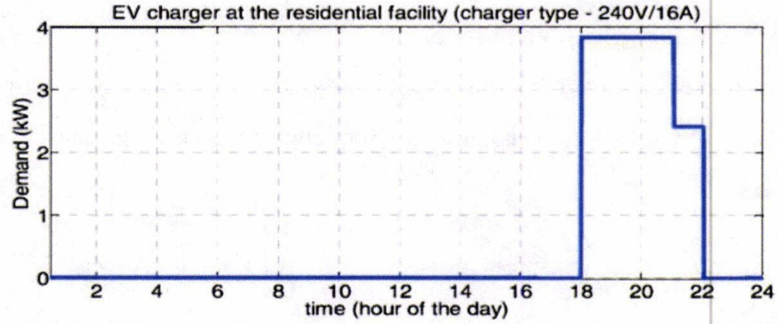


FIGURE 6. An example EV load shape profile for EV load located at a residential facility. EV charger - 240V/16A (3.84 kW)-16-kWh battery.

Contrast this with the load profile if time of use charging is used.[26]

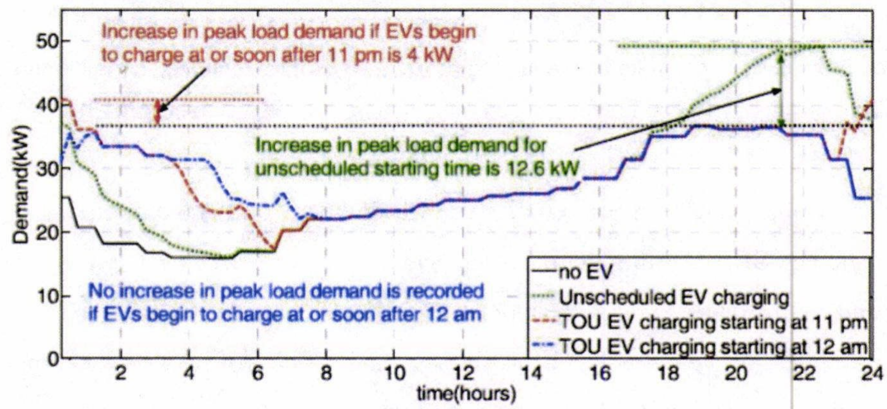


FIGURE 18. Load shape profiles with off-peak rates beginning at 11 pm and 12 am (24-kWh EVs).

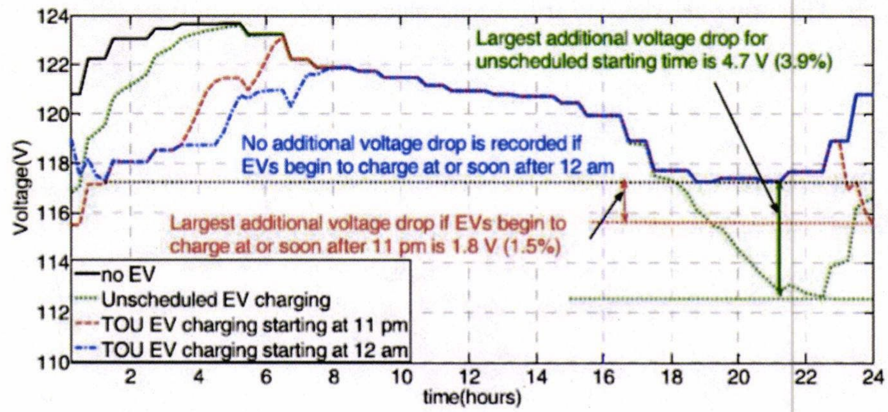


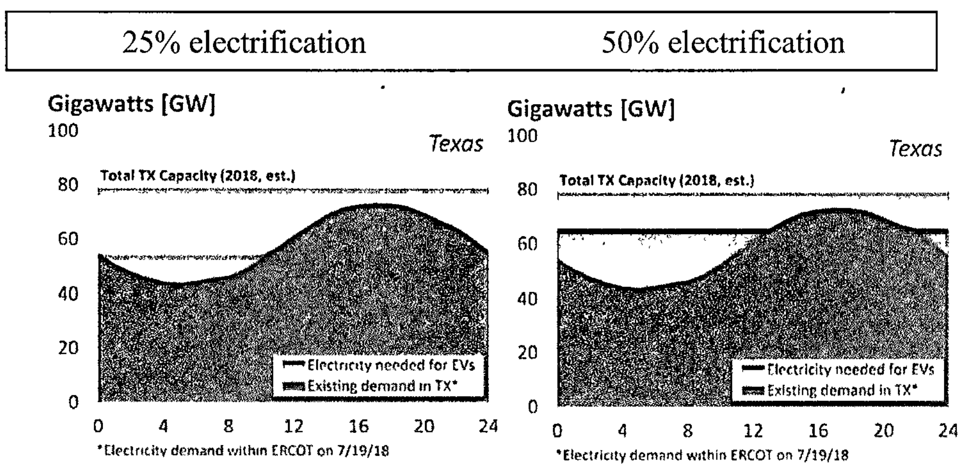
FIGURE 19. Voltage profiles with off-peak rates beginning at 11 pm and 12 am (24-kWh EVs).

[26] *Ibid.*

A subsequent UT study on the impact of EVs shows that with demand management and time of use rates, 100 % of the vehicles in Texas could be electrified and not exceed the reserves at the state's peak:[27]

> [W]e found the ERCOT grid had spare capacity to provide more than 350 gigawatt-hours of additional electricity if idled power plants continued to operate throughout the day, not just during peak demand.
> Based on our estimates, the charging requirements for a fully electrified fleet of personal cars in Texas would be about 290 gigawatt-hours per day, less than the available surplus of generation capacity. In other words, the Texas grid could theoretically charge a fully electrified vehicle fleet today if vehicles were charged during off-peak hours.

The graph below shows projected EV load in Texas with smart charging and demand management tools in place. The GIF with this referenced article cited in the footnote below illustrates the different impacts between EV load with and without smart charging and demand management in animated fashion.



The impact of medium and heavy-duty charging profiles are more fully discussed in the answer to Question #6.

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27 F. Todd Davidson, Dave Tuttle, Joshua D. Rhodes, Kazunori Nagasawa, *Switching to Electric Vehicles Could Save Us Billions but Timing is Everything*, www.theconversation.com. https://theconversation.com/switching-to-electric-vehicles-could-save-the-us-billions-but-timing-is-everything-106227.

