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Benefit Cost Analysis For Electric Vehicle Adoption In The Delaware DPL Territory

Prepared By Gabel Associates, Inc.

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Acknowledgements

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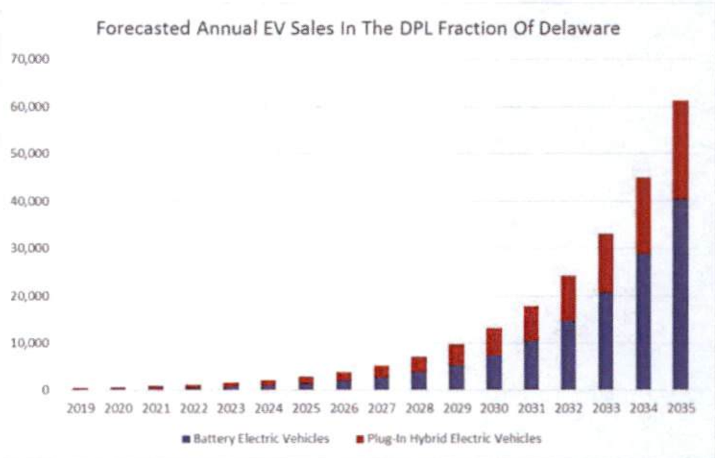
1 Executive Summary

The widespread adoption of Electric Vehicles (EVs) is an emerging trend that is expected to have a profound impact on both personal mobility and electricity markets and infrastructure. As EV use increases, consumers are projected to realize substantial benefits: non-EV owners will benefit from lower electricity costs, and reduced air emissions, while EV owners will realize substantial savings on vehicle operating expense. To both support and enable this opportunity, Delmarva Power and Light (DPL) is proposing a new program for its Delaware territory, with a focus on providing vehicle charging infrastructure, supportive new rate structures, and other innovations. These utility programs provide necessary support for the growing base of EV owners that are now using "electricity as fuel", and will also address known consumer adoption barriers to increase the use of EVs in the DPL-DE territory so that the resulting benefits can be realized by its customers.



This study quantified the projected overall benefits and potential costs of increased EV adoption in the DPL-DE territory, and estimated the NET benefit that will result using three different net benefit tests. The analysis covers the period from 2019 through 2035, and is based on a projection of EV adoption that reflects recent EV sales in Delaware and expected sales rates appropriate for the territory. The projected EV adoption rate achieves approximately 26% penetration of the light duty fleet by 2035. This transition is projected to eliminate the use of 310 million gallons of gasoline, add 2,152.3 GWhrs of electricity consumption, and avoid the emission of 2,076,234 tons of CO_2 over the period. An average Delaware household with one EV is projected to increase its electricity consumption by about 20.4%.

The study is based on detailed simulation of energy market response to EV-induced changes to aggregate load, analysis of DPL tariffs, billing determinants, and revenue requirements, and territory-specific research on travel, consumption, and charging behavior statistics. The resulting specialized model allows for detailed quantification of physical impacts arising from widespread EV adoption, including impacts on electricity use and the environment, while also estimating potential costs to allow for a NET benefit cost analysis over the study period.

In addition to detailed simulation and territory-specific modeling, the analysis considered the specific EV-support program being proposed by DPL for their Delaware customers. The study recognizes two motivations for the proposed utility programs: 1) serving a growing new need by consumers (vehicle charging) in a responsible way, and 2) addressing consumer adoption barriers to encourage higher levels of EV adoption and use. The proposed utility programs create infrastructure which is *needed* to ensure prudent utility accommodation of this new consumer load, and to facilitate realization of the expected benefits in an equitable way. These proposed programs are also *desired*, since they lower consumer adoption barriers, jumpstart increased EV adoption short term, and seed the market for long term growth so as to achieve the widespread EV adoption that benefits for utility customers (and others).

Key conclusions from the benefit analysis (without consideration of cost) include:

- EV-induced benefits are substantial: When considering the broad range of benefits that result from increased EV use, **Delaware residents in the DPL territory will realize a total savings of $996M over the period (nominal sum of recurring annual savings), with an NPV of $478M. This study makes clear that benefits are realized by utility customers that do not drive EVs through lower electricity costs, society at large benefits through cleaner air, and EV owners benefit from reduced vehicle operating expense and federal vehicle purchase incentives.**

- Electricity costs are projected to go down for all utility customers: Electricity rates (including basic wholesale supply, capacity and transmission costs, and utility distribution costs) for ratepayers are projected to go down due to increased EV use. These cost reductions are a result of a) increased overall electricity consumption (which dilutes fixed costs), and b) reductions in wholesale prices due to the fact that most EV charging will be at night during lower-cost off-peak times. **Savings for ratepayers are projected to total $326M over the period (nominal sum of recurring annual savings), with an NPV of $170M.** These savings accrue to utility customers that don't own EVs and EV drivers alike.

- Vehicle operating costs are expected to drop by about half: EV drivers will realize significant savings through reduced operational expense on a recurring annual basis. **In 2019 it will cost approximately 11.95 cents/mile to fuel an average traditional vehicle with gasoline, compared with approximately 6.16 cents/mile for EVs (for both BEVs and PHEVs, blended results) – a reduction of about 48.4%.** Reduced fueling costs, plus lower maintenance costs, are projected to deliver an estimated $1B in vehicle operating expense savings for EV owners (nominal sum of recurring annual savings), with an NPV of $474M through 2035. Widespread EV adoption frees up disposable income for Delaware households, and is expected to pump additional revenue into the local economy rather than importing petroleum products.

- Widespread EV use reduces air emissions, which has economic value in addition to its positive impact on the environment and public health: The study quantifies the NET change in air emissions that result from EV use, considering the reduction in tailpipe emissions net of increased power plant emissions due to increased electricity use. Key greenhouse gases such as CO2 reduce substantially, so that each electrically fueled mile is projected to have 63.8% less CO2 emissions per mile than an average gasoline fueled mile (in 2019). Other key criteria pollutants, especially NOx which has a direct impact on public health, also decline, with a 15.4% reduction projected over the period. There is value in the reduced air emissions that result from fueling with electricity rather than gasoline. **Society will realize a projected $269M in savings through 2035 (nominal sum of recurring annual savings) due to avoided emissions (especially CO2, and NOx), with an NPV of $124M.**

- EV charging will change loading on the grid, potentially to the benefit of all utility customers. By displacing gasoline use with electricity through vehicle charging, there is projected to be a significant increase in electricity consumption over time. Much of this charging will be done in a residential setting overnight. **By 2035, 21.6% of all light duty vehicle miles driven are expected to be "electrically fueled", which for that year will reduce gasoline consumption by 82,369,166 gallons, and increase electricity use 572,058 MWhrs.** Since this is a large load, and since the timing of those loads can be influenced to happen at optimal times (see managed charging below), these changes represent a profound opportunity for load optimization and improved asset utilization (of all types) – both of which reduce electricity costs as noted above.

- **Managed charging is a unique opportunity to ensure and maximize EV-induced benefits, but requires active measures to achieve.** Most vehicle charging will be done at home, but EV drivers could charge at any time of the day. In a worst case scenario, if all drivers "plug in" as soon as they get home from work, vehicle charging could introduce significant new load at the worst possible peak time, resulting in higher electricity costs for all consumers. There is a natural bias, however, for residential charging to happen overnight, and there is some flexibility in when that charging happens – so long as the vehicle is fully charged in time for use the following morning. While optimal charge scheduling is not a natural consumer behavior, utility sponsored programs can be implemented to encourage optimal charge scheduling – referred to in this document as "managed charging". Managed charging implies conditions where the start of residential charging is deferred until after peak time, *and* vehicle charging is spread out over a full eight hour period over-night. Under scenarios where this type of managed charging is dominant, EV induced load increases during the PJM-coincident peak are expected to be modest: **vehicle charging adds a projected 0.263 MW of load at peak time in 2019, growing to 36.549 MW in 2035. The fact that charging-induced electricity consumption increases significantly, while peak loading increases only slightly, implies a significant increase in the capacity factors for both the generation base and infrastructure (transmission and distribution), and a much flatter aggregate load profile with more consumption in off-peak periods. This outcome is a key driver of the economic benefits outlined above, along with the dilution of fixed costs as detailed further below, and is especially important since it applies to all electricity consumers.** To achieve this outcome, however, managed charging programs must be implemented to encourage optimal consumer charging behaviors. Longer term, managed charging programs could evolve to more sophisticated vehicle to grid (V2G) programs that deliver additional economic advantage by using EV batteries to shave peak load and reduce electricity costs further.

- **Benefits induced by widespread EV use outweigh potential costs, and those benefits accrue to all utility customers, society at large, as well as EV owners.** Potential costs associated with widespread EV adoption were quantified as part of the study, including the costs of the proposed DPL-DE program for infrastructure deployment, the costs of potential long term grid reinforcement that may be required, and investments made by others as part of EV use, including both vehicle purchase premiums and charging infrastructure investment. These benefits and costs were used to determine a NET benefit using three merit tests, each of which combines benefits and costs differently to provide a range of perspectives on economic merit. The three tests were adapted specifically for EV market characteristics, and include a Rate Impact Measure (RIM), the Societal Cost Test (SCT) and the Total Resource Cost (TRC). All three merit tests demonstrate strong NET benefit, including both benefit/cost ratios greater than 1.0, and NET benefits (after considering costs) that are positive. A summary of key benefits, costs and NET impact are provided in the chart below[a].

[a] The benefits noted in this chart include the recurring annual savings for utility customers (through lower electricity costs), EV drivers (through lower operating expense), and society at large (based on the value of lower emissions), combined with the one-time benefits realized by EV owners through the federal vehicle purchase tax incentive.

Benefit/Cost Summary			
Total Benefits (NPV, 2019-2035):	$827,034,789		
Total Costs (NPV, 2019-2035)	$312,943,596		
	RIM	SCT	TRC
Benefit To Cost Ratio (based on NPV):	2.92	2.64	2.25
Net Benefit (benefit minus costs, NPV):	$112,058,830	$514,091,193	$390,544,344

The RIM test specifically considers benefits for all utility customers through lower electricity costs resulting from EV adoption as balanced by recovery of utility investments through rates. The positive RIM test results demonstrate that utility customers, even those that don't drive an EV themselves, realize savings from lower electricity costs that exceed investments being recovered by the utility.

In Conclusion: the study quantified benefits that apply across a broad range of populations, along with associated potential costs, so that NET benefit merit tests could be conducted. The detailed projections developed in the study demonstrate that benefits exceed costs, and that there is NET benefit across multiple stakeholder groups which justifies the utility programs being proposed. These benefits result from a broad portfolio of impacts including lower electricity costs for all utility customers, increased disposable income for Delaware households due to lower vehicle operating costs, and the multiple benefits of reduced air emissions. The adapted TRC and SCT tests demonstrate that society at large, and particularly residents within the territory, are better off as a result of widespread EV adoption even after considering a broad range of costs. More specifically, the RIM test demonstrates that utility customers realize lower electricity costs that offset proposed and potential investments that would be recovered by the utility through rates. These results demonstrate that the proposed utility programs directly benefit DPL-DE customers (in addition to EV owners), and that the public interests are well served by approval and implementation of the proposed programs.

2 Introduction

The widespread adoption of Electric Vehicles (EVs) is an emerging trend that is expected to have a profound impact on both personal mobility and electricity infrastructure. As EV use increases, a wide range of beneficial impacts are anticipated, including lower electricity costs, reduced air emissions, and substantial savings for EV owners. In response to this opportunity, Delaware Power and Light (DPL) is proposing a new program for its Delaware territory, with a focus on providing vehicle charging infrastructure, supportive new rate structures, and other innovations. These utility programs provide necessary support for the growing base of EV owners that are now using "electricity as fuel", and will also address known consumer adoption barriers to increase the use of EVs in the DPL-DE territory.

Exelon/PHI, DPL's parent, commissioned an in-depth study of the projected impacts of increased EV adoption, identification of specific benefits for a range of populations, and associated costs. The resulting benefit-cost analysis quantifies the NET benefit that results from widespread EV adoption in the DPL-DE territory, including consideration of the costs associated with the proposed utility program to support and encourage that level of EV use (among other factors). The study was conducted by Gabel Associates (Gabel), a consulting firm with well-established expertise in energy, environmental, utility, and policy research. The benefit-cost analysis builds on experience gained conducting similar studies in other jurisdictions.

This document summarizes the benefit-cost analysis, including methodology review, quantification of the benefits expected to result from the program, an inventory of potential costs, and formal net benefit-cost test results.

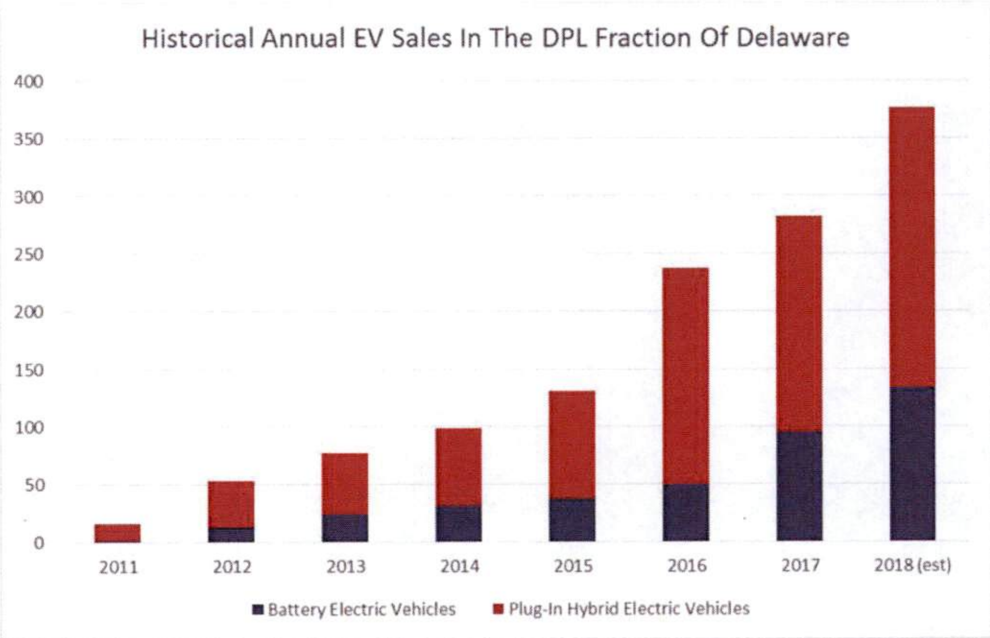
3 Electric Vehicle Adoption Forecast

The study is based on a forecast of EV adoption within the DPL-DE territory from 2019 through 2035. The forecast is based on historical EV sales in the territory[1], extrapolated over the period based on annual sales growth rates consistent with projected market conditions for the territory. The extrapolation accounts growth of the EV fleet through new sales, as well as vehicle retirements[2]. This forecast is the basis for all the impact and benefit analysis, and allows consideration of overall EV adoption impact, not just the impact of the utility program as a stand-alone entity. This approach is appropriate since the proposed utility program is impacting the market simultaneous with other developments that serve to increase EV adoption (lower vehicle costs, increasing vehicle configuration options, growing consumer awareness, etc.). The proposed utility programs are considered an important part of these market growth assumptions, however, since they directly impact key consumer adoption barriers (home charging infrastructure, especially in the challenging multi-family segment, increased public charging availability, improved consumer awareness, etc.)[b]. The proposed utility programs are necessary to respond to a new consumer need (vehicle charging), but also jumpstart EV adoption short term by lowering barriers, seeding the market for long term growth to ensure optimal and equitable realization of benefits across multiple populations.

[b] The proposed utility programs lower adoption barriers, in addition to establishing an important foundation in managed charging.

The forecast (and subsequent analysis) focuses on light duty vehicles (cars, and light passenger trucks such as SUVs) being displaced by "Electric Vehicles", including both pure battery electric vehicles (BEVs), and plug-in hybrid electric vehicles (PHEVs). Both vehicle classes "have a plug", and are able to store electricity in a battery or similar device from a source external to the vehicle. Vehicles "without a plug", such as traditional NON-plug-in hybrids, are not included. The analysis focuses exclusively on light duty vehicles, and does not consider medium or heavy duty vehicle electrification that may be occurring simultaneously.

The following chart summarizes recent EV sales within the DPL-DE region:

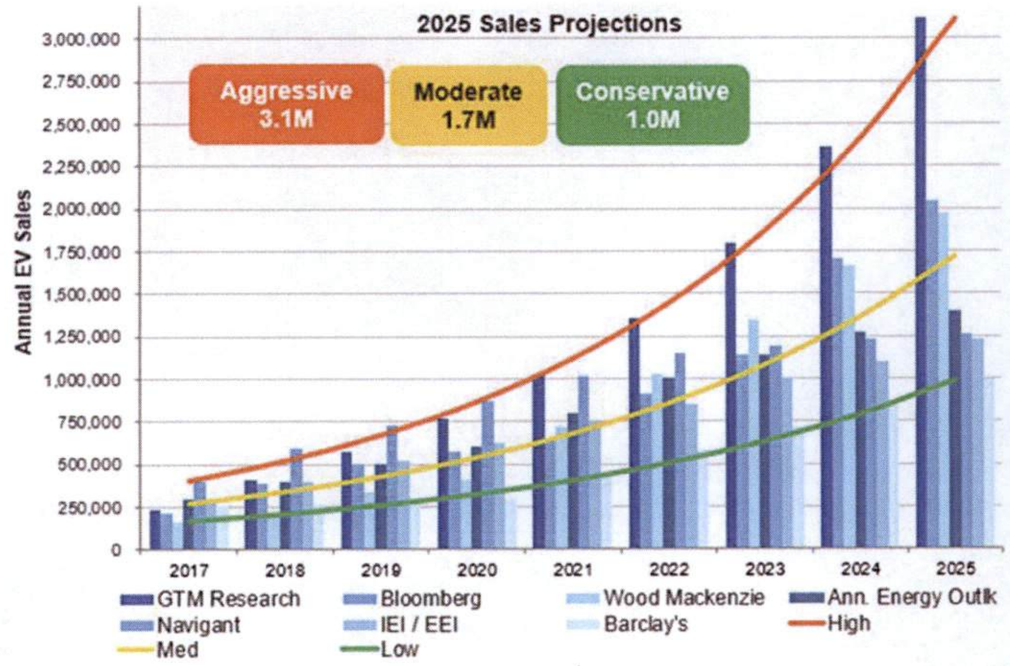


The forecast is based on the EV fleet size in 2018 projected at a 40% growth rate for BEVs, and a 30% growth rate for PHEVs, resulting in a blended growth rate of 34.9%[3]. These growth rates were selected based on consideration of a variety of market growth factors specific to the DPL fraction of the Delaware market:

- EV penetration on a per capita basis in Delaware has been significantly below the national average to date: there are 1.32 EVs per 1,000 residents in Delaware as of the end of 2017, compared with a ratio of 2.21 nationwide, and 8.9 for the leading state California. Leading ZEV states are typically in the range of 2.0 to 3.8 EVs per 1,000 people (as of the end of 2017).

- Despite that relatively small starting base, sales have strengthened recently. Delaware annual sales growth averaged 50.6% over the last two years. For reference, national EV sales demonstrated year/year growth of 36.6% in 2016, 25.9% in 2017, and 35.5% YTD 2018 (through April). These rates are the AVERAGE nationwide, with leading states demonstrating significantly higher growth.

- A wide variety of consulting and market studies have projected EV adoption long term, with estimates generally becoming much more bullish as the market matures. The following chart summarizes the range of projections, which reflect concurrence for "moderate" growth levels being approximately 25%.



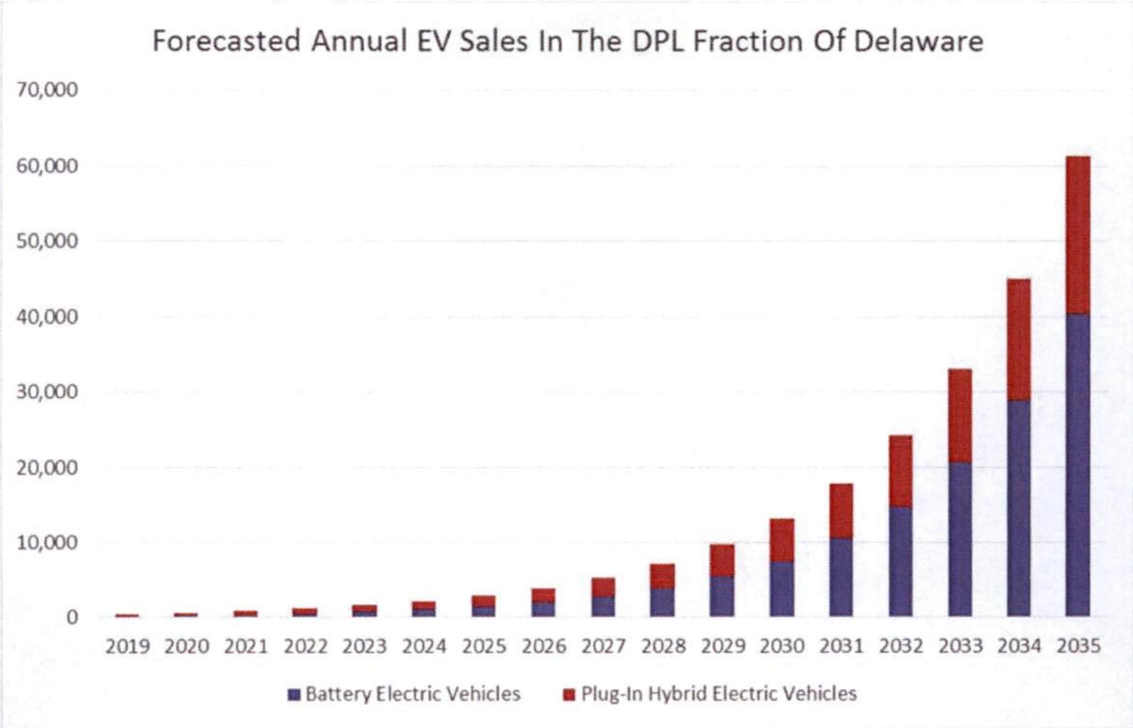
Based on analysis by Atlantic City Electric. Sources embedded in chart.