QUESTION #5

What, if any, emerging vehicle charging technologies are anticipated to be commercially available in the next ten years that could impact electricity markets in Texas?

There are number of significant changes in charging technology that are expected in the next decade. These can be grouped into:

- Changes in charging speed and voltage;
- Wireless charging of buses and delivery vehicles which can lead to energy loss;
- Using capacitors and storage to reduce needed peak energy demanded for ultra-high speed charging and inductive charging; and
- Changes in battery chemistry and materials.

A recent Baylor and Texas A&M study[28] performed a comprehensive analysis of factors affecting charging technology and charging speeds. They find a wide variety of factors could affect charging speed:

- Changing chemistry
- Charging strategy
- Constant charge
- Constant current
- Constant current and voltage
- Pulse charging
- Capacitive charging
- Inductive charging
- Fast charging power electronics
- Battery thermal management

THE RELATIONSHIP OF POWER TO CHARGING TIME

In order to be fully competitive, EV drivers will demand charging times comparable that of a fossil fuel vehicle, or about 10 minutes. If a driver charges his or her car at a fast charging station that provides less than 50 kW, the charging takes about 50 minutes and gives a driving range of about 125 miles. On a long trip, drivers would not want to stop every 125 miles and wait for 50 minutes to continue their trip, resulting in anticipated demand for ultra-fast charging.

The biggest hindrance for ultra-fast chargers is reportedly the size of the current generation of batteries as well as the voltage they can accept. Ultra-fast charging may be the future, but right now battery technology is lagging.

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[28] Ryan Collin, Yu Miao, Alex Yokochi,, Prasad Enjeti and Annette von Jouanne. *Advanced Electric Vehicle Fast-Charging Technologies*. *Energies* 2019, *12*(10), 1839. https://doi.org/10.3390/en12101839.

Despite those restrictions, some newer electric vehicles are beginning to close the gap. Among them is the Jaguar I-PACE which can accept 440 Volts, giving it a total full charge time of 1.5 hours according to the company.

Several battery technologies are also emerging that could help increase range and charging capabilities of electric vehicles. One company, the Australia-based Tritium, says it can provide drivers about 210 miles of charge in just 10 minutes — a feat that would shatter prior standards.[29]

The development of ultra-fast charging will have its own challenges, both for charging operators and utilities. Today, the fastest charger in the field is 350 kW but the resultant load for fast chargers for semi-trucks is 1 MW to 4.5MW of peak charge demand. That could result in 10 to 45 MW of collective peak demand for a truck charging stop.[30]

Wireless changing will be used initially for busses, shuttles and short haul delivery vehicles. It will be used in three types of applications. Short-term bursts of a large amount of voltage can increase stored energy but some energy loss will occur as a vehicle pulls under a charging station or over a plate at a bus stop. This type of charging will be backed up with capacitors and storage. Slower more controlled charging will occur in large facilities like in Austin Energy's bus depot. Slower charging will also occur at a home or office over a stationary plate. Images below depict catenary charging (on the left) and wireless charging (on the right).[31]

[29] James Pero, *New ultra-fast pumps can charge up an electric vehicle in just 10 minutes - but car batteries aren't advanced enough yet to handle it,* TheDailyMail.com ,April 5, 2019. https://www.dailymail.co.uk/sciencetech/article-6892099/New-ultra-fast-pumps-charge-electric-car-minutes-theres-battery-handle-it.html.

[30] Peter Kelly-Detwiler, Forbes. *The Future of Electric Vehicle Charging: Executives At EVgo Weigh In*, January 21, 2019. https://www.forbes.com/sites/peterdetwiler/2019/01/21/the-future-of-electric-vehicle-charging-executives-at-evgo-weigh-in/#191b93e5f24b.

[31] *Charging Systems for Ebuses*, Siemens. https://new.siemens.com/global/en/markets/transportation-logistics/electromobility/ebus-charging.html.

A new type of solid-state battery has recently been announced by John Goodenough, one of the inventors of the lithium ion battery. University of Texas at Austin researchers demonstrated[32] that their new battery cells have at least three times as much energy density as today's lithium-ion batteries, so a driver could go far more miles between charges. The UT Austin battery formulation also allows for a greater number of charging and discharging cycles, which equates to longer-lasting batteries, as well as a faster rate of recharge (minutes rather than hours).

CONCLUSION

In order to allow EVs to refuel in time frames comparable to those of fossil fuel vehicles, ultra-high-speed charging infrastructure will be deployed and will hit the market within a decade. Simultaneously, battery chemistry, materials and storage technology are clearly improving and may affect energy use and miles traveled per kW of energy. These contradictory trends make planning difficult, but it reinforces the need for periodic technology reviews by the Commission that could affect the Long-Term System Analysis and thus Commission policy.

[32] M.H. Braga, N.S. Grundish, A.J. Murchison and J.B. Goodenough, Alternative Strategy for a Safe, Rechargeable Battery, Energy & Environmental Science, 2017. https://pubs.rsc.org/en/Content/ArticleLanding/2017/EE/C6EE02888H#!divAbstract.

QUESTION #6

The Commission requests that parties provide a detailed explanation on the following items:

a. **The anticipated impacts of electric charging, including residential and commercial charging stations on the distribution system;**
b. **The anticipated impact of electric vehicle charging stations on the transmission system in the next ten years; and**
c. **The anticipated impact of electric vehicle charging stations on long-term system planning at the regional transmission organization level, given a widespread adoption scenario.**

The power grid is used to transport electricity from power plants to electric customers and has two major components. The first component is the transmission system, and it is made up of high voltage power lines that transport electricity from power plants and renewable energy farms to electrical substations located throughout the state. The ERCOT system has over 40,000 miles of electric transmission lines operating between 69,000 Volts and 345,000 Volts. In general, transmission lines operating at higher voltages can carry more power (refer to "B. Transmission" in Figure 1).

At electrical substations, high voltage power on the transmission system is lowered and delivered to electric customers across the second major component of the grid called the distribution system. In urban areas, some distribution systems can operate at voltages as high as 35,000 Volts but most distribution systems in ERCOT are designed to operate at 25,000 Volts or 12,500 Volts. (refer to "C. Distribution" in Figure 1). The voltages are reduced further by distribution service providers to less than 500 Volts to provide single or three phase service to retail loads.