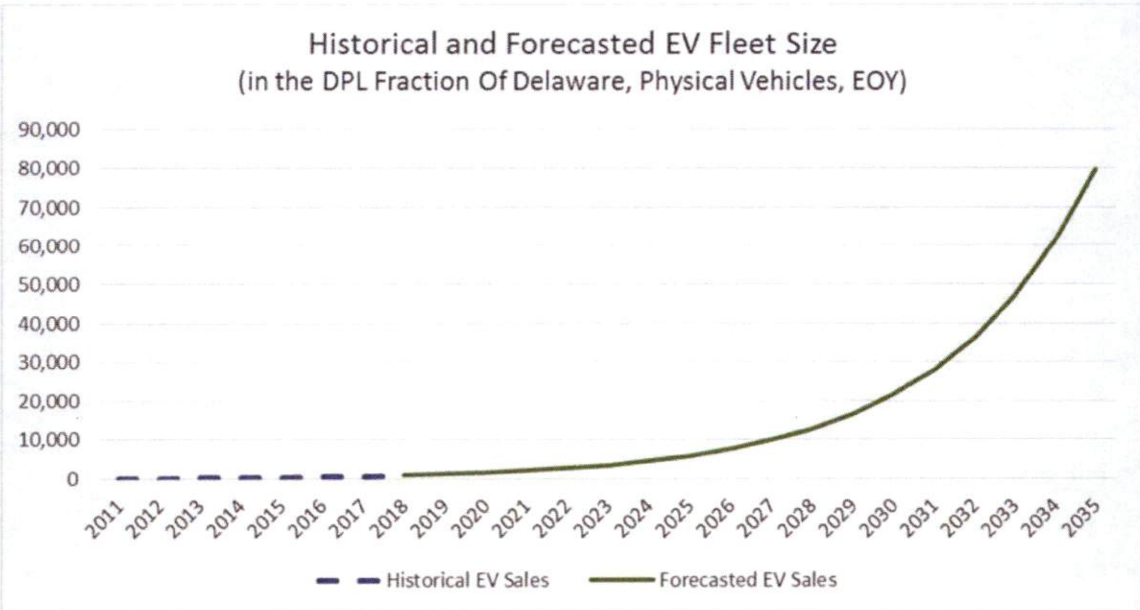
- Average median household income in Delaware is slightly above the national average ($61,017 averaged 2012-2016, compared with ~$57,00 for the U.S. overall (2016), U.S. Census Bureau), which is a positive indicator for strong EV sales. Other demographic factors are particularly strong for EV adoption: a) 92.7% of households have at least one vehicle[4], b) only 17.6% of homes are multi-family, and 70.9% of homes are owner occupied[5], and c) per-capita vehicle ownership is relatively high: 1.2 vehicles per person in 2015[6].

- Delaware has introduced incentives for both vehicle purchase and charging infrastructure, which have likely contributed to the recent increase in EV sales. If continued, and especially with the proposed utility program to provide additional incentives and reduction of market barriers, the recent strong annual sales rate are projected to be sustainable long term.

- Given this combination of factors, and assuming continuation of existing incentives and implementation of utility programs that lower adoption barriers, annual sales growth in Delaware is projected to remain above the national average. That results in the state starting with a relatively small base, but with strong growth long term (especially after 2025). These factors support the estimated growth rates of 40% for BEVs and 30% for PHEVs (34.9% blended rate).

The following charts summarize the forecasted EV sales for the DPL-DE territory and the resulting EV fleet size over the analysis period (after accounting for vehicle retirements)[c].





[c] If BEVs are a larger fraction of the vehicle mix, many of the benefits quantified in the following section will be slightly higher through elimination of occasional gasoline use by PHEVs.

4 Methodology For Measuring Impacts

Many of the impacts from EV use result from how vehicle charging impacts both electricity markets and utility infrastructure. These impacts have physical, economic, and environmental dimensions that can be quantified, in addition to broader strategic implications. The benefit-cost analysis is therefore based primarily on quantifying the net impact of displacing gasoline consumption with electricity use. The analysis is based on the following scope, methods, and assumptions:

1. **Analysis Period:** The study computes annual impacts for the years from 2019 to 2035.

2. **Territory**: The analysis is based on a forecast of EV adoption within the DPL-DE territory over the analysis period, building on a) historical sales of EVs in the territory, and b) expected sales growth as already evident, as reinforced by a variety of positive market developments that are expected to encourage EV adoption growth, including the utility programs being proposed. Section 3 provides details on the EV forecast that is the foundation of the study.

3. **Delaware Market Conditions:** The EV forecast is translated into a variety of statistical models that quantify vehicle use and energy impacts. These models are based on market research for the DPL-DE territory, and reflect customer behaviors and market conditions specific to that territory, including vehicle characteristics (energy efficiency), travel patterns (average miles per day, etc.), charging schedules (where EV drivers charge, and when), baseline electricity consumption patterns, cost factors, etc. *This EV impact study is therefore based on modeling details that are tuned to the DPL-DE territory to the greatest extent possible.* In cases where territory-specific data was not available, regional or national statistics were used.

4. **Charge Schedule:** The impact that EV charging has on electricity markets and utility infrastructure, with the associated physical, environmental, and economic benefits (as detailed in the sections below), depends heavily on WHEN the charging occurs. The analysis assumes "managed charging" schedules, since the utility programs are intended to encourage vehicle charging at optimal times. The loading profile for vehicle charging is based on a detailed market model with six segments (private residential, multi-family residential, workplace, fleet, public corridor charging, and public community charging) and time-of-day usage profiles provided by industry and various studies regarding vehicle charge scheduling. The Managed Charging profile assumes that most residential charging responds to programs intended to encourage optimal charge scheduling, including a) deferral of the start of charge until after peak hours, and b) spreading vehicle charging loads out over an 8-hr period overnight. The utility program being proposed provides for an early implementation of programs to encourage optimal charge scheduling, a mix of solutions to allow learning about which offers work best with consumers, and establishes a foundation for more advanced managed charging programs medium term.

5. **Impact Modeling:** These input statistics are combined in a specialized model that quantifies physical and economic impacts, as described more completely in Section 5:

    a. Physical impacts include gasoline displacement, changes in energy use (MWhrs, PJM-coincident peak), implications for PJM generation requirements, and NET changes in emissions of CO_2, NOx, and SO2. These emission changes account for the NET impact of reduced tailpipe emissions and increased emissions associated with electricity generation induced by vehicle charging. Power plant emissions are determined through the PJM dispatch simulation described below, which aggregates the projected emissions, asset by asset, hour-by-hour, over the year as required to meet the load[d]. *This analysis is therefore based on very granular simulation of actual plant dispatch with known emission rates, rather than using more general gross emission factors.*

    b. Economic impacts are examined from three perspectives: changes in electricity costs as seen by all ratepayers, reduced operating expenses for EV owners, and the societal value associated with reduced emissions, as described in more detail below.

6. **Electricity Costs:** Determining how EV charging affects electricity costs is a primary focus for the study, and is achieved through a comprehensive model that examines wholesale market impacts, implications for capacity and transmission costs, and impacts on the distribution revenues collected by the utility. Both aggregate (total $, and total MWHR) and unit-cost impacts are quantified, which allows for determination of electricity cost changes that affect all ratepayers.

    a. **Wholesale Cost Impacts**[e]: EV charging, especially if done during off-peak times, changes the shape of the aggregate load curve. This modified load curve results in a change in the average wholesale cost of electricity since more electricity is purchased during lower cost, off-peak times[f]. Gabel forecasts these impacts based on a detailed asset dispatch simulation using AURORAxmp (AURORA). AURORA is an

[d] The simulation mostly assumes business as usual for asset dispatch. Increased use of cleaner sources, especially class I renewables, could make the benefit impacts quantified in this study even stronger. Note that the utility program proposal includes use of renewable energy for supply on some program elements, which is more advantageous than the "business as usual" assumptions conservatively used in the study.

[e] For the purposes of this analysis, "wholesale costs" reflect the raw "factory gate" price for generating electricity considering capacity factors, fuel sources and costs, marginal pricing, etc. Other costs that are also part of the wholesale market, including PJM ancillary charges, capacity costs, RPS costs, etc, are captured as part of the other electricity cost elements (either capacity and transmission, or bundled as part of the utility distribution costs). This structure is used because changes in average pricing affect only the raw generation costs, not necessarily other PJM costs in a similar way, and this approach ensures the most conservative, fair, and transparent impact assessment.

[f] EV charging creates a Charging Induced Pricing Effect (ChIPE) that is similar to the Demand Response Induced Price Effect (DRIPE) factor recognized for energy efficiency/demand response programs, although the market impact dynamic is very different. Optimal vehicle charging "fills the trough" in the aggregate off-peak load profile resulting in ChIPE, while demand reduction programs "shave the peak" to create DRIPE. The affects are similar, however in that the modified load curve changes the overall average cost of wholesale electricity.

industry-leading software and data package that simulates the hourly commitment and dispatch of electric generators to serve load, recognizing utility-level peak demand, transmission constraints, operational characteristics of generators, delivered fuel prices, emissions prices, etc. Gabel completed hour-by-hour market simulations using AURORA, for every year from 2018 - 2035. Total electricity costs ($ per year), average wholesale unit costs ($/kwhr)[g], and generation emissions (tons) are the primary outputs of the simulation. *Unlike other EV impact studies that depend on gross emission and cost-change factors, this study makes use of detailed market dispatch simulations specific to the EV adoption forecast and market conditions in the DPL-DE territory and PJM.*

b. **Capacity and Transmission Costs**: The dispatch simulation noted above computes the PJM-coincident peak for each year. Costs related to the charging-induced capacity (with reserve) and transmission requirements are computed based on forecasted cost factors for PJM capacity and transmission. See Appendix A for more details on capacity and transmission cost calculations.

c. **Utility Distribution Costs**: A detailed analysis of current DPL tariffs for the DE territory was completed, as well as analysis of significant information provided by the utility regarding distribution-costs and revenue requirements (see Appendix A for more details). The resulting distribution costs were projected forward using both utility and Energy Information Administration (EIA) statistics on distribution revenue growth to establish the utility distribution costs.

d. **Total Electricity Cost Impacts:** The PJM dispatch simulation and revenue requirement analysis summarized above allows the wholesale, capacity, transmission, and distribution costs for a given load profile to be determined for each year of the study period. This analysis is completed for both the baseline case without EVs, and the load profile under consideration including EV charging. Both the gross electricity costs (annual $) and the average unit cost ($/kwhr) are determined. The difference between the EV scenario and the baseline represents the impact on overall electricity costs. Overall electricity use (total MWhrs) goes up due to the increased electricity use associated with vehicle charging, but unit costs ($/kwhr) go down due to the combination of reductions in average wholesale unit costs due to more optimal loading, and dilution of distribution costs through increased MWhr volume. The combined economic impact of these considerations are summarized in Section 5.2.4.

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[g] This average unit-cost represents a load-weighted average across all times and locations, and is really a gross indicator for wholesale electricity costs. In a competitive market like PJM, those costs efficiencies are expected to eventually flow through to customers. How those savings are allocated to a particular customer class or tariff depends on wholesale market response and future utility rate case decisions, and so individual customer impact may vary by class or tariff.

7. **EV Operating Costs:** It costs less to "fuel" an EV with electricity than it does to fuel a traditional vehicle with gasoline. Furthermore, early market evidence suggests that EVs cost less to maintain due to the simplified drive train. These two factors combine to generate significant savings for EV owner/operators[h]. The fuel savings are computed based on a projection of electricity and gasoline prices, while maintenance savings are estimated based on results from an independent vehicle operating cost study on a per-mile basis. To ensure a fair comparison, an additional expense is assumed for EV owners based on replenishment of the infrastructure funding lost through avoided state and federal gasoline taxes. See Appendix A for more details on EV operating cost analysis.

8. **The Value Of Avoided Emissions**: Current levels of vehicle emissions impose significant costs on society through health care expenses, extreme weather damage, lost worker and business productivity, asset devaluation, etc. Although frequently considered an "externality", there is real economic value that accrues to society due to the avoided emissions enabled by widespread EV adoption. The study calculates the value of this avoided emissions (for CO_2, NO_x, and SO_2) based on social cost studies from independent sources on a per-ton basis. See Appendix A for more details on the economic calculations related to avoided emissions.

9. **Program Costs:** The utility is proposing a program that delivers equipment and services to participating customers to better support the needs associated with EV adoption, and to help address adoption barriers that will help expand and accelerate EV use. These programs represent direct investment and expense. In addition, as EV use grows and utility infrastructure is required to deliver the additional electricity required for vehicle charging, additional investments in grid reinforcement may be required. Lastly, EV adoption imposes additional costs on non-utility participants, such as the premium associated with vehicle purchase, or investments in charging infrastructure being made by private (non-utility) entities. The study estimated the costs associated with all three areas to create a more complete profile of potential costs, which are detailed in Section 6. See Appendix A for more information about how costs were estimated.

10. **Formal Net Benefit Tests:** The net economic benefits from forecasted EV adoption are summarized in Section 5.2, and potential costs are summarized in Section 6. These benefits and costs can be combined to provide a NET benefit, after accounting for costs. There is no formal consensus on how to calculate net benefits related to proposed EV programs, but there are well established methods for evaluating the merit of energy efficiency (EE) programs. These EE tests need to be modified to account for conditions specific to EV adoption, but once properly adapted, they can be used to quantify the policy merit for proposed EV programs. Based on a review of methods used by others and synthesis of associated best practice, three adapted tests have been developed for this study: a Ratepayer Impact Measure (RIM), the Societal Cost Test (SCT), and the Total Resource Cost

[h] The benefit analysis quantifies the operating expense savings realized by EV owners. Full characterization of economic benefit must also consider potential vehicle purchase premiums, as well as other incentives that might apply to offset vehicle purchase price. These factors are incorporated in the NET benefit tests outlined in Section 7.

(TRC) test. These different tests characterize how different impacted populations experience net benefits, and taken together provide a well-rounded view on overall merit. The formal NET benefit tests are described in Section 7.

11. Additional details about scope, assumptions, and methodology can be found in Appendix A.

5 KEY RESULTS: The Impacts Of EV Adoption

EV adoption delivers an unusually broad range of impacts, across a range of populations and market segments. The study quantified these impacts as a function of EV adoption over time, including both aggregate physical impacts, and a variety of economic benefits.

5.1 Key Results: Physical Impacts

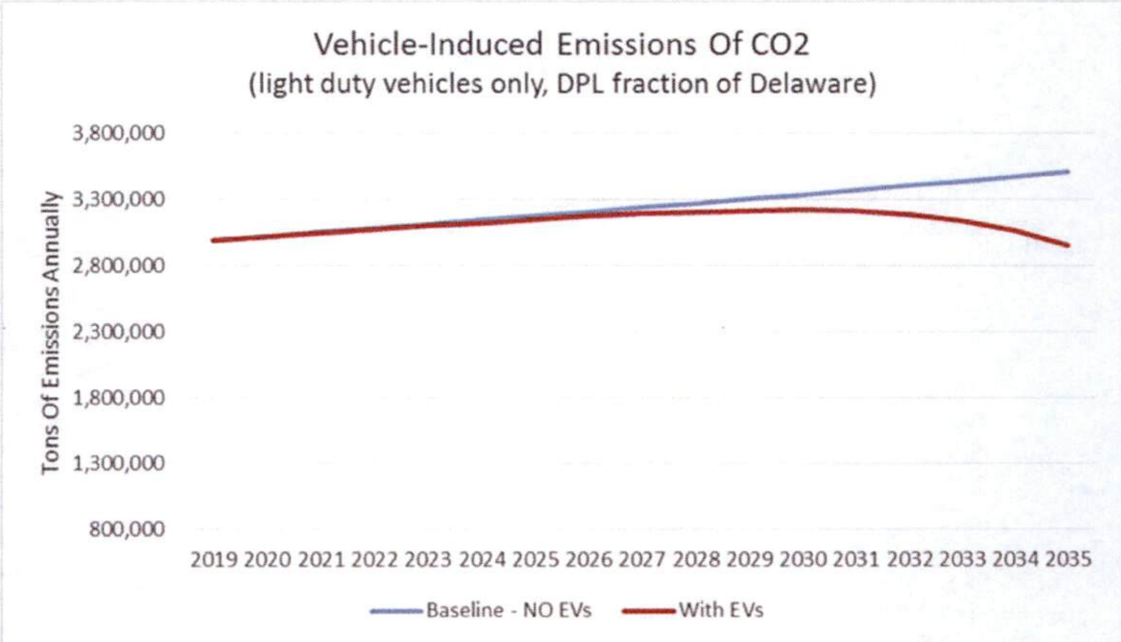
Fueling light duty vehicles with electricity rather than gasoline creates a profound change in fuel usage, electricity usage, and changes in the associated emissions. Based on the EV adoption forecast in Section 4, combined with travel statistics for Delaware and average vehicle performance characteristics, the study identified a variety of physical impacts, including:

- EVs are forecast to account for 0.8% of new vehicle sales in 2019, growing, to 81.2% by 2035.
- EVs account for 0.3% of the light duty fleet overall in 2019, but are projected to grow such that EVs account for 26.4% of light duty vehicles on the road by 2035.
- As EV penetration grows, an increasing fraction of miles driven will be powered by electricity rather than gasoline. By 2035, 21.6% of all light duty vehicle miles driven are expected to be "electrically fueled". This increasing electrification displaces significant gasoline use – in 2035, EVs are projected to avoid consumption of 82,369,166 gallons of gasoline, and a total of 310,183,181 gallons of gasoline will be displaced over the period from 2018 – 2035.
- In 2019, EVs are projected to consume an average of 2,534 kwhrs of electricity per vehicle annually for battery charging[i], or an average 6.94 kwhrs per day. Those consumption factors are expected to increase slightly through 2035, but at a slower pace past 2025 as larger and heavier EVs come onto the market. **For a household with one EV, vehicle charging will account for an average of 20.4% of the electricity consumption for that household over the period.**
- At an aggregate level, EVs are projected to require 3,818 MWhrs of electricity for vehicle charging in 2019 (across all charging segments), growing with EV population to 572,058 MWhrs by 2035.
- When "managed charging" is dominant, most charging (on a kwhr basis) is residential and during off-peak periods at night. In that case, EV induced load increases during the PJM-coincident peak are expected to be modest. Vehicle charging adds a projected 0.263 MW of load at peak time in 2019, growing to 36.549 MW in 2035. The fact that charging-induced electricity consumption increases significantly, while peak loading increases only slightly, implies a significant increase in the overall generation base and infrastructure capacity factors (i.e. utilization), and a much flatter load profile overall with more consumption in off-peak periods. This outcome is a primary driver of the economic benefits summarized in Section 5.2.1.
- By fueling with electricity rather than gasoline, emissions at the tailpipe are eliminated, but emissions at the power plant go up. For most pollutants, vehicle emissions reduce much more

[i] This represents a blended average consumption-per-charge for BEVs and PHEVs.

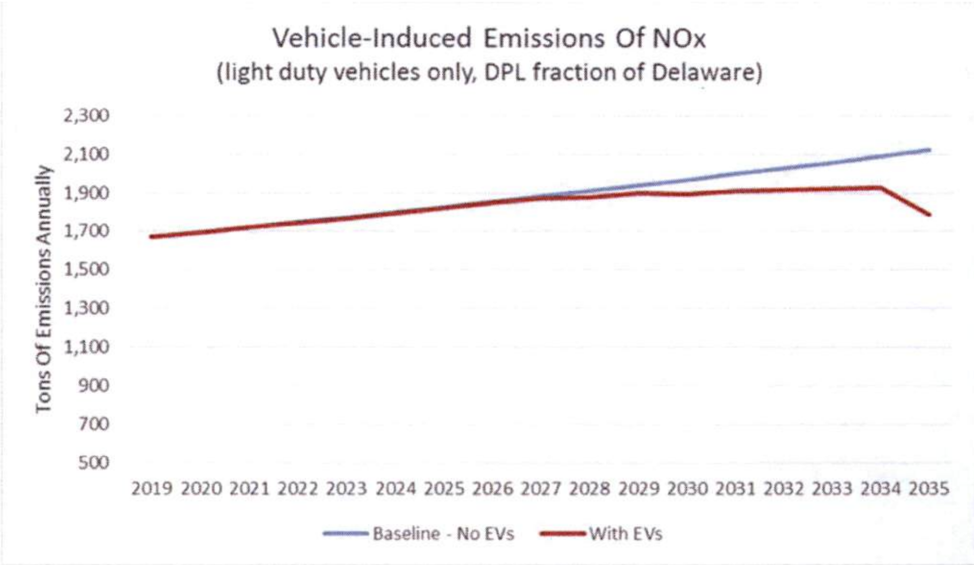
than power plant emissions increase, resulting in a NET reduction overall. **In 2019, each electrically fueled mile is projected to be 63.8% cleaner (for CO_2) than an average gasoline fueled mile.** This "clean-up factor" increases slightly over time as the grid becomes cleaner[j], so that by 2035 EVs could be 70.7% cleaner (for CO_2) than average gasoline vehicles.

- Carbon Dioxide (CO_2) is a primary GHG, and burning gasoline in vehicles accounts for the largest share of CO_2 emissions in the state[7]. As EV penetration grows, NET CO_2 emissions decline significantly. **Transportation induced CO_2 emissions (light duty vehicles only) are projected to reach 3,507,067 tons by 2035 in the baseline case WITHOUT EVs, but would reduce to 2,948,523 tons by under the forecasted EV adoption scenario – a 15.9% reduction. Over the period, a projected 2,076,234 tons of CO_2 are avoided, or 9.01 tons of CO_2 avoided per EV sold.** Note this reduction results from EV penetration of 26.4% in 2035, and CO_2 reductions continue to grow in lockstep with increased EV adoption. The following chart summarizes the reduction in CO_2 emissions resulting from the forecasted rates of EV adoption compared to baseline usage without EVs:

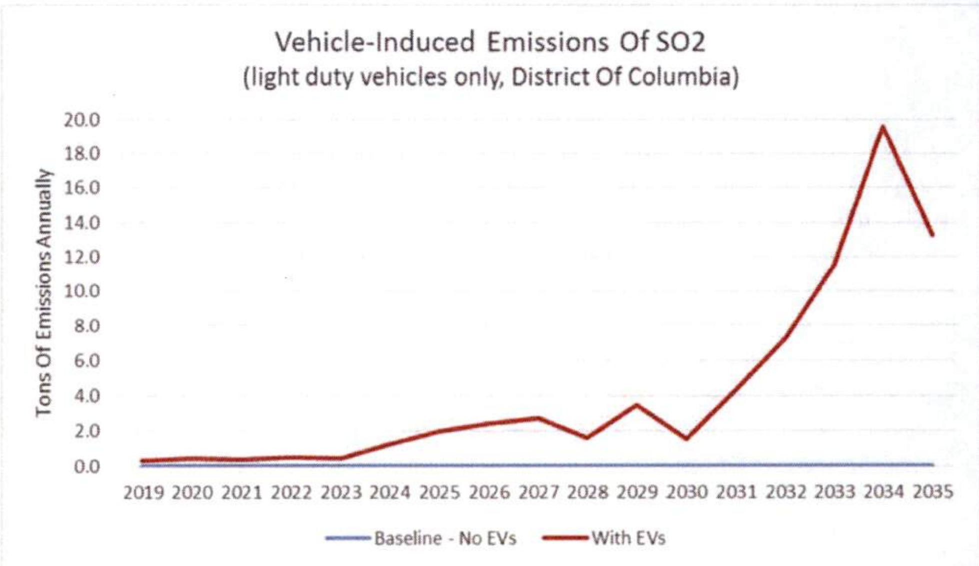


- Nitrogen Oxides (NOx), which are a criteria pollutant that directly affects public health and are also a pre-curser to other forms of air pollution, also declines with increased EV adoption. **NOx declines from a projected 2,121 tons for the no-EV baseline case in 2035, to 1,790 tons instead, a reduction of 15.4%.** The following chart illustrates the decline in NOx emissions resulting from growth in the use of EVs.

[j] The simulation model assumes "business as usual" for existing generation assets and deployment of any new capacity required. Given the significant displacement of coal generation by natural gas already underway, emission factors of the generation base continue to reduce. Those reductions could be faster and larger, however, with increased use of carbon-free renewable energy. There is a significant synergy between EV adoption and increased grid de-carbonization. Note that the DPL-DE EV proposal will offer a 100% clean energy supply option for EV charging, which could make the "clean up" factor quantified in aggregate through this study stronger.



- Sulfur Dioxide (SO_2) is a criteria pollutant that harms human health directly, contributes to the creation of "acid rain", and is a precursor to other air pollutants, especially particulates. SO_2 emissions *increase* with EV use – although only slightly. Light duty vehicles emit essentially no SO_2, but power plants do – especially in cases where coal is used heavily. As a result, the "zero emissions" of SO_2 by gasoline fueled vehicles is replaced by modest SO_2 emissions at the power plant. While this is a negative outcome, the difference in scale associated with SO_2 emissions should be noted: while CO_2 emissions are measured in millions of tons, SO_2 emissions increase by an estimated 19.6 tons at the highest point over the period. More importantly, the emissions rate for SO_2 continues to decline for electricity generation as the grid migrates to cleaner sources, especially solar and wind. The negative SO_2 implications short term will likely soften longer term due to beneficial changes in supply mix.



5.2 Key Results: Economic Impacts

Increased EV use is expected to deliver significant economic benefits for a variety of impacted populations, and these benefits scale strongly with aggregate EV adoption level. As summarized in Section 4, the study quantified beneficial impacts through reduced electricity costs (for all ratepayers), reduced vehicle operating costs (for EV owner/operators), and value from avoided emissions (for society at large). The following sections summarize the economic benefits associated with the EV adoption forecast in Section 3, compared with baseline conditions for the DPL-DE territory.

5.2.1 Avoided Electricity Costs

EV charging increases overall electricity consumption, and shifts the aggregate load profile to include a larger fraction of energy in lower-cost (off-peak) times, especially under the influence of utility "managed charging" programs that help influence vehicle charging schedules. As a result, overall capacity factor for both generation assets and the distribution system increases, and the load curve that affects energy pricing is more optimal. Together, these efficiencies result in a reduced cost of electricity that benefits all utility ratepayers, not just EV drivers. The study quantified these impacts through the methodology outlined in Section 3, resulting in the benefits summarized below:

- **Ratepayers will realize savings through lower electricity costs, scaling upward with increased EV use, with projected savings exceeding $61.6M a year in 2035.** Those savings represent only non-EV-charging usage[k], and are projected to total over $325.7M over the period (nominal sum of recurring annual benefits), with an NPV of $170.3M[l].

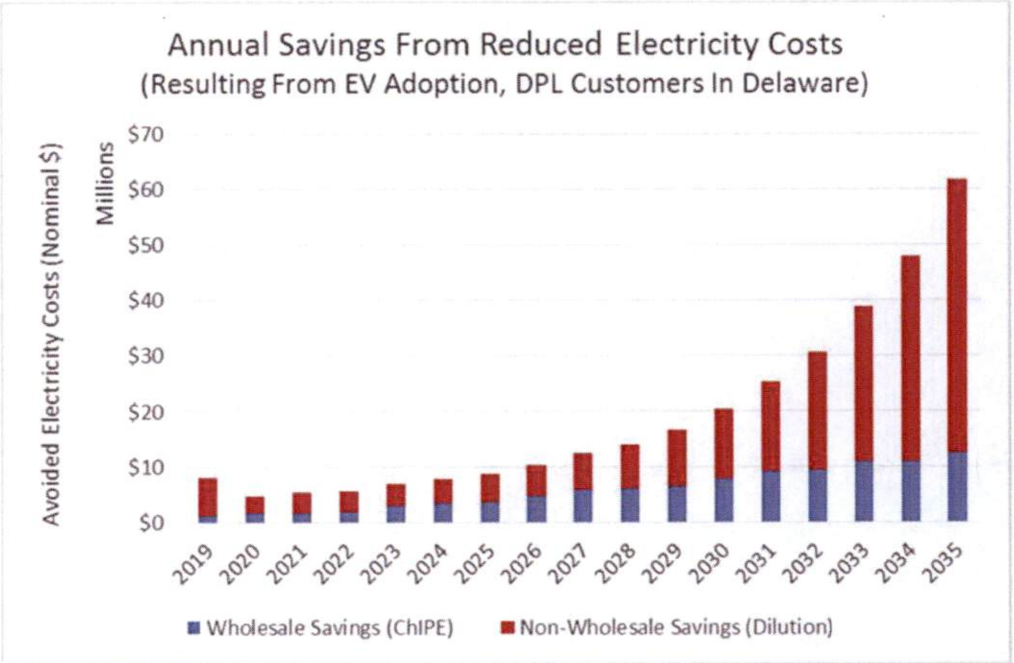
- Electricity costs (on a unit cost, $/kwhr basis) are expected to be 4.5% lower in 2035 than they would otherwise be as a result of the forecasted EV use. Cost improvements continue to accrue as EV adoption grows.

- Those savings reflect a combination of lower average wholesale costs, and dilution of all other costs (especially distribution costs) over larger electricity volume as summarized in the Methodology section (see Appendix A for more details on the energy cost impact calculations). Those impacts vary in proportion over time, with dilution effects

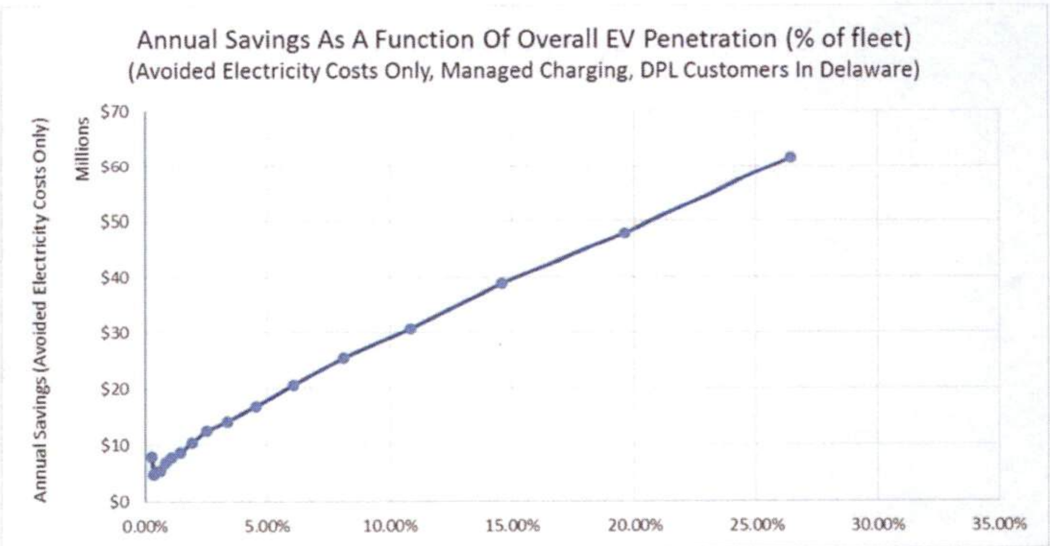
[k] The "rate payer" savings noted reflect the projected lower unit costs ($/kwhr) applied against ONLY non-EV charging loads, which makes that benefit applicable to non-EV owners. EV owners will also realize the benefit of lower electricity costs when powering their vehicle, but that impact is implicitly captured in the EV owner fueling savings. Those calculations are separated to avoid double-counting, and to enable transparent evaluation of the non-EV owner impacts.

[l] As noted in the methodology discussion in Section 4, this analysis identifies overall cost efficiencies at an aggregate level, quantified by an average cost of electricity indicator on a per-kwhr basis. In a competitive market, these cost improvements are expected to eventually flow through to end consumers. Exactly how those cost improvements are applied across rate classes or tariffs, or when those improvements impact bills, cannot be predicted since they depend on a wide variety of future market and regulatory factors. Energy contracting commitments may also impact the timing of when identified cost efficiencies are realized by end consumers.

becoming dominant longer term. This trend is summarized in the following chart, illustrating wholesale pricing effects (ChIPE) versus dilution impacts.



- Electricity cost savings scale strongly with aggregate EV adoption levels (% of light duty vehicle fleet). From a policy perspective, this implies that regardless of what actual EV adoption levels are achieved, incremental EV use generates incremental economic benefit for ratepayers overall. The following chart summarizes the correspondence between EV adoption and avoided electricity costs.



- It is important to emphasize that these benefits are realized by ratepayers overall, not just EV drivers, and reflect only savings delivered through lower electricity costs (not additional economic benefits as quantified below). The fact that overall electricity costs decline as a function of EV adoption is a primary conclusion of the benefit analysis. These economic ratepayer benefits are larger than projected program costs, as quantified more fully in the NET benefit tests in Section 7.

- As noted above, the electric cost reductions noted are based on the scenario where managed charging becomes dominant, as jumpstarted by the utility programs being proposed. The managed charging programs not only enable (and maximize) the potential economic benefits, but also avoid potential harm. For example, as an extreme worst case, if all charging was done at home, and all that charging started when EV drivers got home from work (say at 6PM), that would amplify the existing peak loads (especially during the summer), increase costs, and hasten the need for grid reinforcement (and associated costs). Assuming 75% of all PHEVs are on 1.4KW L1 chargers, 25% of PHEVs are on 7.2KW L2 chargers, and 100% of BEVs are on 7.2KW L2 chargers, in 2035 the projected EV fleet would create 951MW of incremental peak load, in a territory that normally has a PJM-coincident peak around 3,900 MW. That represents an increase of nearly 25% at the worst possible time. Again, this is a worst case scenario that is extremely unlikely to occur since a) some charging happens away from home, and b) even with residential charging, there is a natural spread in the evening. But this demonstrates the potential harm avoided by managed charging (in an extreme case), which both pushes the vehicle charging start past peak time, and when fully implemented, reduces vehicle charging peak load by about a factor of at least six (since it spreads 1-2 hour charging sessions out over a full 8 hour period overnight). The potential economic *harm* that could result from natural charging is not fully represented in this study.

5.2.2 Economic Benefits For Electric Vehicle Owners

After the EV purchase, significant economic benefits are realized by the EV owner through lower operating expenses. In particular, EV drivers "fuel" their vehicles with electricity rather than gasoline, and realize significant savings as a result. In addition, EV drivetrains are much simpler and require lower maintenance expense. Based on drive patterns specific to the DPL-DE territory, the study identified the following benefits for EV owner/operators:

- **In 2019 it will cost approximately 11.95 cents/mile to fuel an average traditional vehicle with gasoline, compared with approximately 6.16 cents/mile for EVs (both BEVs and PHEVs, blended results) – a reduction of about 48.4%.** This benefit increases over time, since the cost of gasoline is increasing faster than the cost of electricity. By 2035, EV drivers are projected to be realizing a 62.8% savings in fueling expense. These projections are conservative since a) they assume a reduction in gasoline prices over time due to softening demand for petroleum, and b) EV drivers are assumed to carry an additional expense sufficient to replenish lost revenues from avoided gas taxes (see Appendix A for more details).

- EVs are also expected to have lower maintenance costs due to the simpler drive train. A recent study by the American Automobile Association quantified maintenance expense for both traditional vehicles and EVs (see Appendix A). Based on these factors, as applied to the forecast for the DPL-DE territory, **owners of traditional vehicles are projected to pay approximately 9.26 cents/mile for maintenance of a traditional fueled vehicle, but only 7.97 cents/mile for an EV (blended rate for BEVs and PHEVs) in 2019.** This represents a 13.9% savings on maintenance.

- EV drivers therefore realize real savings through reduced "fueling" costs and maintenance expense. Taken together, and including gas tax replenishment, **EV drivers will realize over $1.1M in operating expense savings in 2019 (nominal sum of recurring annual benefits). This savings grows to $283.6M in 2035, and totals $1.0B over the period (with an NPV of $473.8M).** This represents an average of $2,056 in vehicle operating cost savings per EV sold over the period (nominal dollars). These benefits represent real and substantial cash flow savings for Delaware residents, much of which is returned to the local economy.

5.2.3 The Value Of Avoided Emissions

Increased EV use provides substantial reduction in air emissions and other pollutants, especially the GHG emissions associated with climate change. The emission reductions for CO_2, NOx, and SO_2 are described in Section 5.1, and represent an externality that delivers economic value to society through avoided emission costs. The value of avoided emissions is calculated on a per-ton basis based on impact factors developed by independent studies (see Appendix A for more details), as follows:

- **Avoided emissions (CO_2, NOx, and SO_2 combined) are projected to generate $213.5K in savings in 2019, growing to $83.5M per year in 2035.** These savings reflect the benefits of decreased CO_2 and NO_x net of the incremental cost associated with slightly increased SO_2 emissions.

- **The societal value of avoided emissions are projected to total $268.8M over the period (nominal sum of recurring annual benefits), with an NPV of $123.5M.**

- Note that these avoided emission benefits capture a wide variety of impacts, including the public health costs associated with air quality issues (at least in part[m]).

5.2.4 Combined Economic Benefits

EV adoption creates economic benefits through reduced electricity costs for ratepayers overall, reduced operating expenses for EV owner/operators, and societal value through avoided

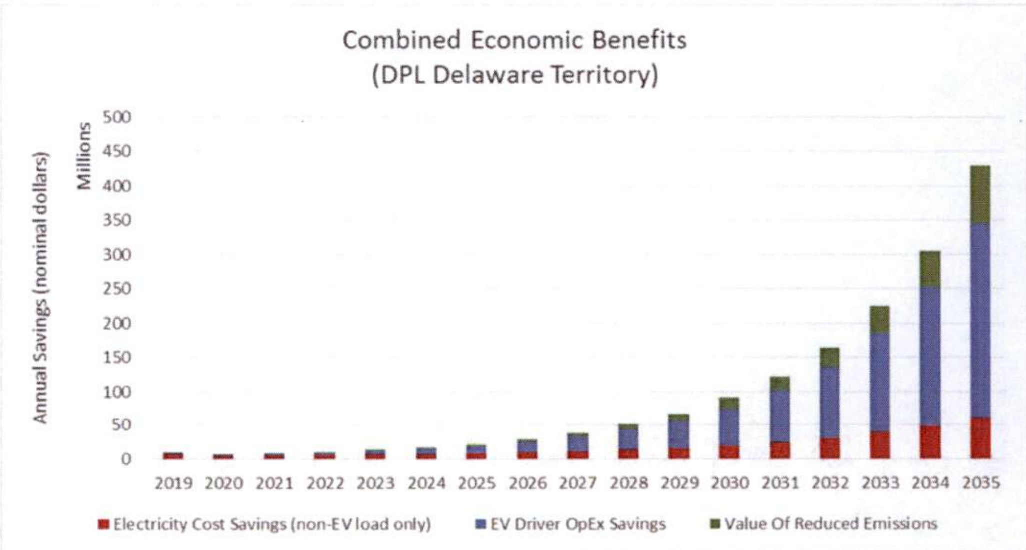
[m] Most studies on air quality impacts attempt to capture costs associated with the public health consequences of air pollution. In most cases, however, they acknowledge that health impacts are so large that their accounting is incomplete. As a result, these projections probably under-estimate the financial value of reduced emissions.

emissions of CO_2 and NOx. Taken together, these benefits combine to generate significant value across the impacted populations:

- Combined benefits are projected to total $9.4M in 2019, increasing to $428.8M per year in 2035. These impacts apply across multiple impacted populations, including ratepayers, EV drivers, and society at large.

- **Total benefits (not reflecting costs) are projected to total $1.6B over the period (nominal sum of recurring annual benefits), with an NPV of $767.6M.**

- There are significant benefits across all three populations, but operating expense savings for EV drivers becomes dominant over time. For context, residents of Delaware currently spend approximately $840M per year on gasoline use in light duty vehicles, and EVs are projected to cut those expenses in half[n]. This is a real cashflow savings delivered to every EV-household that will most likely flow into the local economy. This is a relatively equitable benefit opportunity, since any household that owns a vehicle can transition to an EV and realize the associated savings, especially as EVs become cost competitive with traditional vehicles. Emerging consensus is that transition will happen around 2025. The distribution of savings over time is illustrated in the following chart.



[n] The utility EV proposal also supports electrification of medium and heavy duty vehicles, especially electric school buses. That transition will also deliver significant benefits, beyond those quantified in this study focused on light duty vehicles.

5.2.5 One Time Benefits For EV Owners

In addition to the recurring benefits noted above, consumers that purchase a new EV may also benefit from a federal tax incentive to offset vehicle purchase costs. The amount of the credit varies by vehicle type and range, up to a maximum of $7,500. It is generally modeled as a benefit, since that economic incentive flows to DE residents from the federal government. That tax credit begins to decline when at least 200,000 EVs from a particular manufacturer have been sold, which market leaders (such as Tesla, Nissan, and Chevrolet) are expected to achieve in the next two years. An analysis of cumulative sales rates for different EV manufacturers was completed to determine the current average incentive level available, and the expected decline rate, based on volume-weighted sales in the U.S. The incentive is applied to all EVs purchased in the DPL-DE territory through 2027 (for BEVs) and 2029 (for PHEVs). **The federal tax incentive totals $83.6M over the period, with an NPV of $59.4M.**

6 KEY RESULTS: Program Costs

To properly consider the value of forecasted benefits, it is necessary to also consider potential costs. The study considered three categories of costs related to both the proposed utility EV program, and broader EV adoption as well:

1. **Utility Investments In Charging Infrastructure:** The utility is proposing a variety of customer programs, providing equipment and services that support customers driving an EV. These utility costs include the capital and expense associated with delivering those programs, and is quantified through the proposed program budget. Many of these programs can be considered investments in responsible grid integration of these new EV-charging applications, especially the managed charging programs, which have significant electricity-use and loading implications.

2. **Utility Investments In Grid Reinforcement:** Beyond the direct EV program, there may be the need for additional utility investment in grid reinforcement. As EV adoption grows, the utility will likely be required to deliver more electricity in support of vehicle charging. An estimate of these grid reinforcement investments, which are longer term in nature, has been provided to ensure complete characterization of EV adoption costs. As noted elsewhere throughout this document, the timing of potential reinforcement depends heavily on the success of managed charging programs, as is being initially established by the proposed utility program. Without managed charging, reinforcement requirements will be both earlier and larger.

3. **Investments By Non-Utility Entities:** In addition to actions by utilities, other market participants may be making incremental investments as part of more widespread vehicle adoption. Key examples include premiums associated with EV purchase, customer costs for charging infrastructure (net of utility contributions where applicable), and investments by private capital in public charging infrastructure. Long term estimates of those costs have been provided in support of the broader societal evaluation of net benefit.

6.1 Key Results: Utility Investments In Charging Infrastructure

DPL is proposing a customer support program for its Delaware territory, with multiple offers to address growing customer needs related to EV ownership and to address known adoption barriers that should encourage expanded EV adoption by new customers. Most of these programs are related to vehicle charging infrastructure, which is an appropriate role for the utility in the EV market ecosystem given its close technical connection with utility distribution infrastructure. Several of the programs focus on providing managed charging solutions for residential customers, which is a high impact strategy for minimizing EV charging impacts on the public grid, while also maximizing the economic benefits for other ratepayers (through more off-peak charging). These costs associated with the proposed programs are captured in the program budget, as summarized below.