Level 1 Electric Vehicle (EV) charging systems require the common 120 Volt plug, while Level 2 EV charging requires 240 Volt service (like most household electric clothes dryers, electric ovens and other large appliances). Distribution lines serving Level 3 Direct Current Fast Charging (DCFC) stations need to have three separate wires or phases to carry power (at larger capacity) and a neutral or ground wire on the same pole or in the same conduit.

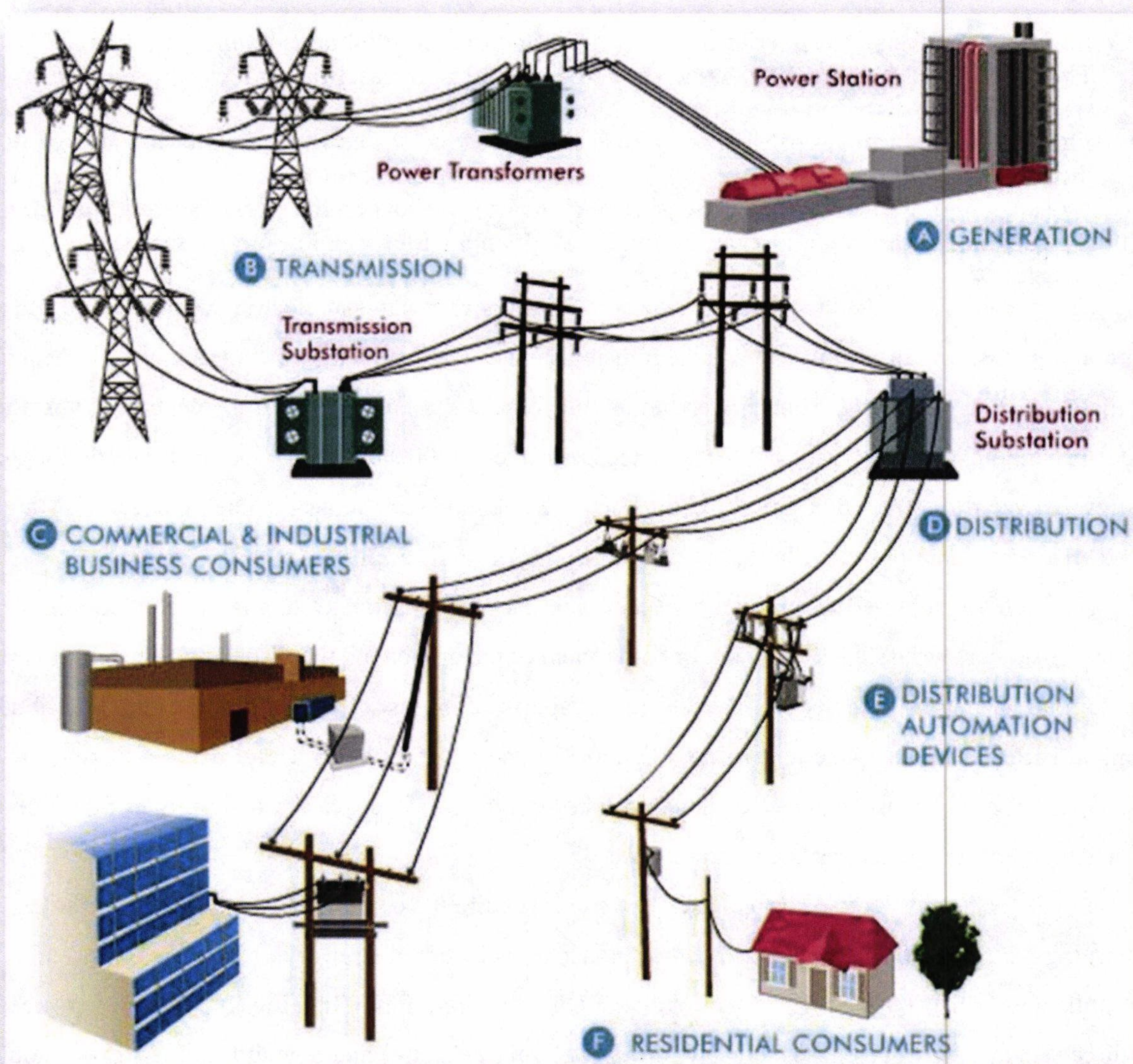


Figure 1

For EV charging at home, there are no insurmountable limitations in the distribution system. Upgrades to these systems may be required, but the incremental electric vehicle charging load is being offset to some degree by lower loads from more efficient LED lighting, home insulation, and HVAC load. The bulk power system and distribution systems have been repeatedly upgraded over the past century for new loads starting with basic lighting a century ago, then home kitchen automation, then TVs, and then with air conditioning. Utilities have been very adept at upgrading circuits over time. If there is clustering of PEVs on a distribution transformer, the local utility can upgrade the transformer and maybe the circuit, but there is no technology breakthrough required. However, a common set of tools and processes should be developed for collecting EV charging information and determining these impacts. Utilities can apply more cost-effective alternatives to the required upgrades including demand response, intelligent charging, re-distribution of load across feeders, etc.

The impact that DCFC stations will have on the grid will be different for light duty vehicles (LDVs) such as cars than heavy-duty vehicles such as trucks. The impacts to the grid will also vary based upon the number of DCFC stations in a particular location and the charging time for the vehicles.

A DCFC station will connect to the local distribution system in the area through a series of devices which will need to be properly sized to meet the charging demand (see Figure 2). A DCFC station with six 50-kW chargers would have a peak demand of 300 kW and a station with six 150-kW would have peak demand of 900-kW. For comparison, a large travel center or truck stop may have a maximum demand of 500-kW and a large retail store may have a demand of 1,000 kW. The City of Luling, located on IH-10 between San Antonio and Houston, has a population of 5,878 and has a peak electric demand just over 12,000 kW (or 12 MW). While the addition of DCFC stations are significant, large spot load additions are not uncommon in Texas. Examples of large load additions in the state in recent years include natural gas compression stations, oil rig pumps, LNG plants, and computing/data centers.

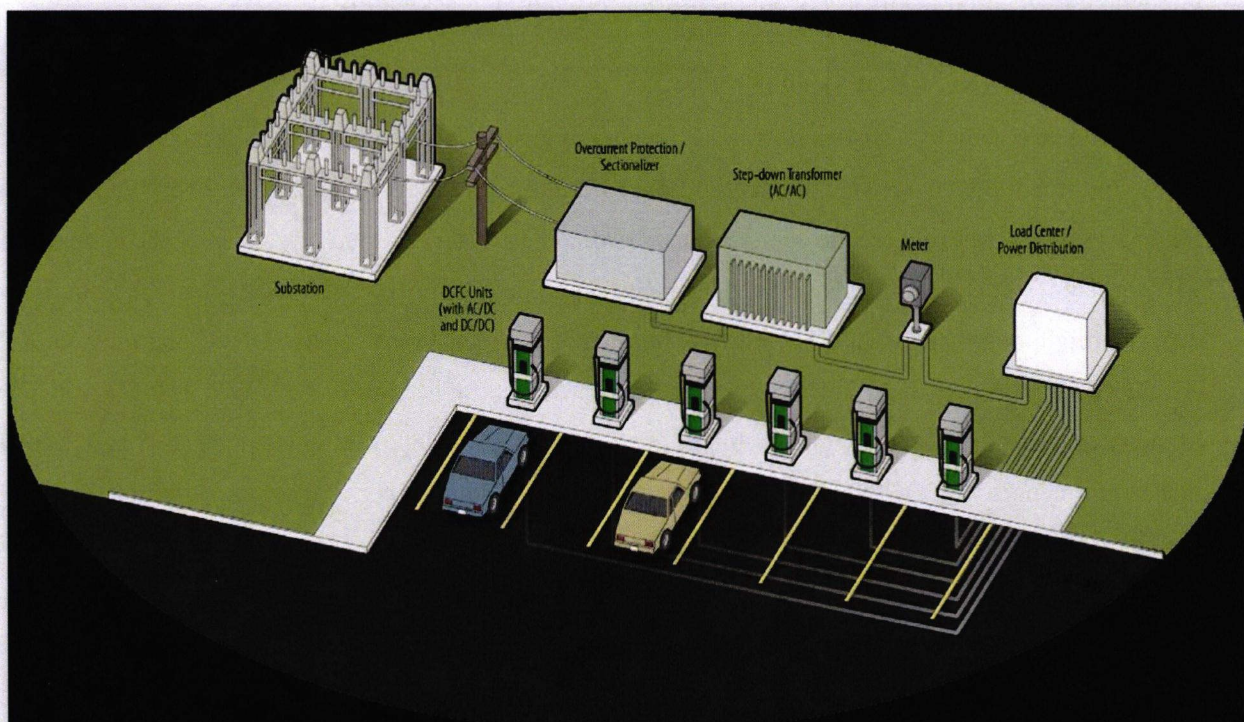


Figure 2

As noted previously, in some areas, individual Level 1 and 2 charging has minimal grid impacts. In older or smaller capacity feeders, there may be a need to change transformers and cabling for EVs as well as for distributed generation and other customer needs. Stations with multiple high power DCFC can present challenges to the distribution system in some cases. Typically, these deployments will require some distribution system upgrades to deploy including transformers and conduit. In some locations, the local substation may need to be upgraded. When siting DCFC stations an analysis of the power availability should always be an early step and a requirement for applicants.

Smart EV charging equipment often has charge management capabilities. Utilities and/or retail electric providers can develop programs to utilize the ability to curtail load from participating residential customers charging to help mitigate grid impacts in certain circumstances. EV charging infrastructure developers should inquire with the site's electricity provider to learn about and use any such programs. In the case of DCFCs, electric providers may send price signals to discourage charging during tight supply conditions. DCFC will typically be installed by owners who have Commercial and Industrial (C&I) tariffs. These C&I tariffs incorporate peak kW demand charges as well as kWh energy charges. These peak kW demand charges create an incentive for the DCFC to reduce peak grid stress by managing the charging or installing behind-the-meter battery storage. For all levels of EV charging, the grid operator may also implement load curtailments to EV chargers prior to a rolling blackout event.

FLEET CHARGING REQUIREMENTS

Electric vehicle fleets such as those being announced by Amazon and UPS have a higher impact on the grid than low charge rate residential Level 1 and 2 distributed vehicles. A delivery van depot with Level 2 – 240V service where the vehicles sit for several hours at a time and can "top off" the battery charge will not require a dedicated 3-phase (large capacity) upgrade. The next level of short-haul medium to heavy duty overnight depot including large buses ("Municipal" services) may require DCFC charging since they are likely to drain their batteries in the course of the day and will require 50 kW to 150 kW (or higher) capacity chargers. A fleet of 30 such vehicles in a single charging depot amount to close to 5 MW of power. The largest depots with DCFC charging systems in excess of 250 kW per charger, or Hot Spots, can require their own distribution substation similar to those required by large industrial consumers (see D. Commercial and Industrials in Figure 1).

The impact of the larger depot and regional/long haul DCFCs on both the transmission and distribution system is not very different than the impact of other industrial loads. Demand tariffs and feeder extension charges may apply to these customers to recover the incremental cost of the grid. Utilities (TDSPs, Munis and Coops) perform the required studies to determine the capacity of the local grid and the ability to support the new loads. To the extent significant and long-lead upgrades are needed, the local utility provides the estimated impact to the customer and, in turn, the customer can decide if an alternative location is more appropriate. Utilities can also forecast their light-duty distribution feeder growth for EV charging at homes and businesses, and they can then "aggregate" all of the large DCFC, Hot Spots, and distribution feeder growth and provide its projections to ERCOT (or other independent organizations as appropriate)

Through its Regional Planning process, ERCOT can work with multiple Utilities in determining the need and timing for large transmission upgrades, if required. The costs associated with upgrades would be treated in the same manner other T&D investments are treated to serve small and large electricity consumers.

In order to provide a comprehensive estimate of the overall impact of large DCFC installations on the grid including loads from medium/heavy duty electric vehicles, **TxETRA recommends** a study be directed by the Commission. Texas utilities can provide their individual forecasts for the integration of DCFCs, and the regional organization (such as ERCOT and SPP) can perform the data aggregation and the studies required to determine the overall impact on the reliability of the system and the ability to serve incremental load. Given the ERCOT market, DCFC depots that require day-time charging may be incented to avoid high demand (transmission) and electricity charges, so a careful review of the anticipated behavior of on-peak vs. off-peak charging is also important.