Program Budget	**Number Of Units**	**Budget**
Offer 1: Residential Whole House TOU Rate	Unlimited	$0
Offer 2: Residential L2 (existing EVSE, with Fleetcarma)	50	$81,550
Offer 3: New Residential Smart L2 Charger (utility installed)	50	$462,500
Offer 4: New Multi-Family Smart L2 Charger	10	$78,000
Offer 5: Neighborhool Smart L2 Chargers	2	$30,000
Offer 6: Public DC Fast Chargers	2	$240,000
Offer 7: Electric School Buses With V2G	TBD	$400,000
Customer Enrollment and Outreach	N/A	$200,000
Admin, IT Costs, Reporting	N/A	$746,500
Total Program Costs:		**$2,238,550**

These costs were included as a utility program cost, recovered through rates, with all disbursements assumed to be in calendar year 2019.

6.2 Key Results: Utility Investments In Grid Reinforcement

EV charging increases the use of electricity, and longer term, could force reinforcement of utility infrastructure to accommodate those changes in load. These implications were not assessed in detail as part of this study, but Gabel has conducted in-depth engineering analysis of EV implications on utility infrastructure for other territories[8]. Those studies identified several general conclusions that we believe are applicable across a variety of territories, and those guidelines were used to estimate potential costs for grid reinforcement resulting from EV charging loads in the DPL-DE territory. Key guidelines include:

a) When the EV population is small (as an aggregate percentage), there is generally sufficient capacity within the distribution system to handle those incremental EV charging loads, although clustering affects (i.e. multiple EVs within a single neighborhood) could cause localized overload conditions.

b) During this early market phase, overload conditions, if they emerge, will be relatively localized and can be dealt with within the boundaries of routine maintenance and upgrade budgets.

c) Based on consideration of a wide variety of EV loading scenarios, in most cases overload conditions will emerge first on residential single phase transformers, and potentially on taps or overload protection components. Larger impacts on conductor capacity, sub-station elements, and transmission infrastructure are likely longer term, if they emerge at all. The timing, and impact scope, of EV charging depends heavily on residential EV charging patterns, and managed charging – if fully deployed – can defer (but not eliminate) these impacts in time.

d) Once the EV population is approximately equal to the number of single phase transformers, overload conditions will become more common since that condition begins to guarantee multiple vehicle charging loads on a single transformer. Past that point, more proactive grid reinforcement would be prudent to ensure responsible support for increased loading related to EV charging.

e) There are 56,613 single phase transformers in the DPL-DE territory. More proactive grid reinforcement therefore becomes necessary at approximately 7% EV penetration of the light duty fleet.

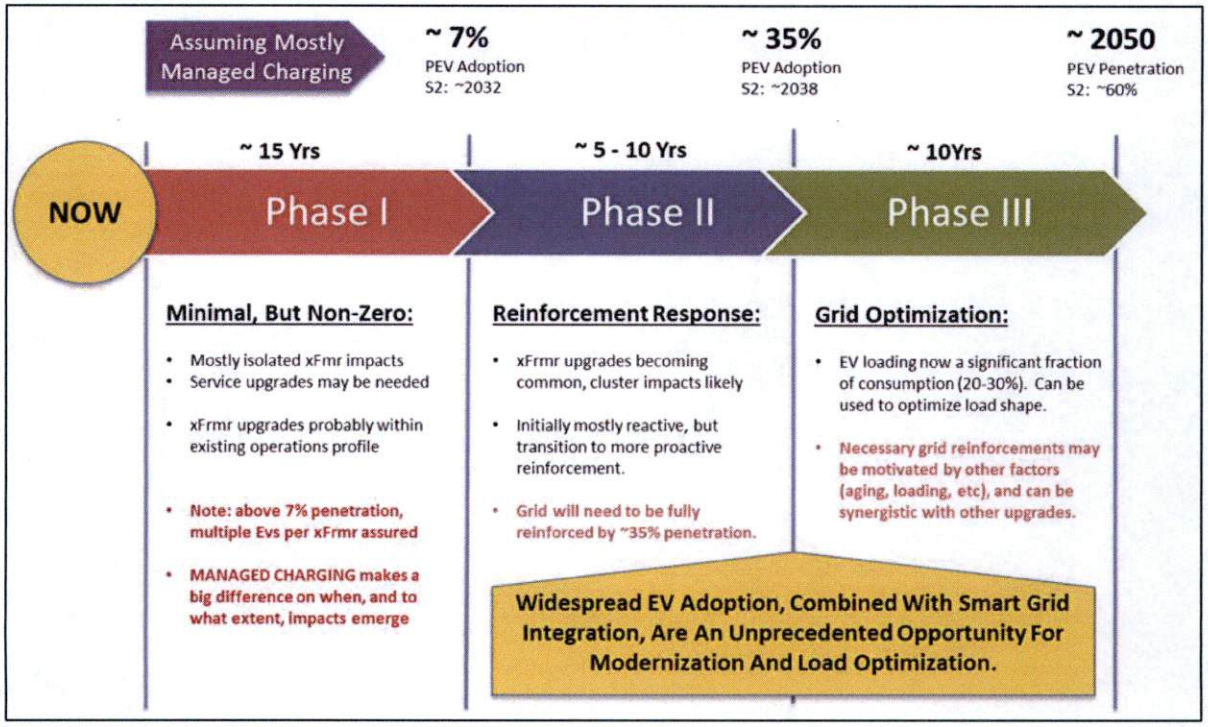
f) The impact analysis from other territories suggests that by the time the EV population is approximately five-times the number of single phase transformers, most grid reinforcement will need to be complete. In the case of the DPL territory in Delaware, this represents approximately 35% fleet penetration. The active grid reinforcement period is therefore expected to be between 7% and 35% EV penetration. For the EV forecast developed for the DPL-DE territory, this is projected to be from approximately roughly 2032 to 2038.

g) Distribution impacts will be felt most strongly on residential circuits, where the majority of vehicle charging electricity is delivered. Impact on commercial circuits, where workplace, public charging, and other specialized infrastructure (i.e. electric buses, etc.) have not been assessed in detail, but are generally expected to be less severe given a) the smaller number of installations and reduced energy delivery requirements (i.e. MWhrs delivered) in those charging segments, and b) the fact that those installations tend to require specialized interconnection engineering by the utility where load requirements can be more specifically accounted for.

h) Past approximately 35% EV penetration, vehicle charging represents a substantial load. A recommended utility priority during this mature phase of market development is using this quasi-dispatchable load to optimize grid loading and maximize economic benefits for ratepayers.

i) The above guidelines assume strong deployment of effective management charging programs, especially for residential customers. These programs must not just delay the start time of evening residential charging, but also spread that aggregate load over the full overnight period (~8 hours). If managed charging is not implemented, bigger impacts on infrastructure are likely to result.

j) The following diagram illustrates these three phases of market engagement based on changing infrastructure needs.



Based these guidelines, proactive grid reinforcement for the DPL-DE territory is assumed to take place from approximately 2032 to 2038, with approximately half the single phase transformer base being reinforced by 2035. A cost of $5,000 per transformer is assumed based on typical equipment and labor costs. Note that these upgrades, although motivated by EV loads, will also accomplish other reinforcement objectives, potentially including improved instrumentation, better resiliency, improved overall capacity, etc. It should also be noted that many of these transformers would require upgrade over a similar period, even if EV adoption did not happen. This assumption of full transformer upgrade is therefore extremely conservative, and probably overstates the costs that should be booked to EV adoption.

Based on these schedule and cost assumptions, **the total utility cost for grid reinforcement is estimated to be $131.1M (nominal sum) from 2032 – 2035, with an NPV of $56.1M.** Additional costs related to sub-station or transmission upgrades, if required, are not reflected[o].

6.3 Key Results: Estimated Non-Utility Costs

A market transition to greater use of EVs implies costs for market entities other than utilities, including EV owners, and other investors in vehicle charging infrastructure. These other multi-party costs – although outside the boundaries of utility investment – should be considered to have a comprehensive

[o] We are not aware of significant sub-station or transmission upgrades being identified as required in any other jurisdictions, even California where EV penetration is much higher. While we haven't studied the DPL-DE territory at an engineering level, our high level assessments of other territories are that the risks emerge first at the single phase transformer level (and perhaps other related feeder equipment), and that substation/transmission impacts, if they arise at all, would arise later.

view of total costs appropriate for the broader cost tests. The analysis considered the following components of non-utility costs:

1. **Incremental Vehicle Purchase Price:** In the current market, EVs are perceived to cost more than traditional gasoline vehicles. This conclusion is based on the fact that the average MSRP for all EVs on the market is higher than the average MSRP for all traditional gasoline vehicles on the market. Although this statistic may not be representative of how actual consumers make decisions at a transaction level, it is clear that this is the market *perception*, and consideration of the perceived premium is included in this benefit-cost analysis to make the analysis as comprehensive and transparent as possible. The premium was based on a study done in California on the average premium associated with EVs, as used by San Diego Gas and Electric in their 2014 EV program filing[9]. Those numbers reflect a purchase price premium of $8,694 for BEVs, and $8,081 for a PHEV (with at least 40 miles of electric range), as projected to 2019. Those premiums are estimated in the California study to decline by 10% a year, and this trend is assumed for this analysis through 2030, after which the premium is assumed to be zero (i.e. EVs are price competitive with traditional gasoline vehicles across a wide range of vehicle categories)[10]. The estimated purchase price premium for each year is applied to the total number of EVs sold in the DPL-DE territory over the analysis period, by BEV or PHEV vehicle type, to quantify this total market impact. This premium is estimated to total approximately $141.8M over the period ($94.0M NPV). Which is a relatively small fraction of the estimated $8-10B projected to be spent on new EVs in the DPL territory of Delaware through 2035.

2. **Non-Utility Investment In Charging Infrastructure:** A wide variety of market participants help pay for charging infrastructure, under a variety of business models and ownership paradigms. This makes estimates of total charging infrastructure costs complicated. However, the charging infrastructure required in key charging segments can be estimated based on the EV adoption forecast. The full cost of that infrastructure was quantified as part of the analysis (using typical installation costs for equipment and labor). The difference between this total infrastructure cost, and the costs proposed to be carried by the utilities through the proposed program, represents the non-utility investments in charging infrastructure. Under this methodology, the combination of utility investments and non-utility investments fully capture infrastructure investment requirements over time. Infrastructure needs were estimated for residential, workplace, public L2, and public DCFC charging segments with costs estimated using typical cost factors obtained from other utilities and industry. In general, these cost profiles include the cost of new service (where required), infrastructure to the EVSE installation, and the EVSE equipment (and network services where applicable). The amount of infrastructure needed across the above four segments was calculated to meet projected USAGE requirements, based on infrastructure supply factors from the recent U.S. Department of Energy (DOE) EV charging infrastructure plan[11]. The following table summarizes key assumptions related to the charging infrastructure requirement estimates:

Charging Infrastructure Estimating Factors	Factor	Units	Trend
Capacity Requirements (Plugs per EV)			
Residential/Fleet (chargers for BEVs)	100.0%	% new BEV sales	Constant -> 2035
Residential/Fleet (chargers for PHEVs)	25.0%	% new PHEV sales	Constant -> 2035
Workplace plugs per EV (BEV & PHEV)	0.03000	Plugs/EV	Constant -> 2035
Public L2 plugs per EV (BEV and PHEV)	0.02200	Plugs/EV	Constant -> 2035
Public DCFC plugs per BEV	0.00387	Plugs/BEV	Constant -> 2035
Cost Factors (Per Plug, equipment and labor)			
Total Cost per plug: residential/fleet L2	$1,631	$/plug	Constant -> 2035
Total Cost per plug: workplace L2	$6,000	$/plug	Constant -> 2035
Total Cost per plug: public L2	$9,000	$/plug	Constant -> 2035
Total Cost per plug: public DCFC (at least 50KW)	$120,000	$/plug	Constant -> 2035
Infrastructure Requirements (plugs)			
New Residential/Fleet L2 Plugs	140,737	Plugs	Total Thru 2035
New Workplace L2 Plugs	3,266	Plugs	Total Thru 2035
New Public L2 Plugs	2,042	Plugs	Total Thru 2035
New Public DCFC plugs	257	Plugs	Total Thru 2035

Total costs for the four identified charging segments, net of utility contribution, are estimated to total $297.4M over the period, with an NPV of $137.8M. Note that some of these assets are for the use of individual vehicle owners (such as private residential settings), others are quasi-public since they are used by multiple approved uses, and the public assets are used by the entire EV ownership fleet. The above numbers represent initial investment for the infrastructure, which may be recovered from EV drivers through usage charges. These non-utility costs are included in the benefit-cost analysis to ensure a broad and comprehensive accounting of net benefit, especially for the broader tests like the TRC and SCT, which are described below in Section 7.

Note: this analysis demonstrates that the utility investment is highly leveraged, meaning that for every utility dollar spent, significant additional investments are being made by other parties. The utility program represents a $2.2M program investment[p] that is matched by $297M of non-utility investment in charging infrastructure as well. The proposed utility programs do not cover the full costs required for infrastructure, and utility investment is matched by significant non-utility investment as well. Since these early stage utility programs help to "seed the market", significant future infrastructure is assumed to be built (especially for residential) without direct utility investment. In addition, the utility programs for public fast charging, are considered highly leveraged since they address key

[p] The cost model also accounts for additional potential utility investment longer term for grid reinforcement to support EV-induced loads. These costs are included to ensure robust coverage of potential costs and conservative net benefit estimates, but may not be required depending on the success of managed charging programs. Note that other investments are also being made – beyond that required for charging infrastructure – including investment in the EVs themselves. Those non-utility investments are also enabled by the utility programs that encourage adoption.

consumer adoption barriers that are expected to significantly increase adoption and grow industry scale, leading to lower EV costs for all consumers medium term.

7 KEY RESULTS: Net Benefit-Cost Tests

The benefits of EV adoption (summarized in Section 5), and the associated costs (summarized in Section 6), can be combined to establish NET benefit in support of determining merit for the proposed programs. Comparing benefits and costs can be complicated, however, since in some cases the population that realizes a benefit may be different than the population that bears the cost. This is particularly true for EVs, since there are a variety of impacted populations involved (ratepayers, EV drivers, society at large).

It is therefore useful to consider a variety of net benefit-cost tests that carefully combine benefits and costs to characterize different policy perspectives on merit. For energy efficiency (EE) and demand response (DR) programs, there are five standard tests used to provide these multiple perspectives. These tests are as defined in the California Standard Practice Manual, which is widely used for evaluation of merit for clean energy utility program filings[12]. These merit tests provide the foundation to determine how benefits and costs are combined to calculate a net impact, with different tests reflective of different impacted population combinations.

The standard tests defined in the EE/DR protocol are not easily applied to EV programs as originally defined. The EE/DR methods were designed to assign merit to reductions in consumption, whereas EV adoption increases electricity use. In addition, there are a variety of categories (such as charging infrastructure investment) that are not naturally represented in the standard tests. These tests can be adapted, however, to provide similar forms of evaluation.

At the current time, however, there is no well-established consensus on how the standard tests should be adapted to utility EV programs. As part of the study, a detailed review of various filings and consultant studies was completed to synthesize "best practice"[13] [14] [15], and determine where common methods or other agreement exist. Although there was wide diversity on what elements were included in each test, and variations in how those elements were defined or calculated, there were several points of agreement on the conceptual structure for merit tests adapted for the evaluation of utility EV programs. Based on that assessment, the following adapted tests were used:

1. **Adapted Ratepayer Impact Measure (RIM):** The RIM test measures what happens to customer rates due to changes in utility revenues and operating costs caused by the program. Rates will go down if the change in revenues from the program is greater than the change in utility costs. Conversely, rates will go up if revenues collected after program implementation are less than the total costs incurred by the utility in implementing the program. For this analysis, changes in utility revenues are captured through the NET impact on electricity rates (as recognized by the consumer), and costs are based on direct utility investments. This test indicates the direction and magnitude of the expected change in customer rate levels. The RIM test is a strict protocol where the cost and benefit populations are strongly aligned: costs carried by utility customers for the EV program are compared with the energy cost savings that accrue to those same utility customers through changes in electricity costs. This test excludes numerous other benefits that are known to exist, especially regarding EV owner savings on operating expense and

environmental benefit. This is a useful test, however, for specifically evaluating the impact on utility customers without consideration of externalities.

2. **Adapted Societal Cost Test (SCT):** The SCT measures the net costs of a program as a resource option based on the total costs of the program, including both the utility's costs and the costs incurred by all other market participants. Similarly, all benefits are included, regardless of the impacted population. The SCT is an intentionally broad test that helps determine if society is better or worse overall as a result of implementing the proposed programs.

3. **Adapted Total Resource Cost Test (TRC):** The TRC is very similar to the SCT, and it measures the net costs of a program as a resource option based on the total costs, including both the utility costs of the program and costs incurred by other market participants. Benefits that are realized by direct program participants are included. The TRC is different than the SCT, however, in that it does not include consideration of the broader environmental benefits that accrue to society at large. The TRC helps determine if the participants that are directly affected (typically within the utility territory) are better or worse overall as a result of implementing the proposed programs, independent of broader externalities that might also apply.

The two remaining standard tests were not included in the evaluation. Specifically, the Program Administrator Cost (PAC) test was not included, since program administrator costs (if any) are completely unknown known at this time. The Participant Cost Test (PCT) was not included since the concept of a "participant" is harder to clearly define in the case of EV programs, especially given that many of the proposed offers are intended, by design, to "seed the market" and have ripple-effects that influence other (and future) EV buyers. The public charging programs, in particular, have a broad and evolving base of "impacted customers" that make a clear definition of the PCT difficult. The three tests defined above, however, provide a comprehensive collection of perspectives to inform evaluation of EV program merit.

Based on synthesis of filing and study examples as noted above, the following inventory of benefits and costs were used to calculate the three adapted merit tests. All of these benefits and costs were described and quantified in detail in Section 5 (benefits) and Section 6 (costs). All costs and benefits are quantified over the analysis period.

a) **Avoided Wholesale Electricity Costs (ChIPE):** Projected reductions in wholesale unit costs due to the optimization of the aggregate load profile, particularly the increased fraction of overall consumption in lower cost, off-peak times. This savings is a result of Charging Induced Price Effect (ChIPE), and was determined through detailed hour-by-hour dispatch simulation of generation assets in PJM as allocated to DPL-DE induced load. The reduced electricity unit-costs are applied to the non-EV electricity consumption only, and are potentially realized by all utility ratepayers.

b) **Avoided Non-Wholesale Electricity Costs (Dilution):** An estimate of all other non-wholesale costs, especially transmission, capacity, and utility distribution costs. Any EV charging-induced increases in capacity or transmission costs, as determined by increases in the PJM-coincident peak (in MW), are calculated based on projections of PJM capacity and transmission costs. Distribution costs are based on detailed analysis of current utility revenue requirements. Overall, after accounting for the impact of transmission and capacity costs, there is a net reduction in effective $/kwhr rates due to dilution of these costs over greater kwhrs-consumed.

c) **NET Value Of Avoided Emissions:** The tailpipe emissions for electrically-fueled miles are zero, replaced by incremental emissions at a power plant that is more efficient and can include carbon-free sources. The NET impact is a significant reduction in emissions, especially CO_2 and NOx, while SO_2 emissions increase slightly. These emission impacts are calculated using the same dispatch simulation described above. The NET value reflects the benefit of reduced CO_2 and NOx, as offset slightly by an increase in SO_2.

d) **NET Savings On EV Driver Operating Expense:** The benefit EV owners gain from using electricity rather than gasoline, and reduced maintenance expenses for EVs due to the simplified drivetrain. The long term NET savings reflect the combination of avoided gasoline costs, incurred electricity for charging, and avoided costs for maintenance. This analysis also assumes that EVs incur an additional expense that replenishes lost gas tax revenues to ensure infrastructure funding.

e) **Value Of Federal Tax Credits For EV Purchase:** The federal tax incentive provided for EVs, declining over time, based on distinct eligibility rules for BEVs and PHEVs.

f) **Utility EV Program Investments In Charging Infrastructure:** Capital and expenses for the proposed utility EV program, to be recovered from utility customers through rates. The majority of these programs are related to providing charging infrastructure and encouraging the adoption of managed charging solutions.

g) **Utility Investments In Marketing And Consumer Outreach:** Expense associated with proposed consumer education programs for both customer adoption into the planned programs, and more general EV awareness building.

h) **Other Utility Program Investments:** Related costs, including Administration, Information Technology costs, and program reporting.

i) **Utility Investments in Grid Reinforcement:** Estimated costs for utility reinforcement of the distribution system medium term, including replacement of approximately half of all single phase transformers by 2035.

j) **Non-Utility Investments In Charging Infrastructure:** Potential costs incurred by non-utility market participants for charging infrastructure over the analysis period. These costs are estimated based on usage requirements using infrastructure factors from the DOE national EV charging infrastructure plan, NET of any investments made by the utility through the proposed programs.

k) **EV Driver Vehicle Purchase Premium:** An estimate of the purchase premium paid by EV owners, declining over time as EV prices continue to drop due to lower battery prices, increasing industry scale, and competition.