TxETRA also recommends the Commission request that TDSPs work with providers of proposed electric charging stations to identify where the grid is adequate to handle the additional load for DCFC fast charging stations for light duty charging depots (in the 5 MW range) and heavy duty charging depots (in the 10-20 MW range) along the highways of interest. These developers of highway charging depots can then review optional interconnecting sites where charging drivers have reasonable proximity to amenities such as restaurants and other roadside attractions before making a final decision. The proximity of the charging depots to the substations where the grid can handle incremental loads will also reduce the impact of long-distance transmission or distribution lines and/or reinforcements to existing ones due to poor siting decisions.

Standard practice by utilities is to provide information for siting decisions to EV infrastructure developers to help guide their siting decisions and to avoid the cost of line extensions.

QUESTION #7

What is the overall anticipated impact of electric vehicle charging in the next ten years in terms of energy and peak demand? What changes, if any, should be made to energy and peak demand forecasts to incorporate this impact?

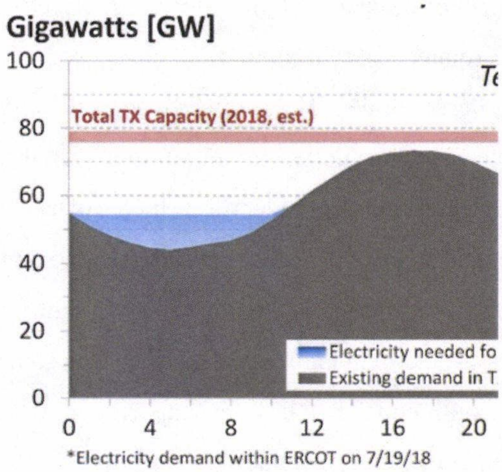
As discussed above, a moderate incremental EV charging load is being offset to some degree by lower loads from more efficient LED lighting, home insulation, and HVAC load. In the extreme of all passenger cars in Texas being electrified today, approximately 110 more terawatt-hours of electricity consumption would be added – that is a 30% increase over the current consumption in Texas.[33]

Because of the coincidence of peak demand with air conditioning load, the Texas grid has excess capacity during off-peak hours of the day. If price signals created by the right regulatory structures cause EVs to be charged during off-peak hours, the Texas grid could be served without incremental generation capacity. As shown in the summer demand profiles below, Texas uses about half of its generation capacity of roughly 82.4 GW to serve demand in early morning hours while it uses most of that capacity to serve demand between 3 and 7 pm. The large daily and seasonal variations in electricity demand means the state has power plants that sit idle throughout many hours of the year.

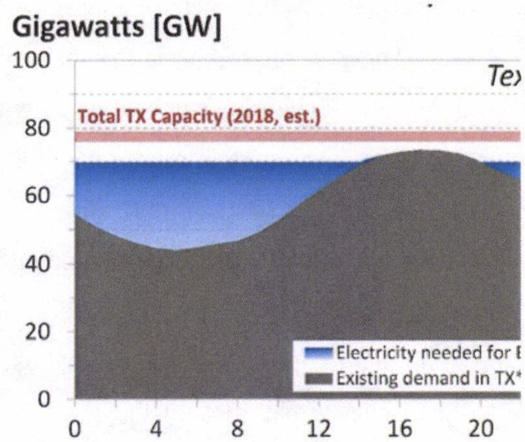
[33] *Switching to electric vehicles could save the US billions, but timing is everything.* December 4, 2018. https://theconversation.com/switching-to-electric-vehicles-could-save-the-us-billions-but-timing-is-everything-106227.

The charts show how large percentages of EVs (from 25% to 100%) could be charged during off-peak hours provided the charging times are not coincident with peak demand hours. [34] Electrification of transportation offers load growth to utilities. This is typically good for utilities and their

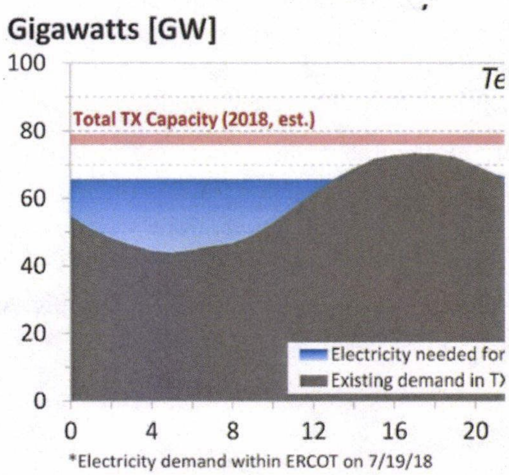
25% electric vehicles



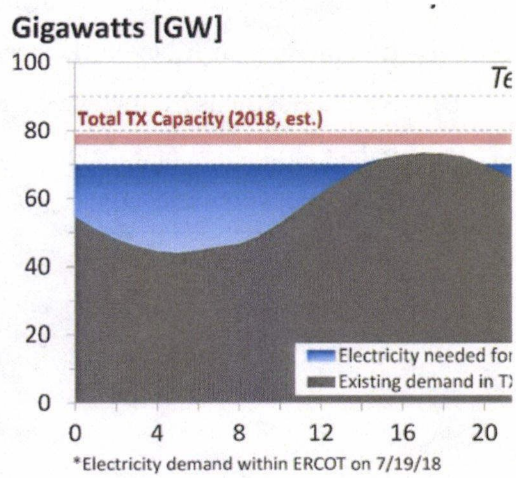
75% electric vehicle



50% electric vehicles



100% electric vehicle



customers as it increases revenues and allows the cost of fixed assets to be recovered over a larger base of consumption. What makes the most sense financially is load growth without increasing capital equipment expenditures (CAPEX) or additional fixed costs. This can be done when load growth occurs when there is excess supply of inexpensive generation and spare T&D capacity. Electrification of transportation offers

[34] Todd Davidson, Dave Tuttle, Joshua D. Rhodes and Kazunori Nagasawa, *A Tale of Two Grids: How California n and Texas are Preparing for the EV Revolution*, December 11, 2018, GreenBiz. https://www.greenbiz.com/article/tale-two-grids-how-california-and-texas-are-preparing-ev-revolution.