The following chart summarizes how each of these elements were included in the three adapted merit tests:

Gabel EV Standard Test Methodology				
Impact To Be Included	**Population Impacted**	**Adapted-RIM**	**Adapted-SCT**	**Adapted-TRC**
Avoided Wholesale Generation Costs (ChIPE)	All Ratepayers	Benefit	Benefit	Benefit
Avoided C/T/D Costs (through dilution)	All Ratepayers	Benefit	Benefit	Benefit
NET Value Of Avoided Emissions (CO2, NOx, SO2)	Society		Benefit	
NET Savings on OpEx For EV Drivers ("fueling" and maintenance)	EV Owners		Benefit	Benefit
Value Of Federal Tax Credits For EV Purchases	EV Owners		Benefit	Benefit
Utility Investments In Charging Infrastructure	All Ratepayers	Cost	Cost	Cost
Utility Investments In Marketing And Customer Outreach	All Ratepayers	Cost	Cost	Cost
Other Utility Program Investments (admin, billing, etc)	All Ratepayers	Cost	Cost	Cost
Utility Grid Reinforcement	All Ratepayers	Cost	Cost	Cost
Non-Utility Investments In Charging Infrastructure	EV Owners And Others		Cost	Cost
EV Driver Investments: Vehicle Purchase Premium	EV Owners		Cost	Cost

All three adapted tests have been applied to the proposed DPL-DE program, consistent with the EV adoption forecast outlined in Section 3. All three tests delivered both a positive Benefit/Cost ratio (greater than 1.0) and a positive Net Present Value (NPV) over the analysis period, as defined in the sections below.

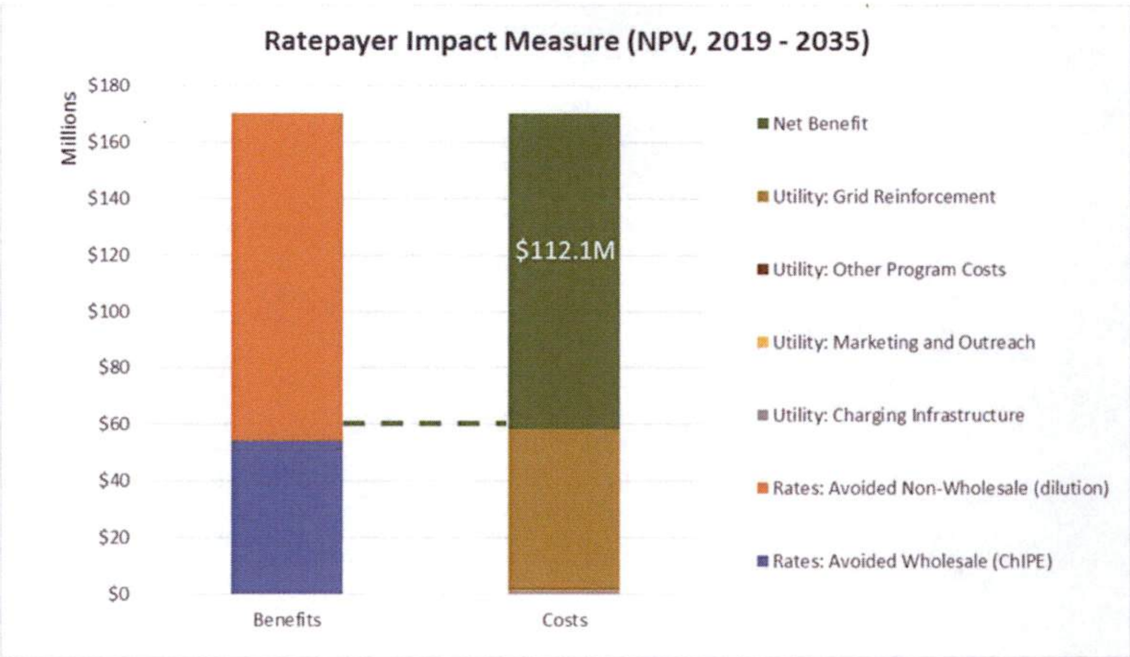
7.1 Key Result: The Adapted Rate Impact Measure (RIM)

The adapted Rate Impact Measure (RIM) yielded a Benefit/Cost ratio of 2.92, and a projected NET benefit (after costs, NPV basis) of $112.1M through 2035. Details are provided in the table below.

Adapted RIM Test	
	NPV (2019 - 2035)
Benefits Delivered To Rate Payers (non-EV load only)	
Benefit: Avoided Wholesale Generation Costs (ChIPE, $)	$53,912,238
Benefit: Avoided Non-Wholesale (C-T-D) Costs Thru Dilution ($)	$116,377,949
Total Avoided Electricty Costs ($):	**$170,290,187**
Costs - Utility Investments Recovered From Rate Payers	
Costs: Utility Investments In Charging Infrastructure ($)	$1,224,692
Costs: Utility Investments In Customer Acquisiton and Outreach ($)	$189,573
Costs: Utility Investments In Other Program Costs ($)	$707,583
Costs: Utility Investments In Grid Reinforcement ($)	$56,109,509
Total Utility Investment Costs ($):	**$58,231,357**
Total NET Benefit (benefits minus costs, NPV):	**$112,058,830**
Total Benefits (NPV):	$170,290,187
Total Costs (NPV)	$58,231,357
Benefit To Cost Ratio (based on NPV):	2.92
Net Impact Per PEV Purchased Over The Period (based on NPV)	$486
Average Net Benefit Per Year (2019-2035, $/Yr):	$11,315,015

Given the very narrow range of benefits considered in this simple test, this outcome is significant. It demonstrates that utility investment in EV programs does not suffer from the "Reverse Robin Hood Effect": utility investments that are recovered from all ratepayers generate benefits that flow back to all utility customers, with net positive benefit. Put another way, action by some utility customers (driving an EV and charging mostly at home, mostly off peak) has a broader economic impact across the entire rate base.

The following diagram compares the costs and benefits associated with the RIM test, and the net benefit that results.

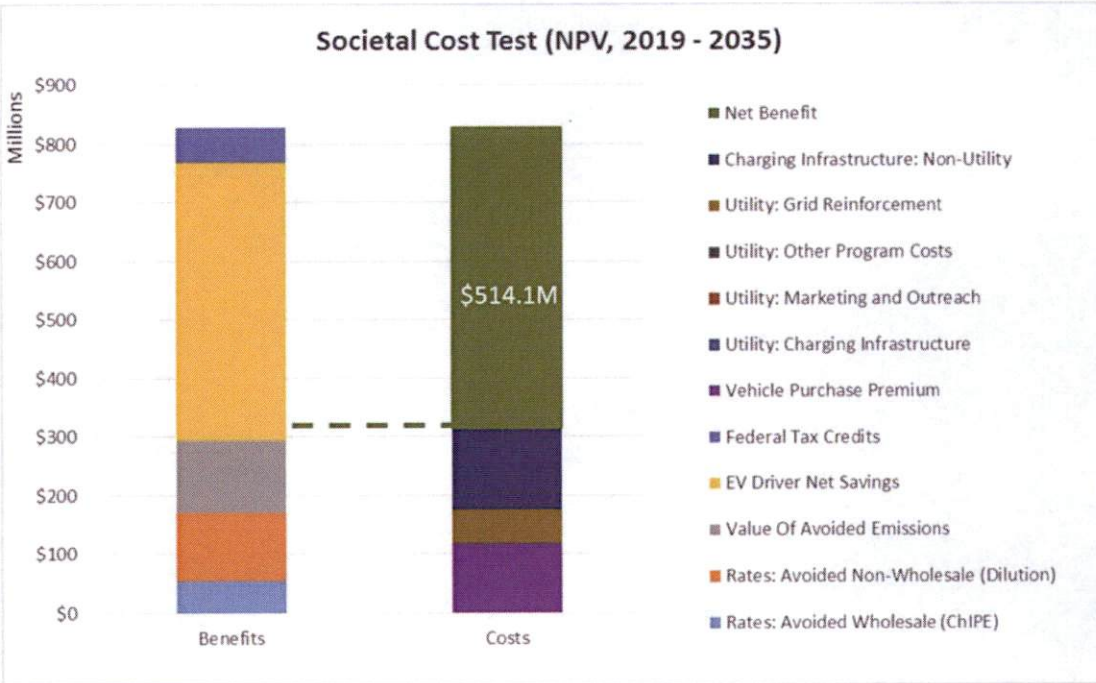


7.2 Key Result: The Adapted Societal Cost Test (SCT)

The adapted SCT provides a more comprehensive view of results, and yielded a Benefit/Cost ratio of 2.64, and a projected NET benefit (after costs, NPV basis) of $514.1M through 2035. Details are provided in the table below.

Adapted SCT	
	NPV (2019 - 2035)
Benefits Delivered To Rate Payers (non-EV load only)	
Benefit: Avoided Wholesale Generation Costs (ChIPE, $)	$53,912,238
Benefit: Avoided Non-Wholesale (C-T-D) Costs Thru Dilution ($)	$116,377,949
Total Avoided Electricty Costs ($):	**$170,290,187**
Benefits Delivered To Society At Large	
Benefit: Value Of Avoided Emissions ($)	**$123,546,849**
Costs And Benefits For EV Owner/Operators	
Cost: Vehicle Purchase Premium	$116,901,771
Benefit: Net Value Of Savings On Operating Expense ($)	$473,804,080
Benefit: Federal Tax Credits	$59,393,673
Total Net Benefits For EV Owners/Operators ($):	**$416,295,982**
Costs - Utility Investments Recovered From Rate Payers	
Costs: Charging Infrastructure ($)	$1,224,692
Costs: Customer Acquisiton and Outreach ($)	$189,573
Costs: Other Program Costs ($)	$707,583
Costs: Grid Reinforcement ($)	$56,109,509
Total Utility Investment Costs ($):	**$58,231,357**
Costs - Non-Utility Market Participants	
Costs: Charging Infrastructure	**$137,810,468**
Total NET Benefit (benefits minus costs, NPV):	**$514,091,193**
Total Benefits (NPV):	**$827,034,789**
Total Costs (NPV)	**$312,943,596**
Benefit To Cost Ratio (based on NPV):	**2.64**
Net Impact Per PEV Purchased Over The Period (based on NPV)	**$2,231**
Average Net Benefit Per Year (2019-2035, $/Yr):	**$63,495,806**

The following diagram compares the costs and benefits associated with the SCT, and the net benefit that results.

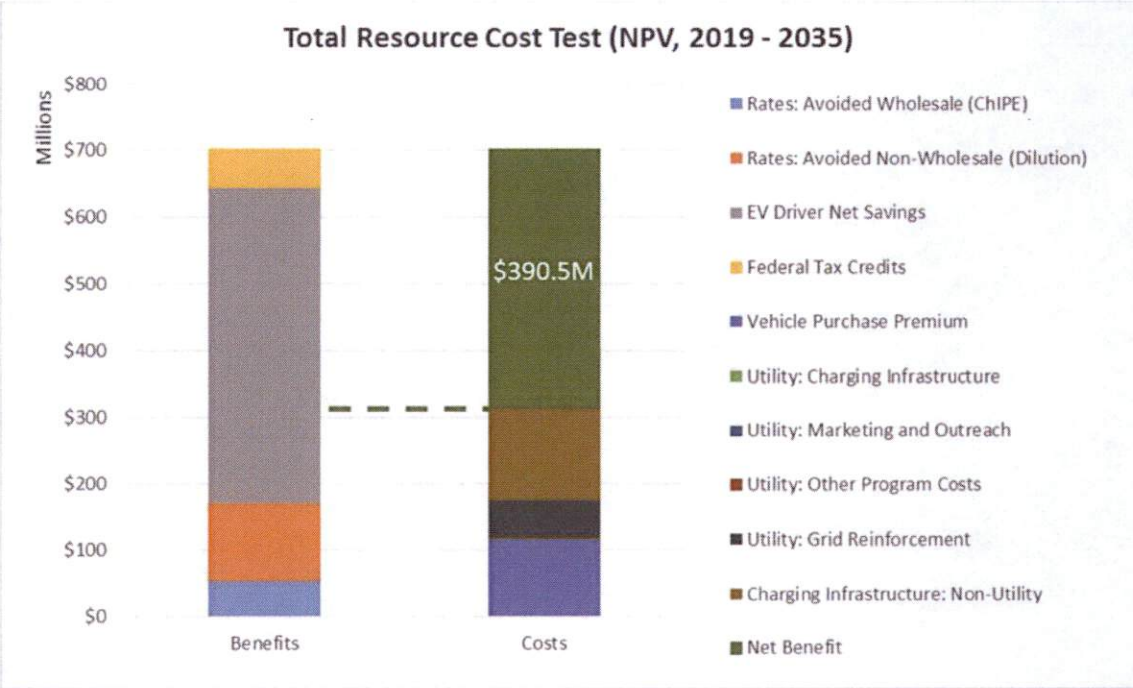


7.3 Key Result: The Adapted Total Resource Cost (TRC)

The adapted TRC yielded a Benefit/Cost ratio of 2.25, and a projected NET benefit (after costs, NPV basis) of $390.5M through 2035. Details are provided in the table below.

Adapted TRC	
	NPV (2019 - 2035)
Benefits Delivered To Rate Payers (non-EV load only)	
Benefit: Avoided Wholesale Generation Costs (ChIPE, $)	$53,912,238
Benefit: Avoided Non-Wholesale (C-T-D) Costs Thru Dilution ($)	$116,377,949
Total Avoided Electricty Costs ($):	**$170,290,187**
Costs And Benefits For EV Owner/Operators	
Cost: Vehicle Purchase Premium	$116,901,771
Benefit: Net Value Of Savings On Operating Expense ($)	$473,804,080
Benefit: Federal Tax Credits	$59,393,673
Total Net Benefits For EV Owners/Operators ($):	**$416,295,982**
Costs - Utility Investments Recovered From Rate Payers	
Costs: Charging Infrastructure ($)	$1,224,692
Costs: Customer Acquisiton and Outreach ($)	$189,573
Costs: Other Program Costs ($)	$707,583
Costs: Grid Reinforcement ($)	$56,109,509
Total Utility Investment Costs ($):	**$133,305,550**
Costs - Non-Utility Market Participants	
Costs: Charging Infrastructure	**$137,810,468**
Total NET Benefit (benefits minus costs, NPV):	**$390,544,344**
Total Benefits (NPV):	**$703,487,940**
Total Costs (NPV)	**$312,943,596**
Benefit To Cost Ratio (based on NPV):	**2.25**
Net Impact Per PEV Purchased Over The Period (based on NPV)	**$1,695**
Average Net Benefit Per Year (2019-2035, $/Yr):	**$47,685,141**

The following diagram compares the costs and benefits associated with the TRC test, and the net benefit that results.



8 Discussion

The merit test results presented in Section 7 build upon detailed analysis of the benefits that result from EV adoption, with projected impacts across a variety of populations. In most cases, assumptions and methodology choices were made to ensure the analysis was as transparent and conservative as possible. Taken together, we believe these benefit estimates to be a lower bound on the actual impact. There are a variety of factors that were not included in the analysis, which if accounted for, would likely make the benefit portfolio even stronger:

a) Wholesale market modeling demonstrates that EV charging – if done at optimal off-peak times – will decrease the average wholesale cost of electricity. This analysis accounts for that benefit *only for DPL-DE consumers.* In fact, that impact would apply across all of PJM, and could deliver reduced electricity costs to consumers in other states as well. That benefit is not accounted for. In addition, this analysis does not account for EV adoption that may be happening in other PJM states, and which could beneficially impact Delaware consumers as well. There will be a synergistic impact for all PJM consumers from EV adoption happening simultaneously in multiple states, and that dynamic is likely to increase the electricity cost benefits quantified in this Delaware-focused analysis.

b) This analysis makes very conservative assumptions about long term gasoline prices. The EIA projection for gasoline prices (as scaled to Delaware conditions) was used through 2025, but only HALF the EIA growth rate was used from 2026 to 2035. This assumption is consistent with widespread EV adoption, which should soften overall petroleum demand and depress prices. Similar dynamics are already evident in the global market due to EV adoption in Europe and China especially. If, however, gasoline prices retain strength, or are more in line with the long term EIA forecast, then the savings projected for EV drivers fueling their vehicles with electricity rather than with gasoline could be higher, potentially much higher.

c) If gasoline prices decline long term, in response to widespread EV adoption, those lower prices will benefit NON-EV drivers fueling their traditional vehicles as well. This impact is potentially very large since it applies to all drivers. That potential impact is not considered in this analysis.

d) The analysis assumes an upgrade of approximately half of the single phase transformer base by 2035. Those upgrades will likely bring benefits beyond just supporting additional EV load. Instrumentation, overall capacity, and resiliency of the grid could also be improved. In addition, many of the transformers would have likely been replaced for other reasons (age, loading, etc.), in which case assuming an EV-driven replacement could be duplicative. To be conservative, however, this analysis "booked" the costs of all transformer replacements solely against EV-related benefits, but it is possible that costs could be lower (since some transformers are already being replaced for other reasons), and not all benefits associated with those upgrades are captured.

e) This initial analysis quantified the value of reduced emissions based on CO_2, NO_X, and SO_2 impacts only. EVs are also likely to reduce other criteria pollutants, especially volatile organic compounds (VOCs) and particulates. More complete consideration of other emissions and pollutants could increase those benefits substantially.

f) Managed charging only captures trough fill of the aggregate load curve (i.e. adding additional load to underutilized periods at night, through one-way charging), not peak shaving (i.e. using electricity stored in vehicles to offset peak generation through two-way charging). If those impacts are included, cost efficiencies increase and electricity costs could decline further.

g) Economic impacts of public health implications are probably significantly under-represented. The studies that provided the factors used to assess the economic value of reduced emissions acknowledge that they only partially account for public health impacts.

h) The full benefits of increased electricity infrastructure utilization may not be fully captured, especially for the power plant fleet. The forecasts on capacity costs, in particular, assume essentially "business as usual" regarding plant utilization. To the extent a more optimal load increases capacity factors across the generation fleet, capacity prices may decline as well. That would increase the benefit-cost realized by electricity consumers.

i) This analysis considered only light duty vehicles consuming gasoline, which accounts for the overwhelming majority of the vehicle miles travelled. However, electrification is beginning to grow in other vehicle segments as well, including buses, delivery trucks, and long haul transport. Diesel displacement by electrified vehicles is very likely to happen in lockstep with the light duty vehicle transition, and would provide significant additional benefits. Note that the utility EV program proposal should help to encourage electrification for medium and heavy duty vehicles, especially school buses, but those diesel-specific impacts are under-represented in this analysis.

j) The results of the asset dispatch simulation are predominantly based on "business as usual" assumptions about the generation fleet in PJM. If the grid gets cleaner in parallel with increased EV adoption, the benefits quantified in this study (especially the environmental ones) will be stronger. Note that the utility program intends to secure 100% class I renewable energy for all the electricity consumed by the public charging stations, as well as a clean energy option for residential customers (see Section 5.1). That impact was not quantified in this study, and if it were, would make the benefits noted stronger.

Beyond the economic and environmental impacts of increased EV adoption quantified in this study, there are a wide variety of more qualitative benefits that also apply. Based on a survey of existing literature, the following general outcomes could reasonably be expected to result from increased EV use, most of which are directly related to the reduced use of petroleum.

a) The beneficial impact of reduced air emissions will likely accrue disproportionally along travel corridors and in urban centers. There are therefore significant social equity implications to widespread EV adoption resulting from improvements to air quality in urban centers and along travel corridors where low income and environmental justice communities are often located.

b) The EVs introduced to date have been well rated from a safety perspective, and EVs benefit especially from a low center of gravity due to the typical under-carriage placement of the batteries. Widespread EV adoption could therefore reduce vehicle-related safety risks for the traveling public.

c) EVs are much quieter than traditional vehicles, and reduced vehicular noise will be a significant benefit along some travel corridors. There is a related risk that needs to be addressed as well, which is that EVs are so quiet that pedestrians may be unaware of approaching vehicles, especially those pedestrians that suffer from sight-challenges and depend on vehicle noise indicators to navigate safely. Standards are now emerging that will require a minimum level of warning noise at low speeds to address this concern.

d) EVs can be used to provide power to the home in the event of a grid outage, although this feature is still a new capability for most currently available vehicles. There are therefore potential resiliency benefits from "stored on-site power" in the residential sector.

e) A significant fraction of the US trade deficit is related to the use of imported petroleum. As EV use increases, petroleum use, especially imports, will decline. Widespread vehicle electrification could therefore have a strong positive impact on the overall US trade balance.

f) The geopolitical implications of the existing petroleum industry are substantial, including impacts on where conflict zones emerge, global trade balances, the fact that petroleum revenues are a primary source of income for terrorist organizations, etc. The geopolitical implications of a world with dramatically reduced petroleum use are profound.

g) The majority of the transportation sector depends primarily on a single source of energy: petroleum. An added advantage of "fueling" vehicles with electricity is that electricity generation benefits from a highly diversified base of primary sources – potentially including lower carbon sources in the future. Overdependence on petroleum as the sole source for transportation energy is evident through the recurring impact increased oil prices have on the broader economy. Vehicle electrification therefore provides significant strategic benefit through diversification of the primary energy supplies that support the crucial transportation sector.

h) This analysis assumed "business as usual" for both the existing generation base and future additional capacity, consistent with current industry practice. However, profound shifts are happening in the supply mix in parallel with growing EV adoption, particularly regarding a shift to class I renewable sources. There are likely significant synergies between the *simultaneous* adoption of EVs and a shift to carbon free renewable generation. This synergy happens in both directions: a) the existence of more grid-integrated storage (in the form of vehicle batteries) could help firm the intermittent supply associated with solar and wind, and b) every carbon-free kwhr generation by solar or wind is not just displacing traditional fossil-fuel generation, but also highly inefficient combustion of petroleum in vehicles. As the supply mix becomes cleaner, the "clean-up" factors noted in this analysis, especially regarding reduced CO2 and NOx, will become stronger and result in greater reduced emissions benefit.

Vehicle electrification is happening in parallel with other profound changes in personal mobility, including a) autonomous vehicles, b) an increase in car sharing and ride hailing, c) connected vehicles (that are communicating with each other, with the road, and with external information points), and d) an increased focus on the needs of urban drivers. Some projections of EV adoption attempt to account for these simultaneous trends, including an eventual decline in personal vehicle ownership. We acknowledge the existence of these parallel trends, but our research into this topic suggests that although WHO is doing the driving, or who OWNS the vehicle may be changing, the amount of travel activity changes little. For example, if private vehicle ownership goes down due to car sharing, average miles traveled per vehicle goes up since shared vehicles have much higher utilization. For purposes of this analysis, the primary consideration is the amount of energy involved, and that is tied to the amount of travel being done (and other factors like vehicle efficiencies, etc.). Therefore, to simplify the analysis and minimize the number of assumptions that must be made, this study assumed a continuation of current vehicle and travel trends, as justified by the expectation that total energy usage projections remain representative despite the possibility of other simultaneous changes taking place.

Much of the infrastructure analysis focused on residential charging (where most of the charging is actually done), workplace L2 chargers, and public chargers (L2 and DCFC) – consistent with current industry experience. New trends are emerging in which specialized charging infrastructure may be advantageous. Examples include "charging barns" (for taxis or shared vehicles), community charging hubs, en-route chargers for electric buses, and very high power chargers for long haul vehicles. These changes probably won't impact the ENERGY assumptions this study is based on, but may call for the development of more specialized charging infrastructure, typically on commercial circuits, with a need for specialized interconnection engineering.

Finally, the study recognizes that the utility program is proposed for TWO reasons: 1) serving a growing new need by consumers responsibly (vehicle charging), and 2) addressing adoption barriers that help encourage adoption. In the first case, utility involvement is *needed* in response to changing consumer loads, while in the second case utility programs are *desired* since they can reduce consumer barriers, which increases adoption, ensures and maximizes benefits, and helps ensure that those benefits are delivered equitably to utility customers. This analysis is based on the expectation that the proposed utility program serves both needs. EV charging is a new load that must be supported by the utility, just like any other emerging load trend in the past (such as home air conditioning) – so part of the utility proposal is needed to accommodate this change in consumer need. In particular, it is prudent for the utility to encourage managed charging so as to minimize potential harmful impacts on the grid (longer term), and to maximize benefits. At the same time, however, the program also addresses barriers that ensure a stronger growth profile and therefore helps realize the substantial benefits that widespread EV use can bring. The EV adoption growth assumptions are predicated on removal of current barriers, for which the utility program is making a critical contribution. The EV adoption forecast is therefore a combination of existing adoption rates within the territory, as augmented by projections of a strong growth due to a supportive marketing environment as enabled (in part) by the utility program. Deployment of public DCFC infrastructure is expected to be a particularly impactful market development investment, since a) lack of convenient public charging infrastructure is one of the most significant consumer adoption barriers, b) those assets are used by all EV drivers, and c) some of the costs of those systems are recovered through user fees.

9 Conclusions

This study quantified the impacts that increased EV adoption are projected to have in the DPL-DE territory. Beneficial impacts were identified based on lower overall electricity costs, reductions in emissions and other pollutants, and cash flow savings for EV drivers through lower vehicle operating expenses. These recurring annual benefits are substantial, totaling a projected $1.6B through 2035 (nominal sum), with an NPV of $767.6M and an average benefit of $94.6M per year over the period. The lower electricity costs accrue to ratepayers overall (not just EV drivers): these utility customers are projected to average $26.50 per household in annual savings over the period. This savings is significantly larger than projected household bill increases from the proposed utility programs. EV drivers are also projected to save an average of $2,056 per year (per EV) on operating expense over the period.

This growing use of EVs is projected to displace 310 million gallons of gasoline over the period, resulting in a reduction of CO_2 emissions by 2,076,234 tons by 2035. Electricity consumption is projected to increase by 572 GWhrs per year in 2035, and vehicle charging will induce an additional 2,152,347 MWHrs of electricity sales over the period. If managed charging becomes dominant, there is projected to be only a modest impact on either generation assets or transmission capacity: the PJM-coincident peak increases by only 36.5 MW in 2035. Encouraging optimal off-peak charging is a key objective of the residential smart charging program included in the utility proposal. Absent influences to ensure residential charging at optimal times, peak loading impacts induced by vehicle charging are likely be much larger – in an extreme worst case, adding as much as 25% to peak loading by 2035.

In support of these increased loads, and to reduce consumer adoption barriers and encourage strong long term EV growth, the utility is proposing a program that provides equipment and services, primarily for EV charging infrastructure. After considering the costs of the proposed utility support program, the costs of grid reinforcement that may be required, and costs by others as part of EV adoption, the net benefit is projected to be positive in all cases. Three merit tests – based on adapted versions of the RIM, SCT, and TRC tests – demonstrate positive benefit/cost ratios (over 1.0) and strong NET benefits (after accounting for costs). Even in the most limited case – where utility costs are balanced against benefits realized directly by ratepayers through lower rates – benefits exceed costs. More generally, the broader tests demonstrate that society overall is better off given the net benefits. Given these results, there is strong justification for the proposed utility EV program which helps jumpstart and seed the market as necessary to achieve the adoption levels that deliver the benefits quantified.

10 Appendix A: Additional Details On Analysis Methodology

Section 4 provided a high level summary of the scope, assumptions, and methodology for the study. Additional details are provided below:

1. Analysis Window: The benefit-cost analysis covers the period 2019-2035. This analysis window is considered appropriate since a) the proposed utility program will be implemented primarily in 2019, but with operating impact thereafter, b) many of the new EVs put into service during the program period will remain in operation over this window, c) many of the customers directly impacted by the utility program will help stimulate additional EV adoption over time (word of mouth, consumer familiarity, growing industry scale and lower costs, etc.), and d) some of the assets implemented by the program – especially public charging infrastructure – will have an operating life through 2035 at least.

2. PEV Adoption: The PEV adoption forecast is based on a) the historical BEV and PHEV sales rates in Delaware, b) extrapolation of sales at 40% for BEVs and 30% for PHEVs, and c) retirement of both BEVs and PHEVs after eight years in service. The overall size of the light duty fleet is not projected to deviate significantly from historical trends as a result of electrification. The assumption of 40% and 30% growth rates is based on comparing key market condition benchmarks for Delaware with other EV adoption states. BEV sales growth year/year averaged 63.3% (2016-2017), and PHEV sales growth averaged 50.0%. Longer term, BEV sales are expected to strengthen as battery prices decline and PHEVs lose their price advantage over BEVs. The PEV forecast assumes continued availability of current incentives, and supportive utility programs that reduce adoption barriers for consumers. The statewide forecast for the DPL-fraction of Delaware was assumed to be 70%, scaled by electricity consumption of the state vs the DPL territory as determined from EIA form 861 and 861S for 2016. This percentage was scaled up slightly to account for the fact that New Castle is within the DPL territory, consistent with population distribution for the state.

3. Savings Basis: Savings will be computed as the difference between total costs WITH EV adoption (as per the adoption profile above) relative to a baseline of "no EVs", which essentially means assuming no additional EVs sold beyond what is already in the market. This method provides an appropriate method of quantifying the impact of EV adoption overall.

4. The overall market simulation is applied against PJM overall, as induced by DPL-DE load. Those consumption results are then scaled to the DPL-DE territory based on the fraction of DPL volume in Delaware. This fraction is computed based on the baseline DPL consumption for 2019 – 2022 (from Aurora) compared with the utility forecast for DPL-DE over the same period. Based on this analysis, 42.62% of PDPL consumption is in Delaware, and this is assumed to be constant over the analysis period.

5. Capacity and Transmission costs based on a forecast by Gabel Associates using data provided by PJM on current and projected capacity costs. Other PJM cost factors taken from PJM references[16].

6. Discount Rate: All Present Value calculations are based on a discount rate of 5.5%.

7. Drive Patterns: Travel statistics, especially regarding average miles traveled per day, are based on the Light Duty Vehicle (LDV) fraction of total VMT[17], including passenger cars, crossovers, SUVs, minivans, and pickup trucks, divided by the number of vehicles in the applicable weight classes, based on publicly available sources[18].

8. Statistics For Traditional Vehicles (Internal Combustion Engines): Existing traditional vehicle performance will be based on the national fleet average (MPG), beginning at 22.1 MPG in 2019[19], and growing by 0.2 MPG annually through the analysis period. MPG for the fueled miles of PHEVs will be based on the average of MPG quoted for PHEVs currently on sale in the U.S. (39.0 MPG, flat through the analysis period).

9. PEV Statistics: Efficiency parameters for PEVs are based on the sales weighted average (YTD 2018) of specifications for vehicles currently on sale in the U.S[20]. This assumes 3.6 miles/kwhr for BEVs in 2019, and 2.63 miles/kwhr for PHEVs in 2019. The BEV efficiency changes slightly over time reflecting duel impacts from a) improving powertrain design, and b) increased penetration of heavier vehicles and form factors. The BEV factor plateaus at 3.9 miles/kwhr in 2025, and the PHEV factor is constant over the period.

10. Charging Segmentation: The same six-segment EVSE segmentation model developed for the ChargEVC-NJ study was used[21].

11. Charge Scheduling: Managed charging will be assumed, based on the same methodologies used in the ChargEVC-NJ study[22]. This profile accounts for charging through all six segments, but forces residential charging to be between 10PM and 7AM. The same schedule is assumed for all years in the analysis window, and for both private and multi-family residents. All days are assumed to be equal regarding both travel and charging (i.e. no distinction for seasonality or day-of-week variations).

12. Cost of Gasoline: $/gallon data for each territory from the price tracking website gasbuddy.com, with extrapolation through 2035 based on EIA projections[23]. The EIA growth rate is used through 2025, but only HALF the EIA growth rate was used from 2026 to 2035 to reflect reduced gasoline prices that are expected to result from EV adoption and reduced petroleum demand.

13. Infrastructure Tax Adders: An operating expense for EV drivers is added that is equivalent to the federal and Delaware gas tax to ensure that infrastructure funding is continued long term. Based on the current gas taxes for Delaware ($0.230/gallon for Delaware, plus $0.184/gallon federal), that rate is $0.0186/mile for an average vehicle (in 2019), declining slightly over time as MPG increases.

14. Vehicle Emissions: Emissions per gallon of gasoline were taken from the 2013 update of the federal MOVES database[24], based on E10 gasoline blend.

15. Economic Value Of Reduced CO_2 Emissions: To determine the economic value of reduced CO_2 emissions, the analysis used the "Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866" produced by the Interagency Working Group on Social Cost of Greenhouse Gases, United States Government, as updated August 2016. Specifically, the analysis used the "3% Average" case which represents a mid-point of the three primary CO_2 cost scenarios. This analysis, when adjusted to nominal dollars in each year of emissions, provides an economic estimate of the value of avoided CO_2 emissions.

16. Economic Value Of Reduced NOx and SO_2 Emissions: To quantify the benefits of SO_2 and NOx reductions, Gabel reviewed the Environmental Protection Agency (EPA) benefit-cost-analysis associated with the Cross-State Air Pollution Rule (CSAPR), which replaced the Clean Air Interstate Rule as of May 1, 2017 [source: https://www.epa.gov/csapr/presentation-proposed-air-pollution-transport-rule]. EPA's analysis is a very comprehensive assessment of the social costs associated with power plant emissions and the health benefits created by the reduction of those emissions. SO_2 and NOx contribute to ground-level ozone and acid rain and are precursors to the formation of airborne particulate matter, i.e. PM2.5. PM2.5 is too small for human lungs to filter out and causes a wide variety of respiratory illnesses resulting in health care costs, lost workdays, and premature death. Based on this analysis of emissions reductions and their associated health and social benefits, Gabel calculated a $/ton benefits value for both SO_2 and NOx.

17. EV Driver Savings: All EV drivers operating expense savings will be based on the average costs for electricity (plus the gasoline tax replenishment adder), the projected gasoline costs, average vehicle MPG and efficiency, and maintenance costs (for EVs vs. traditional vehicles) as estimated in an independent study by AAA[25].

18. Vehicle Charging Electricity Costs: The model computes the average cost of electricity, across all segments, for each year of the study period, based on the aggregate load curve. When computing vehicle charging costs at home, the residential rate for electricity is used, which is typically several cents/kwhr higher than the overall average. The residential adjustment is based on the most recent data from EIA comparing average electricity rates and residential rates[26].

19. Federal Vehicle Purchase Premium: The vehicle purchase premium for PEVs compared with traditional vehicles is based on a California study on that topic (San Diego Gas and Electric Company, Filing to the California Public Utilities Commission on April 11, 2014, Chapter Six, direct testimony of J.C. Martin). The premium for BEVs and PHEVs in 2018 is assumed to be $9,660 and $8,979 respectively, and declines relatively linearly to zero in 2031.

20. Non-Utility Charging Infrastructure Investments: Vehicle charging infrastructure requirements are based on factors for Delaware from the DOE National Infrastructure study,

September 2017, specifically for Delaware. Both workplace and public L2 plug-count were based on the overall PEV sales rate (BEVs and PHEVs), while public DCFC plug-count was proportional to BEV sales. The factors used were 0.03000, 0.02200, and 0.00387 plugs per relevant vehicle (workplace, public L2, and public DCFC respectively), held constant over the analysis period. Residential L2 chargers were assumed to be needed for 100% of new BEV sales, and 25% of new PHEV sales (many PHEVs, with smaller batteries, can be charged easily overnight with a standard L1 charger, as included with the vehicle).

21. Utility EV program costs include all programs proposed, in aggregate.

End Notes and References

[1] EV sales taken from the Auto Alliance Advance Technology Vehicle Sales Dashboard: Statistics compiled by the Alliance of Automobile Manufacturers using information provided IHS Markit, Data last updated 4/25/18, retrieved May 2018 from https://autoalliance.org/energy-environment/advanced-technology-vehicle-sales-dashboard/.

[2] EVs are assumed to retire from the fleet after eight years, consistent with most EV warranties being between eight and ten years. Note that although many EVs are leased for shorter periods (typically three years), those vehicles usually remain in the fleet as a used car and are therefore counted as still being in service.

[3] The forecasted blended growth rate of 34.9% is close to the Navigant base case CAGR for Delaware of 37% (through 2027).

[4] American Community Survey for Delaware, 2012-2016.

[5] Delaware Housing Fact Sheet, 2016, from the Delaware State Housing Authority.

[6] Federal Highway Administration, State Statistical Abstracts, for the state of Delaware 2015.

[7] Delaware's 2010 Greenhouse Gas Emissions Inventory, Final Report, prepared by the Division of Air Quality, published February 2014, Delaware Department of Natural Resources and Environmental Control.

[8] Detailed physical infrastructure impact studies were completed for a utility in New Jersey as part of the ChargEVC market opportunity assessment (Electric Vehicles in New Jersey – Costs and Benefits, ChargEVC, principle investigator Mark Warner, Gabel Associates Inc and Energy Initiatives Group LLC, January 26, 2018), and also specifically for the utility infrastructure on Long Island (Electric Vehicles On Long Island – Costs and Benefits, Principle Investigator: Mark Warner, Gabel Associates Inc. and Energy Initiatives Group LLC, May 4, 2018).

[9] Revised and Prepared Direct Testimony of J.C. Martin, Chapter 6, on behalf of San Diego Gas & Electric Company, Application for approval the company's electric Vehicle-Grid Integration Pilot Program, Filed April 11, 2014, Table 6-6.

[10] As a cross-check on these vehicle purchase premium assumptions, prices for the 2018 Hyundai Ioniq were compared. This vehicle is unique in that the EXACT SAME VEHICLE is available in three different drivetrains: basic hybrid (with no plug), a plug-in hybrid (with 28 miles of electric range), and a pure battery electric vehicle (with 118 miles of electric range). This particular vehicle makes it easy to provide a strong apples-to-apples comparison between vehicles that have identical features and differ only by drivetrain. The Ioniq Plug-In Hybrid has an MSRP premium of between $800 and $2,750 depending on trim level, compared with the non-plug-in hybrid. The pure battery electric has an MSRP of between $5,000 and $7,300, depending on trim level, compared with the non-plug-in hybrid. These data points, based on a real vehicle for sale in U.S. market in 2018, substantiates the numbers from the California study (as projected into 2018 and beyond), after accounting for the relatively modest electric range of the Ioniq compared to the average EV range assumed in the analysis (40 miles for the PHEV, at least 200 miles for the BEVs).

[11] National Plug-In Electric Vehicle Infrastructure Analysis, US DOE, Office Of Energy Efficiency and Renewable Energy, September 2017.

[12] California Standard Practice Manual, Economic Analysis Of Demand Side Programs And Projects, California PUC, October 2001. This reference can be found at the online reference below:
http://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy_-_Electricity_and_Natural_Gas/CPUC_STANDARD_PRACTICE_MANUAL.pdf

[13] Revised and Prepared Direct Testimony of J.C. Martin, Chapter 6, on behalf of San Diego Gas & Electric Company, Application for approval the company's electric Vehicle-Grid Integration Pilot Program, Filed April 11, 2014.

[14] California Transportation Electrification Assessment, Phase 2: Grid Impacts, October 23, 2014

[15] Cost-Benefit Analysis of Plug-In Electric Vehicle Adoption in the AEP Ohio Service Territory, E3 Consulting, April 2017.

[16] State of the Market Report for PJM, by the Independent Market Monitor, March 08, 2018, Volume 1: Introduction

[17] Federal Highway Authority, Vehicle Miles Traveled by functional system, by State (Table VM-2), years 2007 – 2016.

[18] Federal High Administration, Table MV1, Vehicle Registrations 2016

[19] On-Road Fuel Economy of Vehicles in the United States: 1923 – 2015, Michael Sivak and Brandon Schoettle, University of Michigan, Report No SWT-2017-5, March 2017

[20] PEV performance statistics based on an analysis by Gabel Associates of all PEVs for sale in the US market as of the end of 2017, based on specifications published by vehicle manufacturers. All range specifications are based on EPA ratings for each vehicle.

[21] Electric Vehicles In New Jersey, Costs and Benefits, Prepared for ChargEVC by Gabel Associates Inc, Mark Warner, January 26, 2018

[22] Real world time-of-day charging distributions for each of the charging segments was collected from industry partners in the ChargEVC coalition. This information was augmented by research from UC Davis, Institute of Transportation Studies, Working Paper – UCD-ITS-WP-13-01, "California Statewide Charging Assessment Model of Plug-In Electric Vehicles: Learning from Statewide Travel Surveys:, January 2013, Michael A Nicholas, Gil Tal, Justin Woodjack.

[23] EIA 2018 Energy Outlook, forecast of nominal price of motor gasoline use in the transportation sector (national average). This information was scaled from national average pricing to state-specific pricing using information from the EIA State Profiles, Table E16, Motor Gasoliine Price and Expenditure Estimates, Ranked by State, 2015.

[24] Updated Emission Factors of Air Pollutants from Vehicle Operations in GREET Using MOVES, Hao Cai, Argonne National Laboratory, Energy Systems Division, September 2013.

[25] Your Driving Costs, American Automobile Association, 2017 Edition

[26] Energy Information Agency, Electric Power Monthly, published February 2018 with data through December 2017, Table 5.6.B.

E-2, Sub 1197 and E-7, Sub 1195
Public Staff - Exhibit C

Electric Vehicle Charging Update

Florida Public Service Commission
Office of Industry Development and Market Analysis
September 2018

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Section 1. Executive Summary

On July 1, 2012, Chapter 2012-117 Laws Of Florida became effective creating Subsection 366.94(4), Florida Statutes. This subsection required the Florida Public Service Commission (Commission) to study the effect of electric vehicle (EV) charging on both energy consumption and the electric grid in Florida, as well as the feasibility of using off-grid solar photovoltaics (PV) for EV charging. In December of 2012, the Commission published the Report On Electric Vehicle Charging (2012 Report).[1]

The Commission reported the following general findings and conclusions in the 2012 Report concerning electric vehicles, effects on energy consumption and the electric grid, and the feasibility of solar PV for off-grid charging:

- All-electric and plug-in hybrid electric vehicles (PHEVs) are considered a niche product that are, and will continue to be, a small percentage of total vehicles sold each year
- EV charging is expected to have a negligible effect on electricity consumption in Florida within the ten-year planning horizon
- EVs are not currently expected to cause a significant increase in electric demand or contribute significantly to a need for new generation
- Individual vehicle charging is not expected to affect distribution systems; however, clusters of vehicles charging simultaneously may potentially require older transformers to be upgraded or replaced
- “Quick-charge” stations may pose potential challenges for distribution systems
- The use of off-grid solar photovoltaics for EV charging is technically feasible, but may only be practical in unique circumstances due to economic considerations

Keeping with the Commission’s objective to monitor electric vehicle charging and its potential impacts on utility infrastructure and planning, the Commission convened the Electric Vehicle Charging Roundtable on October 17, 2017. This event provided interested stakeholders the opportunity to present information and discuss issues concerning the impacts of electric vehicle charging on electric energy consumption and the state’s electric grid.[2] Up-to-date information and estimated future impacts were presented by Florida’s utilities, electric charger manufacturers, vehicle manufacturers, and trade representatives. This report provides an update to the 2012 Report based on information presented at the Electric Vehicle Charging Roundtable as well as other data and current forecasts from federal agencies and other involved industry groups. Additionally, this report addresses and supports the conclusions in the 2012 Report.

As presented in this update to the 2012 Report, the market for all-electric vehicles and plug-in hybrid vehicles is expanding with more car manufacturers offering more models for purchase. However, the EV market is still considered a niche market representing a small percentage of total vehicles sold each year. Therefore, EV charging is not expected to have a material impact

[1] http://www.floridapsc.com/Files/PDF/Publications/Reports/Electricgas/Electric_Vehicle_Charging_Report.pdf#search=electric%20vehicle.
[2] See Appendix B. for a summary of the 2017 Roundtable presentations and comments.

on the demand for electricity or contribute significantly to a need for new generation through Florida's current electric utility planning cycle (2018-2028). The 2012 Report noted a concern that clustering of chargers in an area served by smaller transformers may result in the need to upgrade these transformers. To date, there have been no reported power outages caused by the operation of an EV charging station in Florida. Finally, the use of off-grid solar photovoltaics for EV charging remains technically feasible, but due to economic considerations, this type of charging will likely be considered for deployment in a limited number of unique circumstances.