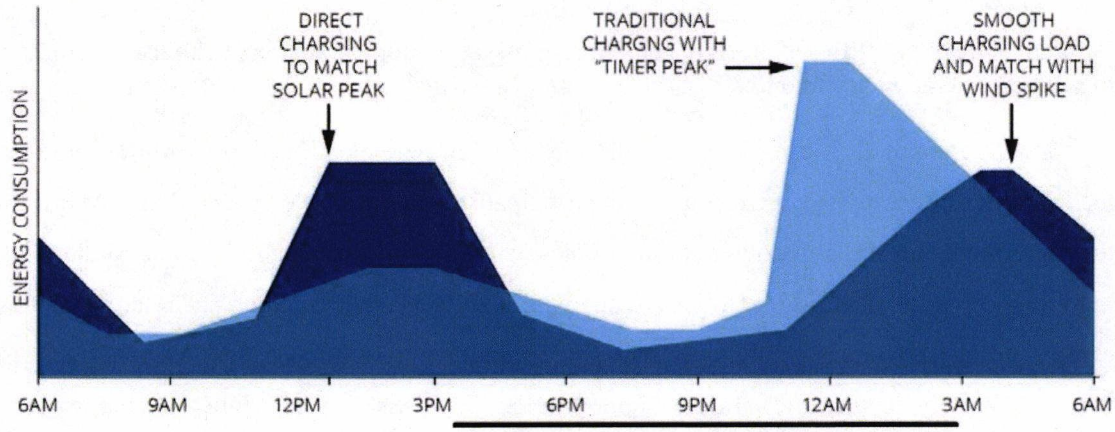
this possibility. Typically, peak demand determines the equipment that must be installed. However, T&D and generation assets are then underutilized during off-peak hours. This leads to underutilization of the existing capital assets and hence increases the cost per unit of electricity. The portion of a customer's bill that is related to fixed costs could decrease if electric vehicles are charged off-peak and do not require incremental CAPEX. The fixed costs would then be spread over greater kWh sale, potentially lowering consumer costs. In this scenario, the fixed assets are better utilized and thus more cost effective.

The portion of the customer's bill that is related to (variable) fuel costs might not increase meaningfully if charging can be aligned with low wholesale prices. Those lower wholesale cost savings are passed on to customers in retail rates. ERCOT is experiencing increasing amounts of variable renewable generation that can serve more flexible loads such as electric vehicles. Electric vehicles offer the possibility of a new and unique large, flexible, and intelligent load. Managed charging does not require a technological breakthrough. Because charging load is flexible, it can be optimally deployed by AI equipped chargers programmed to optimize based time of use (TOU) rates and demand response (DR). The same equipment could discharge batteries to the grid. TxETRA recommends that utilities experiment with intelligent charging to better understand the charging patterns and customer response.

To summarize, intelligent charging can:

- improve grid economics by achieving higher utilization rates, and therefore capacity factor, of transmission, distribution and generation assets;
- reduce emissions by aligning charging with surplus renewable generation;
- reduce grid stress and maintain grid stability by incorporating a new type of large, flexible and intelligent load reducing the strain on distribution transformers; and
- reduce the need for new peak generation and distribution capacity resulting from EVs charging during peak hours and taking advantage of vehicle-to-grid capabilities in the coming years.

An example of these benefits is shown below in Figure 1.



Hour Charging

Figure 1. Opportunities for managed charging to meet grid needs (illustrative)[35]

It may be illustrative to size the opportunities for Texas. A first rough estimate of the scale of the opportunity can be highlighted with the following examples.

1. Home charging typically happens at 7kW. When 1 million EV drivers come home from work and hook-up their EV between 5 and 7 pm, they could potentially contribute to peak demand by as much 7GW. This would be a worst-case to illustrate the order of magnitude. EV charging at peak cuts into reserve margins. 2 million EV drivers will consume more than the current ERCOT reserve margins. ERCOT expects 3 million vehicles on the road by 2030 and it expects that approximately 5 to 6 GW of charging demand was expected for hours ending 1600 through 1800 in what is referred to as a high penetration scenario.[36]
2. Demand from a complete electrification of transportation is expected to add about 30% of load[37], or 20+GW for Texas most if which can be handled with the existing amount of generation when charging is managed.

In order to provide a comprehensive estimate of the overall impact of electric vehicle charging on the energy and peak demand forecasts, **TxETRA recommends** a study be directed by the Commission. Texas utilities can provide their individual forecasts for the integration of electric vehicles in the next ten years in terms of energy and peak demand, and the regional organizations (such as ERCOT and SPP) can perform the demand and energy integration studies required to determine the system impacts.

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[35] Smart Electric Power Alliance, 2017. Utilities and Electric Vehicles – The Case for Managed Charging. April 2017.

[36] ERCOT, 2018. 2018 Long-term System Assessment for the ERCOT Region, December 2018.

[37] *Switching to electric vehicles could save the US billions, but timing is everything*. December 4, 2018. https://theconversation.com/switching-to-electric-vehicles-could-save-the-us-billions-but-timing-is-everything-106227.

QUESTION #8

What are the capabilities of electric vehicle related technologies, such as vehicle-to-grid, to participate in wholesale electricity markets?

EV technologies can participate directly in wholesale electric markets to the same extent as any load resource or energy storage resource can participate in wholesale electric markets. At this time, though, the opportunity for direct participation in wholesale electric markets is limited due to the relatively small number of EVs and charging facilities located within ERCOT, their smaller size relative to other loads and energy storage resources, limitations that some manufacturers impose on EVs (such as discharging a vehicle's battery to the grid), limited opportunities that exist in the wholesale market for aggregated distributed energy resources to participate, and limited economic signals that can support participation in wholesale electric markets by EV technologies. As a result, while the potential participation of EV technologies in wholesale electricity markets is a broad issue that the Commission should keep an eye on and work to address with ERCOT in anticipation of the future growth of EV technologies, it is not an issue that should distract the Commission from focusing on areas in which EVs have a real opportunity to benefit the electricity market today or in the very near future.

Today, EV technologies in other jurisdictions across the country support the distribution grid as a flexible load resource that can shift their consumption from the electric grid quickly and strategically.[38] As discussed above, these technologies have the potential to be more flexible in their demand response capabilities than many other load or energy storage resources. The opportunity to provide these demand response and load shifting capabilities can be supported by direct signals to EV chargers (active smart or managed charging), as well as with well-defined time of use pricing (passive smart or managed charging).