Section 2. Introduction

After publishing the 2012 Report, the Commission continued to monitor electric vehicle charging and its potential impacts on utility planning. The term EV refers to all-electric vehicles, including plug-in hybrid electric vehicles (PHEVs). Non-plug-in hybrid electric vehicles (HEVs), which make-up the largest portion of the electric vehicle market, were not included in the 2012 Report or this update because these vehicles use electricity generated by an on-board gasoline engine and therefore will not impact the statewide electrical grid.

As part of its monitoring activities, the Commission annually collects utility information addressing EVs and EV charging impacts on the electric grid as part of the electric utility ten-year site plan review. Additionally, on October 17, 2017, the Commission convened the Electric Vehicle Charging Roundtable (2017 Roundtable) to once again gather information from stakeholders and examine the impacts of electric vehicle charging on electric consumption and the state's electric grid. Topics discussed during the 2017 Roundtable included:

- EV sales and charging forecasts through 2025
- Market developments and consumer preferences
- Planning for the future market and infrastructure needs
- Impacts on grid reliability and utility planning
- Future regulatory considerations

Presentations were provided at the 2017 Roundtable by the Edison Electric Institute, Drive Electric Florida, General Motors, Tesla, ChargePoint, EVgo, Florida Power & Light Company, Duke Energy Florida, Tampa Electric Company, Gulf Power Company, Florida Public Utilities Company, Orlando Utilities Commission, the City of Tallahassee, and the Florida Electric Cooperatives Association.

At the conclusion of this roundtable event, the Commission solicited additional comments from stakeholders. Five parties provided post-roundtable comments, including: ChargePoint, Florida Tesla Enthusiasts Group, Siemens AEE, Greenlots, and a private EV owner. In general, these comments addressed policies the Commission should adopt to support utility programs or activities that encourage growth in EV ownership, direct utility investment, ownership of EV chargers, and rate programs that would reduce the operating costs of EV charging and may provide other benefits for utility ratepayers.

Data requests were issued to many of Florida's electric utilities in December 2017 to gather more specific information regarding EVs and EV charging in their service territories. This report includes currently available data and a number of forecasts for EVs and EV chargers, including information presented at the 2017 Roundtable. The primary purpose of this report is to update and determine whether the conclusions identified in the 2012 Report are still relevant with developments in the EV market during the last five years.

Section 3. Background Data for Electric Vehicles

In 2012 the Commission staff held a workshop allowing stakeholders to present information and discuss issues relevant to EVs and the effects EV charging may have on Florida's electric power grid. As presented during the 2012 workshop, approximately 10 major automobile manufactures were offering a limited number of EV models to consumers during the 2012 model year. The Electric Power Research Institute (EPRI), one of the participants of the workshop, provided a three level forecast (low, medium, high) of estimated EV sales in Florida for the years 2012 through 2021. For 2012, EPRI estimated a range of sales from a low of about 1,040 vehicles to a high of 5,580 vehicles. Florida Power and Light Company (FPL) also provided a statewide forecast which estimated that about 6,222 EVs were located in Florida during 2012.

Staff reviewed data from the Florida Department of Highway Safety and Motor Vehicles while preparing the 2012 Report. In October of 2012, the Department reported that 28,403 vehicles were registered in Florida using the fuel type "electric". However, as noted in the 2012 Report, fuel type information is based on voluntary reporting by the vehicle owner and the category "electric" does not distinguish between EVs, PHEVs, or HEVs.

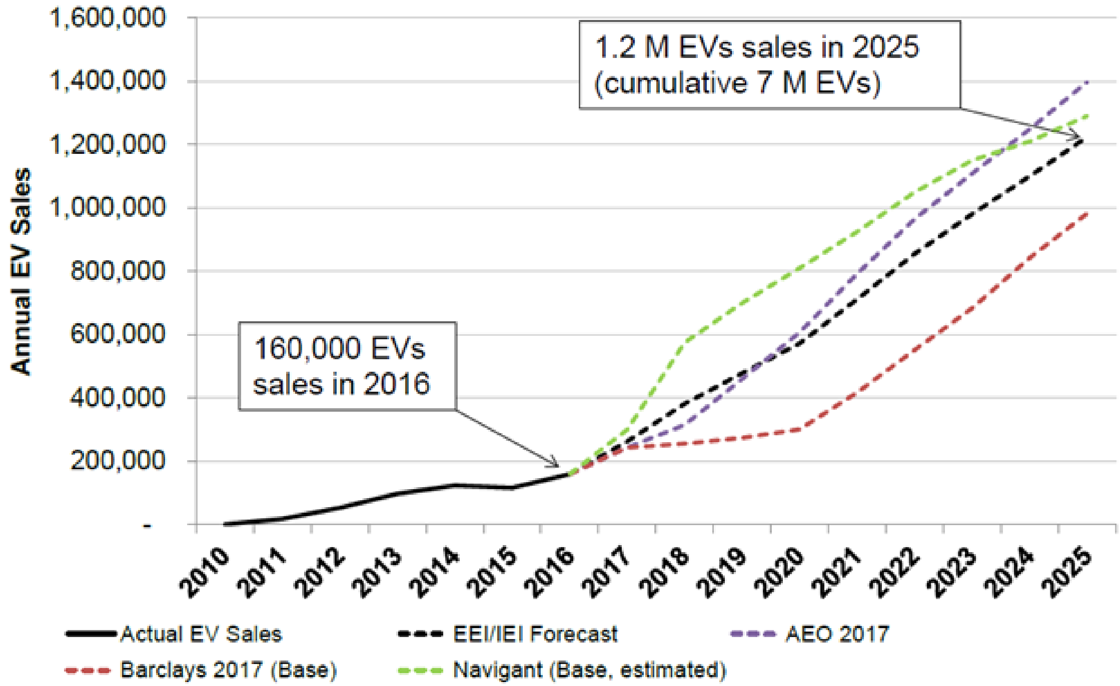
Differing projections for the development of the EV market were was also presented during the 2012 workshop. For example, FPL estimated that Florida would have about 73,000 EVs by 2017, while EPRI estimated a range between 36,140 to 142,950. The 2012 Report noted that EVs should be considered a niche product and presumed that EVs would likely be a small percentage of total vehicles sales each year.

This report addresses and considers information presented during the 2017 Roundtable and information from state and national sources. In early 2018, InsideEVs, a trade group for electric vehicles, reported that over 20 auto manufactures were offering 38 models of plug-in electric vehicles for sale in the United States and that over 690,000 electric vehicles have been sold in the United States since 2010.[3] InsideEVs also stated that 2017 sales in the United States of plug-in electric vehicles increased 32 percent over sales in 2016. The Florida Department of Highway Safety and Motor Vehicles showed in its October 2017 report that there were 23,452 electric vehicles registered in Florida.[4]

The Edison Electric Institute presented the following graph during the 2017 Roundtable showing forecasts by various groups of future EV sales in the U.S.

[3] InsideEVs.com, Plug-In Electric Vehicle Sales Report Card
[4] FDHSMV.gov, Vehicle and Vessel Report and Statistics

Figure 3-1
EV Forecast



Source: Edison Electric Institute

The Edison Electric Institute reported estimated national sales of EVs in 2016 of 160,000. This sales level is used as the starting point for all of the various forecast scenarios shown on the graph above. Edison Electric also presented what they called a “reality check” of their estimated 2025 EV sales forecast. They believe that based on just the stated sales goals of 5 of the 20+ EV manufactures, Edison’s forecast of 1.2 million EV sales in 2025 is obtainable and reasonable.

The U.S. Annual Energy Outlook Report presents sales and forecast information from automobile manufactures by different categories of vehicles. For EVs these categories include: 100 mile electric vehicle, 200 mile electric vehicle, plug-in 10 gasoline hybrid, and plug-in 40 gasoline hybrid. In its 2017 report, national sales for these types of vehicles during 2016 were reported as 163,785 units or approximate 2 percent of all new vehicle sales for the year. The report also presents sales for just the southeastern U.S. Reported southeastern EV sales for 2016 were 35,200 units or approximate 3 percent of new vehicle sales within the southeast. This trend of EV sales, being between 3 or 4 percent of all new vehicles, is projected to continue at least through 2028. The Energy Information Agency predicted that EVs will continue to make-up about 1 percent of all vehicle sales in the southeast during this same time period.

Based on a review of all of the above estimates, there appears to be general agreement that there has, and will continue to be, increases in the total number of EV’s in Florida. All of the forecasts put the total number of EVs as compared to all other vehicles at around 1 percent. The finding in the 2012 Report that EVs are a niche product still remains the case for 2017.

The 2012 Report also expressed uncertainty in obtaining accurate estimates of EV charging stations. This same concern remains and is similar to the uncertainty in estimating EVs in Florida. As shown in the 2012 Report, Florida's utilities estimated that a combined total of 1,459 Level 1 and 2 chargers were located within the state. No Level 3 chargers were reported to be in operation. At the 2017 Roundtable, Florida utilities made a similar estimate that predicted a combined total of 2,214 Level 1 and 2 chargers would be located in Florida by year end. These utilities also estimated that 52 Level 3 chargers would be in operation during 2017. The utilities did not identify how many of these Level 3 chargers would have public or private access. In January 2018, Tesla announced completion of its 28th "supercharger"(Level 3) station in Florida, all of which have public access[5]. PlugShare, an electric vehicle charging station location service, reported in February 2018, that a total of 343 public access charging stations are located in Florida. In contrast, the U.S. Department of Energy's Alternative Fueling Station Locator web site shows that 949 Florida stations were open to the public as of February 2018.

As noted in the 2012 Report, there continues to be no single group responsible for tracking the total number of electric vehicle chargers in Florida. Regardless, information that is available suggests that the number of public access charging stations is increasing consistent with the general trend in EV ownership.

In October 2016, the U.S. government granted final approval of a $14.7 billion settlement against Volkswagen for equipping more than 500,000 of its diesel vehicles to cheat U.S. vehicle emissions tests in violation of the Clean Air Act. Volkswagen will spend $10 billion on vehicle buybacks and $4.7 billion to mitigate the pollution from these cars and invest in green vehicle technology. The $4.7 billion settlement payments will be split into two distinct funds. Volkswagen will place $2.7 billion into an Environmental Mitigation Trust to fund projects that reduce nitrogen oxide emissions. The remaining $2 billion will go toward zero emissions vehicle investments to improve infrastructure access, and education to advance zero emission vehicles.

One such program is the funding of publicly accessible infrastructure to support zero emission vehicles. For Florida, the potential amount that could be allocated to the "Light Duty Zero Emission Vehicle Supply Equipment" program is approximately $22.8 million.[6]. This program can provide funding for the construction of new publicly available EV charging stations. Given this additional funding source, the number of publicly available EV charging stations should grow at a rate higher than expected without this program.

Consistent with the general findings in the 2012 Report, EVs are considered a niche product and will continue to make up a small percentage of total vehicles sold during the current Florida Electric Utilities' ten year site plan cycle (2018-2028). Determining the precise number and type of EV chargers in Florida continues to be difficult. Nevertheless, the information that is available would suggest that the number of public access charging stations is increasing consistent with the general trend in EV ownership.

[5] Tesla.com, Press Information, Charging
[6] Florida Department of Environmental Protection, Volkswagen Clean Air Act Civil Settlement

Section 4. Effects on Energy Consumption

The 2012 Report noted that growth in EVs was expected to lead to an increase in the total consumption of electricity and a decrease in the total consumption of petroleum-based fuels. Displacement of petroleum-based fuels will be based on the actual number of the different types of EVs and their overall market penetration. It was also noted that EVs may increase the consumption of electricity at times of high demand on the grid. This section of the report examines EV charging and changes in energy consumption patterns.

Growth in electrical energy consumption in Florida, due to EVs, has been modest to date and is expected to remain so throughout the current ten year utility planning cycle. Average electricity consumption per EV is estimated to be approximately 2,708 kilowatt hours (kWh) per year, or approximately 7.4 kWh per day. In 2017, a typical Florida residential customer consumed 13,031 kWh of electricity a year. If a typical Florida residential customer added an EV to their household, annual yearly consumption of electricity would increase to about 15,739 kWh.

As previously noted in the 2012 Report, the increase in total electricity consumption will not necessarily result in higher rates for ratepayers. However, EV owners will likely see an increase in their electric bills due to increased consumption of electricity from charging. If EV charging is primarily done off-peak, it could result in more efficient use of existing generation assets by the utilities. However, if large quantities of EVs are charged at peak demand in the same geographic region, it is theoretically possible that a need for new generation could occur.

The application of time-of-use rates can help utilities manage potential increases in utility peak demand due to EV charging. A time-of-use rate is a rate structure under which a customer pays a reduced rate for consuming electricity at off-peak times, while paying a higher rate at peak times. The ability of a utility to offer time-of-use rates has not changed since 2012 and as such remains a useful strategy for mitigating potential increases in peak demand due to EV charging.

Given the current size of the EV market in Florida, and the level of Florida utility reserves, growth in EV charging is not expected to cause a need for new generation. Likewise, it is not envisioned that any increase in base rates due to EV charging during times of peak demand in Florida will occur during the course of the utilities' current ten year planning cycle. If EV sales and market penetration vastly exceed current expectations, it is possible that the additional charging load could affect utility distribution systems and service reliability.

As presented in the 2012 Report, EV charging will affect energy consumption in Florida by increasing electricity consumption and lowering petroleum-based fuel consumption. The magnitude of these effects is highly dependent on the overall market penetration of EVs. While EVs may add an increasing amount of demand to the grid in Florida, the increase will be minimal. The current level of reserve margins of Florida's utilities will help prevent or delay any need for new generation due to EV charging. Additionally, time-of-use rates are a useful strategy to mitigate potential increases in peak demand that may be associated with EV charging.

Section 5. Impact on the Electric Grid

Since 2012, Florida's electric utilities have incorporated potential EV charging impacts into their respective ten year planning process.[7] They have concluded that there will not be any significant impact on the electric grid through 2030. However, the utilities also indicated that there may be instances where it would be necessary to retrofit facilities in order to address the addition of EV charging abilities, if currently served by a small transformer. EV charging is more likely to have an effect on the distribution network than on the generation or transmission systems.

The aspect of EV charging most likely to have an effect on the distribution system is the clustering of EV chargers. Multiple EV chargers operating simultaneously can collectively draw a fairly high electric load. While this effect is unlikely to result from a single Level 1 or Level 2 charger, multiple EV chargers operating simultaneously on a single transformer may exceed the design limitations of certain residential transformers. Therefore, some residential transformers may need to be upgraded or replaced in order to handle higher demand.

In 2012 there were no Level 3 chargers in Florida. Level 3 chargers, or "quick-charge" stations, can draw relatively high loads of 50 kW or more. At the time there was concern that public quick-charge stations may have an effect on the distribution system due to the higher load requirements. Since 2012, 52 Level 3 chargers have been installed in Florida. Unlike a Level 1 or Level 2 charger, a Level 3 charger typically requires the installation of additional distribution equipment, similar to what a utility would need to do when connecting a business with comparable load requirements. To date, there has been no report of a power outage caused by the operation of an EV charging station in Florida. The lack of outages to date suggests utility actions may be adequately addressing the effect of EV charging on the distribution system.

EV charging is more likely to require utility investment in upgrades to the distribution system than to trigger any need for additional generation. Any need for distribution upgrades would be localized and isolated. The aspect of EV charging most likely to require action by electric utilities will be clustering of electric chargers in a localized residential area. To date, there have been no reported power outages caused by the operation of an EV charging station in Florida.

[7] http://www.floridapsc.com/ElectricNaturalGas/ElectricVehicles2017

Section 6. Feasibility of Solar PV for Off-Grid Charging

The 2012 Report stated that off-grid solar photovoltaic EV charging could be technically feasible in the future but was economically impractical at the time. For an EV charging station to use solar photovoltaics as the main source of power for charging operations, it would require a significant footprint of land to support the solar panels. An energy storage device would also be needed to charge vehicles during nighttime hours or on cloudy days. This equipment and land requirements would be needed for almost all types of charging, but especially for Level 2 or higher charging. Given this, it would be cost prohibitive to use off-grid solar photovoltaic technology to fuel EV charging stations as compared to interconnecting with an existing electric grid.

While the cost of solar panels has significantly decreased since 2012, the cost of energy storage and the amount of land needed to support these solar panels has not materially changed since 2012. Therefore, it remains economically impractical to use off-grid solar photovoltaic for dedicated EV charging.

Section 7. Conclusion

The review of currently available information suggests that the market for EVs and EV charging stations has expanded since 2012. However, even with this growth, the overall demand for EVs and EV public charging stations remains relatively limited. Actual growth in the EV and EV public charging markets in Florida is well below what was expected from the forecasts that were presented during the 2012 Workshop. Nationally, the long-term growth in EV sales is forecasted to be 3 to 4 percent of all vehicle sales. This forecasted growth in the U.S. will continue to keep the total number of EVs at about 1 percent of the total market for all vehicles.

Based on current information regarding the EV and EV charging markets, it is not expected that the current trend of expansion in these markets will affect the nature of the conclusions that were offered in the 2012 Report. Developments in the EV and EV charging markets in Florida are also not expected to have a material effect on overall electricity consumption or contribute significantly to the growth in demand during the ten year electric utility planning cycle. Finally, while off-grid solar photovoltaic EV charging remains technically feasible, it is generally economically impractical, except for a very limited number of situations were interconnecting to an existing electric grid is impossible.

Appendix A. State Specific Electric Vehicle Programs

Incentives to Promote EV Adoption

Many states are considering a variety of incentives to promote electric vehicle (EV) adoption. As of September 2017, thirty-eight states and the District of Columbia (D.C.) offer various types of incentives to EV owners. Examples of these incentives include: high-occupancy vehicle (HOV) lane exemptions, financial incentives for the purchase of EVs or purchase of electric vehicle supply equipment (EVSE), vehicle inspections or emissions test exemptions, parking incentives, or utility rate reductions. Alaska, North Dakota, South Dakota, and Kansas do not have any laws or policies in place that would specifically impact the purchase of an EV or the construction of EVSE.

Financial incentives, including tax credits and registration fee reductions, are popular ways to promote adoption. Rebates or tax credits for purchasing EVs and Hybrid Electric Vehicles (HEVs) range from $50, offered annually to Plug-In Electric Vehicle (PEV) owners within California's San Diego Gas and Electric (SDG&E) service area, to a $10,000 one-time break in Delaware and other states. Additional incentives include electric charging infrastructure tax credits, research project grants, alternative fuel technology loans, and establishing requirements for government fleets. Some states (Connecticut, Arizona, Illinois, and D.C.) have reduced annual registration fees for electric or alternative fuel vehicles. Eighteen states, however, have imposed additional annual fees for the registration and licensing of certain HEVs and EVs.

Provided below is a brief description of the categories of programs that states are currently offering:

- Licensing or Road Use: Four states have decreased licensing, registration or road use fees for HEVs or EVs. However, 18 states have additional licensing, registration, or road use fees for HEVs or EVs.
- Financial Incentives: Twenty-two states and D.C. provide a wide array of financial incentives to lower the cost of purchasing a HEV or EV. For example, Kentucky provides rebates for purchasing EVs while Texas provides vouchers for the purchase of EVs.
- Electric Utility Incentives: Thirteen states have utility companies that provide incentives for EV buyers in the form of reduced utility rates or rebates for charging HEVs or EVs.
- EV Supply Equipment: Twenty-five states and D.C. provide incentives, grants, financing, rebates, or loans to reduce the cost of constructing EVSE, like EV charging stations.
- Fleet Requirements: Twenty-eight states and D.C. have HEV or EV fleet requirements, acquisition goals, or a stated preference for the state's government to purchase HEVs or EVs. These policies can impact government fleets or private fleets and can require the fleets to have a specified percentage or number of HEVs or EVs in each fleet.
- HOV Access or Free Tolls: Thirteen states offer free access to toll roads and parking spaces. Some of these states also waive, for HEVs or EVs, the requirement that multiple people must be riding in a vehicle in order to use HOV lanes.
- Emissions Testing: Fourteen states exempt HEVs or EVs from emissions testing.

- Miscellaneous programs include: Insurance discounts (CA), EV fleet user fee exemptions (IL), EV charging tariffs (MN), Heavy-duty alternative fuel and advanced vehicle purchase vouchers (NY), AFV and HEV funding (PA), PEV cost recovery (SC), AFV safety inspection and permit (UT), and EVSE return on investment incentive (WA).