The Commission and ERCOT should be forward-looking to consider the ways in which EV technologies may be able to participate in the wholesale market so that the predicates can be established that are necessary to allow these technologies to support reliable operation of the electric grid. Enabling such participation also has the potential to provide additional revenue that can make these vehicles and their charging stations more affordable – to residential consumers, business customers with fleets of light duty vehicles, large commercial customers with medium and heavy duty electric vehicles, and even governmental entities such as school districts with fleets of electric buses. The Commission and ERCOT should develop the rules and protocols necessary to enable the aggregation and deployment of these EVs and their charging stations to provide demand response. In other states, aggregated demand response provided by EVs already is being dispatched by the grid operator on a regular basis, however this has been

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[38] *See, e.g.*, Julian Spector, EMotorWerks, *Is Using Its Network of 10,000 EV Chargers to Bid Into Wholesale Markets*, Greentech Media, Sept. 25, 2018. https://www.greentechmedia.com/articles/read/emotorwerks-wholesale-markets-ev-charger-network.

relatively small in scope.[39] In the longer term, this participation may expand to include the discharge of stored energy to meet market needs (V2G).[40] In any event, though, as the Commission considers these issues, it is important to recognize that technology and related capabilities already are and will continue to rapidly evolve. Thus, longer term projections – more than 5 years – may be too speculative to support major policy or wholesale market reforms.

1. EV Technology and Demand Response

A key opportunity for EV technology to participate in wholesale markets is as a demand response resource. In many instances, the time for charging an EV will be flexible, and the opportunity to aggregate EVs and exercise control over their charging may be similar to air conditioning management programs provided by retail electric providers and other load serving entities. However, EVs are not like air conditioners since they are mobile, and their charging needs do not necessarily correlate to weather patterns in a region. They also can be more flexible in their operation than an air conditioner. An EV owner who drives their EV from home to work and parks the vehicle at their office generally will not be as concerned about when the EV is charged during the day as much as the state of charge at the end of the workday when they drive home. This flexibility provides a significant opportunity to modulate the times of charging for demand response purposes.

A key limitation in the potential participation of EV technologies (as well as all other load resources and smaller energy storage resources) in the wholesale electric markets is the continued difficulty to aggregate and offer smaller resources into the market for demand response. ERCOT previously considered the issue of how load could be aggregated and bid into the wholesale market.[41] At this time, though, only loads aggregated by a single load serving entity, such as a retail electric provider, municipal electric utility, or electric cooperative may be bid into the wholesale market.[42] To date, no such entity has managed to comply with ERCOT's processes to make this work. Not only does ERCOT need to enable these current load serving entities to successfully aggregate and bid these resources into the wholesale market, but also enable third party aggregators to aggregate and bid their resources into the wholesale market.

For EV technologies, the difficulty to meet ERCOT's current requirements may be even more difficult since the individual resources are mobile and likely will not be located in the same place throughout a day. A more flexible approach, both in terms of who can aggregate these resources and their locations, will be necessary to enable their integration into the wholesale market.

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[39] *Id.*

[40] Jonathan Coignard, et al, *Will Electric Vehicles Drive Distribution Grid Upgrades?* IEEE Electrification Magazine (June 2019) at 49-50 (https://ieeexplore.ieee.org/document/8732007).

[41] This issue was considered by the Demand Side Working Group in 2011-2014.

[42] See NPRR 555, Load Resource Participation in Security-Constrained Economic Dispatch (adopted July 3, 2003). http://www.ercot.com/mktrules/issues/NPRR555.

Even in the absence of participating in ERCOT's wholesale markets, though, aggregations of EV technologies may be used to benefit load-serving entities directly in the same way these retail electric providers, municipal electric utilities, and electric cooperatives already aggregate customer loads like their customers' air conditioners to provide demand response as a hedge to reduce their energy procurement obligations during system peak demand conditions. Smart charging technologies that have communications capabilities are able to enable these strategies in a cost-effective manner.

2. EV Technologies Providing Energy to the Electric Grid

As discussed above, there are a number of pilots underway to evaluate the potential for EVs to directly support reliable operations of the wholesale electric market. There remain a number of practical limitations to develop these pilots in ERCOT, though. In addition to the inability to aggregate distributed energy storage resources and bid them into the wholesale market, a key impediment is the potential that discharging an EV's battery for purposes other than to operate the EV may void a manufacturer's warranty for the vehicle and its battery. At this time, the only consumer vehicle that allows this activity is the Nissan Leaf.[43] In the absence of a broader opportunity to pursue this with other vehicles, this will be a significant obstacle to harness this potential resource.

The relative size of different electric vehicles is another factor in the opportunity for EVs to support the electric grid. For example, as a practical matter, it may be more difficult to aggregate the number of consumer and light duty commercial vehicles to provide the same potential support to the electric grid as an aggregation of medium and heavy duty EVs. In the case of larger EVs that are parked at the same location during the day or night, such as school buses, the potential to aggregate the capabilities of these vehicles may be greatly simplified and enable them to provide services directly to the wholesale market. In the case of school buses in particular, these vehicles tend to have limited operation times in the mornings and later afternoons, and in the afternoon and evenings, these vehicles are parked and, other than ensuring a sufficient charge to serve their specified route, these vehicles can be available for discharge during the middle of the day, early evening and at night to address system needs as well as charging at night and other off-peak times to take advantage of abundant energy generated by renewable resources.

In addition to considering the opportunity to utilize the energy stored in EVs, there may be opportunities for energy storage enabled charging stations to participate in the wholesale electric market. These resources, which will be much larger than the batteries in individual vehicles, have the potential to participate in the wholesale energy market on the same terms as any other large energy storage resource as long as they balance their participation in the market with their need to support their charging functions as well.

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[43] The fact that Nissan will allow this activity is a key factor in supporting the development of EV to home programs in Japan.

A key benefit of the ERCOT market that will enable these potential uses to develop is its pricing transparency. This visibility can enable potential participants to evaluate the costs and benefits of potential strategies for participating in the wholesale electric market. Nonetheless, due to the technical challenges with V2G technology as discussed above, which likely won't be resolved in the near term, a focus instead on V1G technology and grid integration is appropriate, which can provide much of the value of V2G with current-state technology and less complication.

QUESTION #9

Please explain any preferred or best practice facilities siting and design standards for commercial electric vehicle charging stations and why such standards are recommended.

When siting locations for EV charging, one generally does not have to take into account as many regulations and code requirements as that of erecting a standard petrol fueling stations. Because electricity is present in almost every location around us, the availability to simply tap into these lines for EVSE infrastructure is easier and cheaper than it's ever been before. The availability of high-power lines along major traffic and highway corridors makes the implementations of potential Level 2 (240V) and DCFC infrastructure that much easier on the load capacity demands inside such territories.

In general the developer of an EVSE charging infrastructure project will want to account for future scalability, asset protection, signage and striping, in addition to having the location of such assets near other retail, eating and hospitality facilities with complimentary amenities. Layout design for traffic flow, and ease of access off interstates and highways is very important when choosing system design.

There are tiers of Level 2 and DCFC standard design packages that could affect the usage case for the customer. For instance, an energy provider would want to set up a site design for 10-12 350kW DCFC stations at each site as a standard, while a retail provider for a large box store may want to set up 4 50KW DCFC stations for their preference. Ownership of the charging station site may choose not to own, but pursue host agreements from EV and/or EVSE OEMs to lease their land out for charging, where the OEM/EVSE company in this case owns the equipment and takes all profit from usage and the site host gets paid a premium for the lease the land for the site. In this case, the EVSE OEM bares the capital cost burden of the equipment and cost of construction and electrical tie-in to the grid. Ownership and/or customers practicing these preferred standards maintain significant leverage as they will not only protect such owners from industry shortcomings, OEM bankruptcies and fallouts, but also help the public as more and more reliability and confidence finds its way to public charging standards.

Our EV adoption and growth curves yield load demand figures according to the amount of power needed to charge an EV for a single day based on the class and/or type of EV. For this instance, we've broken it down to reflect three different classes of EV with three different growth curve scenarios. Below are our findings, based upon the Projections for Electric Vehicle Deployment 2020 – 2030, presented in Question #1.

2020			
Scenario: IEA NPS			
Type	**Number of EVs**	**Per Day EV Charging (kWh)**	**Total Capacity (MW)**
Light Duty Vehicles	47,691	20	**95**
Buses	35	350	**1**
Trucks	65	600	**4**
Scenario: BNEF			
Type	**Number of EVs**	**Per Day EV Charging (kWh)**	**Total Capacity (MW)**
Light Duty Vehicles	55,606	20	**111**
Buses	212	350	**7**
Trucks	49	600	**3**
Scenario: SUV Analogue			
Type	**Number of EVs**	**Per Day EV Charging (kWh)**	**Total Capacity (MW)**
Light Duty Vehicles	53,714	20	**107**
Buses	212	350	**7**
Trucks	49	600	**3**

Now, given the 2020 power capacity demands we cross reference year by year.

DEMAND											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Scenario: IEA NPS											
	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)
Light Duty Vehicles	95	121	151	191	243	310	393	499	632	801	1,014
Buses	1	4	8	13	20	28	38	50	63	78	94
Trucks	4	12	25	42	63	89	120	157	198	245	297
Scenario: BNEF											
	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)
Light Duty Vehicles	111	165	236	353	524	758	1,068	1,480	2,015	2,713	3,605
Buses	7	23	47	79	120	170	229	298	377	466	565
Trucks	3	9	18	31	47	67	90	117	149	183	223
Scenario: SUV Analogue											
	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)	Total Capacity (MW)
Light Duty Vehicles	107	175	307	569	1,085	2,104	3,139	4,191	5,260	6,347	7,451
Buses	7	23	47	79	120	170	229	298	377	466	565
Trucks	3	9	18	31	47	67	90	117	149	183	223

When cross referencing the vehicle adoption and growth rates with the amount of power needed per vehicle[44] we can see the capacity requirements needed to sustain the grid. Analyzing year-over-year EV growth with technologies such as smart charging and demand management, Texas is in very good shape to support the additional loads placed on the grid by EVs. With smart charging and smart planning, coordinated with data and actions by our State's utility companies and policy makers, we can look to a bright future as EVs emerge in our everyday lives.

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[44] ERCOT's 2033 Long Term System Analysis June 2018 draft suggestions in its emerging technology scenario.

CONCLUSIONS

Electric Vehicles (EVs) are about to roll into Texas in a big wave. What can the Commission do to assure they are not inundated but surfing the EV wave?

- Chose anticipated growth projections of low, medium and high cases and analyze the impacts of the growth of EVs on the grid.
- Make suggestions for needed policy changes for the 2021 session.
- Continue to monitor and review the development of this technology and lessons learned in other jurisdictions after cost parity is achieved between 2022 and 2023, and the flush of the 200 plus anticipated new EVs hit the market between now and 2023, and discuss new policies and make recommendations to the legislature in 2024.
- Plan another review of the growth in EV sales and technological changes as the market matures and trends become clearer later in the decade – perhaps in 2028.
- Discuss how to implement proven solutions to shift peak EV charging onto off-peak times through the use of demand management and time-of-use rate structures.
- Harness the research capabilities of Texas universities into a scientific advisory panel.

Additionally, the Commission should develop a common set of tools and processes for utilities to collect EV charging information and utilities should be asked to provide their EV forecasts in terms of energy and peak demand with any projected upgrades attributed to the growth of EV charging load. Utilities should be asked to analyze and utilize cost-effective alternatives to proposed grid upgrades including demand response, intelligent charging, re-distribution of load across feeders, development of distributed energy resources, and other cost-effective alternative strategies.

The Commission and ERCOT should consider ways in which EV technologies may be able to participate in the wholesale market so that ERCOT's protocols can be amended as necessary to allow EVs to use proven technologies to support reliable operation of the electric grid. Enabling such participation also has the potential to provide additional revenue that can make these vehicles and their charging stations more affordable – to residential consumers, business customers with fleets of light duty vehicles, large commercial customers with medium and heavy duty electric vehicles, and even governmental entities such as school districts with fleets of electric buses. The Commission and ERCOT should develop the rules and protocols necessary to enable the aggregation and deployment of these EVs and their charging stations to provide demand response.

Just as in surfing, the wise regulator will judge the wave as it presents itself and begins to crest and adjust course to always be just ahead of the crest.

Have fun.

Respectfully submitted,

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