EV and AFV Incentives by State																					
	AZ	AR	CA	CO	CT	D.C.	DE	FL	GA	HI	ID	IL	IN	IA	LA	MD	MA	MI	MN	MO	NE
Miscellaneous			*					*				*							*		
Special Vehicles Registration Fee (for HEV/ EVs)			*	*	*				*		*	*	*					*	*	*	*
Emission Inspection Exemption (for EVs)	*				*						*	*					*			*	
Rate Variants (for PEV charging)						*					*	*					*			*	
Grants (for PEV/ EVSE/ Clean Fleets)				*	*												*				
Loan Programs (For EVSE/ AFV)			*					*													
Rebate Programs (for AFV/ AF Refueling Stations/ PEV/ EVSE)		*	*		*		*				*					*	*	*			
Traffic Exemptions (for HOV Lane/ HOV Toll Lane/ Toll Roads	*		*					*	*	*						*					
Tax Credits (For EVSE/ PEV/ EV/ AFV/ AF Production/ AF Infrastructure/ Commercial AFV Income)	*			*		*								*	*	*					
Tax Exemptions (for AFV/ AF/ EV Batteries/ EV Infrastructure/ AFV & Fuel-Efficient Vehicles Titles)	*					*															
Parking Incentives, Requirements, and Exemptions (For AFV)	*		*							*											

EV and AFV Incentives by State																				
	NV	NJ	NM	NY	NC	OH	OK	OR	PA	RI	SC	TN	TX	UT	VA	WA	WV	WI	WY	Totals
Miscellaneous				*					*		*			*		*				9
Special Vehicles Registration Fee (for HEV/ EVs)					*			*			*	*			*	*	*		*	19
Emission Inspection Exemption (for EVs)	*			*	*	*				*					*	*				13
Rate Variants (for PEV charging)															*					4
Grants (for PEV/ EVSE/ Clean Fleets)													*	*						5
Loan Programs (For EVSE/ AFV)								*						*						4
Rebate Programs (for AFV/ AF Refueling Stations/ PEV/ EVSE)				*				*		*										12
Traffic Exemptions (for HOV Lane/ HOV Toll Lane/ Toll Roads	*	*		*	*							*		*	*					13
Tax Credits (For EVSE/ PEV/ EV/ AFV/ AF Production/ AF Infrastructure/ Commercial AFV Income)							*	*												9
Tax Exemptions (for AFV/ AF/ EV Batteries/ EV Infrastructure/ AFV & Fuel-Efficient Vehicles Titles)		*	*		*									*		*		*	*	9
Parking Incentives, Requirements, and Exemptions (For AFV)	*							*						*						6

EV Initiatives in Florida

All-Electric Vehicle Rebate: Duke Energy Florida (DEF) and Orlando Utilities Commission (OUC) customers and employees are eligible for a rebate when purchasing a new 2018 Nissan Leaf at participating dealerships. A rebate totaling $10,500 is available to DEF customers and is comprised of a $3,000 incentive, provided by Nissan, and the remaining $7,500 can be recovered through applying for a federal tax credit. A rebate totaling $10,700 is available to OUC customers and is comprised of a $3,000 incentive, provided by Nissan, a $200 rebate, provided by OUC, and the remaining $7,500 can be recovered through applying for a federal tax credit. Rebates are available through September 30, 2018.

Authorization for Alternative Fuel Infrastructure Incentives: Local governments may use income from the infrastructure surtax to provide loans, grants, or rebates to residential or commercial property owners to install EVSE as well as liquefied petroleum gas (propane), compressed natural gas, and liquefied natural gas fueling infrastructure, if a local government ordinance authorizing this use is approved by referendum.

Electric Vehicle Supply Equipment Financing: Property owners may apply to their local government for funding to help finance EVSE installations on their property or enter into a financing agreement with the local government for the same purpose.

HOV Lane Exemption: Qualified alternative fuel vehicles (Inherently Low Emission Vehicle or HEV) may use designated HOV lanes regardless of the number of occupants in the vehicle. The vehicle must display a Florida Division of Motor Vehicles issued decal, which is renewed annually. Vehicles with decals may also use any HOV lane designated as a HOV toll lane without paying the toll. This exemption expires Sept. 30, 2019.

PEV Rebate: Jacksonville Electric Authority (JEA) offers rebates for PEVs with a battery less than 15 kilowatt-hours in capacity to receive $500, and PEVs with larger battery capacity are eligible for $1,000. A copy of a valid Florida vehicle registration, proof of sale, and a recent JEA Electric bill are required.

EV and EV Charging Pilot Programs in Florida

Gulf: By Order No. PSC-17-0178-S-EI, Gulf Power Company (Gulf) was authorized by the Florida Public Service Commission (FPSC) to implement an EV charging station pilot program. This pilot program will be revenue neutral and extend over a period of the lesser of either five years or when Gulf initiates a proceeding for approval of a permanent EV charging station offering. In reporting to the FPSC on an annual basis, Gulf must at least include financial and unit sales information and dollar amounts expended and generated as an addendum to its Annual Depreciations Status Report (ADSR).

Gulf's pilot program offers EV owners electricity rates with lower off-peak pricing during EV charging, partial rebates on home chargers, and an expanding list of charging locations in Northwest Florida. Eligibility requirements for Gulf's EV charging program include:

- Must be a Gulf Power residential customer who purchased or leased a qualifying plug-in EV.
- Qualifying vehicles include new or pre-owned, highway capable battery EVs, plug-in hybrid electric vehicles, and extended range EVs.
- Low speed EVs (top speed of 35 mph) are not eligible for this incentive.
- An itemized paid sales receipt must be submitted as proof of purchase.
- A completed incentive application form must be submitted no more than 60 days after purchase or lease of qualifying vehicle.
- This program is limited to the first 1,000 participants and expires on December 31, 2018.

If Gulf approves an application, the EV owner applicant may receive $750 to help offset some of the costs associated with installing a charging station in their home. Gulf's most recently filed ADSR from May 2018 reflects that no rebates have been issued.

DEF: By Order No. PSC-2017-0451-AS-EU, DEF was authorized by the FPSC to purchase, install, own, and support EVSE at DEF customer locations as part of a five year EVSE pilot program. DEF may incur up to $8 million plus reasonable operating expenses, with a minimum deployment of 530 EVSE ports. At least ten percent of EVSE ports must be installed in low income communities (as defined in Section 288.9913(3)). As part of the program, DEF will be deploying Level 2 and direct current fast chargers through this program and will fund consumer education up to $400,000. DEF is required to report information to the FPSC annually that includes comprehensive data on charging station deployment, installation cost, load growth, potential demand responses, load profiles, electricity prices paid, and EV charging equipment providers. The FPSC will make a determination about the appropriate regulatory treatment for recovery when the pilot program ends in 2022. DEF will initiate a separate proceeding for approval of a permanent EV charging station offering within four years of pilot program initiation or will explain why a permanent offering is not warranted.

DEF's pilot program is titled, "Park & Plug". Requirements for participation include:

- Site host must be a current DEF customer in Florida.
- Site host must agree to participate in the program through December 2022.
- Site host must agree to an electricity usage agreement.

- Site host must agree to establish a separate account, meter, and be responsible for ongoing tariff charges (DEF will install the new meter at no cost).
- Site locations must be safe, in a well-lit area, be paved, have adequate ingress/egress, and have adequate power in close proximity to the chosen site.
- Site locations must have one parking space per charging port.
- Site locations must have non-discriminatory access for EV chargers.
- Site locations must comply with all Americans with Disabilities Act requirements.

During the pilot program, DEF will own and operate the charging station network and will require access (easement). DEF provides the equipment, installation, warranty and network connection services free of charge to the site hosts through 2022. Site hosts will be responsible for the cost of electricity used by the charging station. Site hosts can provide stations either as an amenity to drivers or by charging a fee to the driver enabled by a smartphone or radio-frequency identification card. The Park & Plug program began in April of 2018. DEF has received 30 site applications since then and is currently reviewing them to work toward finalizing some initial site locations.

Information Regarding The VW Settlement

In October 2016, the U.S. government granted final approval of a $14.7 billion settlement against Volkswagen for equipping more than 500,000 of its diesel vehicles to cheat U.S. vehicle emissions tests in violation of the Clean Air Act. Volkswagen will spend $10 billion on vehicle buybacks and $4.7 billion to mitigate the pollution from these cars and invest in green vehicle technology. The $4.7 billion settlement payments will be split into two distinct funds. Volkswagen will place $2.7 billion into an Environmental Mitigation Trust to fund projects that reduce nitrogen oxide emissions. The remaining $2 billion will go toward zero emissions vehicle investments to improve infrastructure access, and education to advance zero emission vehicles.

From the Environmental Mitigation Trust to fund, the potential amount that could be allocated to The “Light Duty Zero Emission Vehicle Supply Equipment” program is approximately $22.8 million. This program can provide funding for the construction of new publicly available EV charging stations.

The regulating of EVs is beyond the jurisdiction of the FPSC. Attempting to assist in the allocation and plans for utilization of the $22.8 million would be one of the few avenues the FPSC could take if it desired to promote EV adoption.

Appendix B. Summary of 2017 Roundtable Presentations and Comments

2017 Roundtable Non-Utility Presentations

Edison Electric Institute

Kellen Schefter spoke on behalf of the Edison Electric Institute (EEI). Mr. Schefter stated that the focus of his presentation would be big picture, or the transitioning of the transportation market to electrification. Mr. Schefter stated that the transition is still in its very early stage but suggested that electrification of the transport sector will provide many direct and indirect benefits to customers, the electric grid and society in general.

Mr. Schefter then presented EEI's view concerning current and future sales of EVs. Mr. Schefter stated that over 690,000 EVs have been sold in the United States since December of 2010 and that sales in 2017 increased 32% over sales in 2016. Mr. Schefter further defined the growth in the EV market by stating that over 20 automobile manufactures are now offering 38 plug-in Electric Vehicle (PEV) models for customers to choose from. Mr. Schefter also presented forecasts made by EEI, Barclays, AEO, and Navigant of projected EV sales through 2025. He stated that EEI's forecast of 1.2 million EV sales in 2025 is reasonable and obtainable. Mr. Schefter also stated that for these forecasted EV sales numbers to materialize, the infrastructure for EV charging would need to see substantial growth over the next few years. According to EEI, there are fewer than a million EV chargers, of all types, currently available in the U.S. Based on studies done by NREL and EPRI, the U.S. would need to see the EV charging infrastructure grow by at least three fold to support the forecasted 2025 sales figures. Mr. Schefter stated that electric utilities must play an important role to support market acceleration of both EVs and EV charging infrastructure.

Mr. Schefter offered EEI's takeaways to the Commission:

- Electric transportation is coming – no longer a question of if, but how fast
- Many different actions can help accelerate this transition
    - Technology cost reduction and model availability
    - Market awareness and customer education
    - Infrastructure access and availability
- Electric utilities are well positioned to deliver grid benefits, positive outcomes for customers, and accelerate the market.

Drive Electric Florida

Peter King, Chair, spoke on behalf of Drive Electric Florida. Drive Electric Florida has a diverse membership with a mission to advance and promote the growth of electric vehicle (EV) ownership and the accompanying infrastructure. Mr. King stated Florida is a top ten state in total EVs in operation and in EV growth in the United States (U.S.). His data ranks Florida second in PEV sales in the U.S. and forecasts Florida EV growth to reach 279,870 EVs by year 2025.

Drive Electric Florida believes there is a positive economic benefit, or "multiplier effect," to the growth of EVs. This means that growth in EVs will positively impact several economic arenas. The company also believes this same positive impact can be seen through environmental benefits.

General Motors

Britta K. Gross, Director Advanced Vehicle Commercialization Policy, spoke on behalf of General Motors (GM). Ms. Gross stressed the importance of EVs being capable of 40 miles of daily electric driving. This is pertinent because the company's data shows 78% of EV customers commute 40 miles or less daily. The company believes if it can consistently provide specific vehicles that will reach this large demographic, then EV adoption will be more likely. Ms. Gross believes EV adoption is in the early adopters phase of penetration into the market and expects the market to grow in the future.

GM has concerns about EV awareness, stating that most people still do not know much about EVs. Of those who are familiar with EVs, a large portion won't consider them due to lack of EV infrastructure. GM believes utilities need to be active in growing the PEV industry, or else it will remain a "niche" market. Ways it suggests growing the PEV market include: driving consumer demand for PEVs, building awareness of PEVs, installing charging infrastructure at a faster pace, making PEVs affordable and providing incentives for switching.

Tesla

Patrick Bean, Associate Manager, Energy Policy & Business Development, spoke on behalf of Tesla. Mr. Bean covered the vehicle, storage, and solar products that Tesla offers. The Tesla vehicles described in detail were the Model S, Model X, and Model 3. The company has produced vehicles at a higher volume and lower price in an effort to appeal to more buyers.

Tesla stated that it plans to have 10,000 superchargers deployed by the end of 2017, with several located in Florida. It is releasing an app to make finding and scheduling charging during trips easier. The app will be available to help navigate a desired trip with superchargers integrated conveniently into the route. The superchargers should only take 30 minutes to complete a full charge and the app will notify the driver when the charging is complete.

ChargePoint

David Schatz, Director, Public Policy, spoke on behalf of ChargePoint. ChargePoint claims to be the world's largest network of EV charging stations in the U.S., Australia, and Europe, with over 40,000 charging spots and growing. In Florida, ChargePoint has 13,000 member drivers, 1,356 public ports, and has had 200,000 charging sessions in 2017. The company believes EV adoption is growing rapidly and that EVs provide significant benefits to drivers, the environment, and the economy.

ChargePoint has two recommended actions for the Commission. First, they suggest there be an open dialogue, led by the Commission, to clarify regulatory conditions on EV charging infrastructure. The second recommendation is for the Commission to conduct regular workshops for all associated stakeholders to engage and inform the Commission.

EVgo

Terry O'Day, Vice President, spoke on behalf of EVgo. EVgo has 244 fast charging locations in Florida, with an average of 10 sessions per site per day. Mr. O'Day shared some comparative statistics from California (CA). In CA, the average Direct Current (DC) fast charger electricity cost is higher than average gasoline cost to consumers. The company provided load profiles for various charging site locations. The company estimates that for DC Fast Charging sites, only 40% of operational costs are attributed to electricity.

2017 Roundtable Florida Electric Utility Presentations

Florida Power & Light Company (FPL)

Brian Hanrahan, Director, In-Home Technologies and Electric Vehicles for FPL, opined that the electric vehicle and infrastructure landscape has evolved since 2012. He noted that more models are available with improved range and at lower prices. Florida now has approximately 2,000 public charging stations. He also noted a shift towards DC fast charging and that some banks as large as 1-3 MW are being installed within FPL's service area.

FPL views PEV related activity as part of normal business. FPL's electric grid reliability study modeled power distribution scenarios through 2030 showing no significant impact. The life cycle of small residential transformers presented the highest risk. However, FPL was not aware of any outages caused by charging. FPL's strategy remains unchanged and focuses on reliability, meeting customer expectations, and supporting market expansion.

FPL states that there is no present need to request a special charging rate because its research shows most people charge outside of FPL's peak hours and customers can opt for FPL's whole house time-of-use rate. FPL expressed concern that a special charging rate could require a separate meter resulting in additional customer costs.

Duke Energy Florida, LLC (DEF)

Lang Reynolds, Electric Transportation Manager for DEF, asserted that battery costs have declined and lower costs have supported further market development beyond personal vehicles to include buses and other commercial vehicles. This factor supports continued EV market growth even though gasoline prices are relatively low.

Registered EVs in DEF's service area are approximately 3,700 compared to approximately 20,000 in Florida. Mr. Reynolds asserts that demographics have driven market penetration and EV sales are less than half of one percent of all vehicle sales.

By 2030, DEF forecasts approximately 150,000 EVs within its service area. This equates to approximately 60 MW during the summer. DEF's infrastructure planning is addressing load growth. Continued research and analysis will further determine charging behavior and load impacts.

Mr. Reynolds reinforces that customers requesting EV information tend to contact utilities first. Customer contacts have increased over 100 percent. The barriers to EV adoption continue to be awareness, charging infrastructure, and cost. DEF's initiatives include education and outreach, infrastructure investment, and incentives. DEF's EV charging infrastructure pilot project is consistent with these initiatives.

Tampa Electric Company (TECO)

Kenneth Hernandez, Program Manager for TECO, acknowledged that EV market growth had been slower than originally projected. However, growth has steadily occurred to over 2,000 PEVs in its service area with over 120 public charging stations. Growth is expected to increase as more models are offered along with increasing public awareness.

TECO has a PEV fleet that includes 17 plug-in boom trucks and 5 pick-up trucks, with 31 charging sites for its fleet and employee vehicles. Outreach programs include energy education in five high schools and one university.

TECO's PEV load growth modeling, even at high charging concentrations, demonstrates minimal negative grid reliability impacts. Nevertheless, TECO will continue to monitor developments and use ten year planning cycles to identify and accommodate incremental load growth. Mr. Hernandez notes that future regulatory considerations include potential development of vehicle-to-grid technologies.

Gulf Power Company (Gulf)

Foster Ware, General Manager of Marketing & Sales, highlighted the EV infrastructure within Gulf's service area, its EV fleet, involvement in regional electric transportation activities, grid reliability, and regulatory considerations. Gulf estimated that approximately 68 charging stations at 35 sites exist within its service area. Gulf's EV fleet includes 15 EVs, 2 forklifts and 29 chargers at 11 locations.

Gulf engages in local education and public awareness events, including West Florida Regional Planning Council and military events. Gulf is also developing its five-year pilot program to own and operate EV chargers. Pilot program participant funding will cover the equipment and energy costs.

Mr. Ware notes the gradual pace of EV adoption and asserts Gulf observes electric grid reliability impacts. Gulf asserts that processes in place monitor growth in EV charging and incorporate growth into the normal utility planning process similar to planning for new growth in the residential or commercial sectors. Gulf believes regulatory considerations should be flexible and retain the ability to test different concepts and programs.

Florida Public Utilities Company (FPUC)

Mark Cutshaw, Director, Business Development & Generation, stated that FPUC has minimal EV charging load and has no impact on the grid. Based on system loads and forecasts of future EV sales, EV charging is not expected to have a significant impact on FPUC's system.

However, data related to EV charging within its service area is very limited. FPUC is in communication with local governments regarding development of EV charging installations. FPUC currently does not have any EV charging installation programs or rates specific for EV charging. FPUC asserted a pilot program could provide data related to EV charging. However, no pilot program was presented.

Orlando Utility Commission (OUC)

Linda Ferrone, Vice President, Strategy, Sustainability & Emerging Technologies for OUC, generally supported the comments of the other utilities. OUC installed over 150 public chargers and over 200 EV charging stations are located within OUC's service area. Batteries and other technologies are changing the EV market.

Ms. Ferrone asserted that OUC, as a municipal utility, may be able to explore programs that may be more difficult for an investor-owned utility. Beginning in 2010, during its efforts to promote the siting of EV chargers, OUC observed that owners of potential charging locations were not always receptive. While OUC offers rebates, it is not convinced that rebates are an effective incentive. OUC plans to offer leasing of OUC owned and maintained commercial EV charging equipment.

City of Tallahassee

David Byrne, Assistant General Manager, Electric System Integrated Planning for Tallahassee, generally supported the comments of the other utilities regarding the grid reliability impact and planning. Long leave parking lots, like movie theaters, may be convenient locations for EV chargers. Mr. Byrne also noted that EV charging locations are now readily available through an internet search. He believes this reflects increased public interest.

Florida Electric Cooperatives Association (FECA)

Mike Bjorklund, General Manager for FECA, commented that at this time, there is not a wide proliferation of EVs into the member rural electric cooperatives' service areas. As more interest develops, the impact of EVs will be reviewed to ensure it is integrated properly.

Post-Roundtable Comments

ChargePoint

In its comments, ChargePoint stated that the sustained growth of electric vehicles in Florida, and nationally, points to the increasingly critical need for more charging infrastructure. To support this growing need, ChargePoint believes that utility engagement in EV charging is essential, and that utility investments in EV charging can encourage and enhance the competitive market for charging infrastructure currently active in Florida. ChargePoint recommends that in light of the trend towards electrification and increasing interest among utilities to engage EV charging, the Commission should continue to explore regulatory conditions around charging infrastructure. Commission led workshops and discussion forums with all interested stakeholders at the table, according to ChargePoint, will lead to proactive policies and programs to scale the market for EVs and associated infrastructure. Topics that should be explored in these Commission led dialogues, according to ChargePoint, can be included the following:

- Reviewing electric vehicle market trends and the competitive market offerings for EV charge infrastructure;
- Establishing guidelines for a utility role in EV charging;
- Ensuring equitable access to the benefits of transportation electrification;
- Evaluating how smart charging stations can be utilized to optimize grid benefits from EV charging; and,
- Considering alternative rate structures for fast and high-speed charging sites.

ChargePoint also suggested that the Commission should:

- Enable utility investment in electric vehicle charging;
- Minimize costs and maximize ratepayer benefits from increased EV adoption, improved grid efficiency, operational flexibility, and reliability; and,
- Evaluate alternative rate structures for high energy use charging stations or EV fleet operators.

Greenlots

Greenlots is a leading provider of grid-focused electric vehicle charging software and services. In its post-roundtable comments, Greenlots urged the Commission to embrace its critical and central role in adopting policies that enable and empower utilities to become accelerators of charging infrastructure deployment, facilitating widespread EV adoption across the state in a manner that benefits all ratepayers. Greenlots believes that the current fundamental economics simply do not support sufficient private investment to grow infrastructure deployment at the level it needs to be. Given the early stage of the market of ownership and operation of charging infrastructure, Greenlots believes that it is an appropriate and necessary role for the utilities to take action in accelerating the market. The company believes this utility involvement will help create competition and choice, and attract private investment.

Greenlots also stated that utility involvement in the development of rates and programs that send accurate price signals to EV loads reflecting grid constraints and realties is essential. Time-of-use rates, they stated, represent a blunt but in some cases appropriate instrument in delivering these price signals, especially at low levels of EV market penetration. Greenlots states that as different EV-specific rates are developed, an eye at mitigating associated metering complications must also be considered, including the use of metering capabilities embedded within electric vehicle supply equipment rather than more costly separate traditional meters.

Greenlots believes that the Commission should take on the role of market accelerator, or otherwise facilitate utilities to play that role. Greenlots encourages the Commission to consider providing a modest structure to guide utility filings while providing for the type of flexibility that will ensure utilities are best able to serve their ratepayers. They believe this should include the option of utility cost recovery of EV charging infrastructure through rate base, including chargers themselves, when they meet appropriate and potentially new regulatory standards.

Finally, Greenlots encourages the Commission to consider the virtues of deeper utility involvement in its analysis of the utility's relationship to other market participants and the market as a whole. They stated that adopting a modest policy or framework that affords utilities sufficient flexibility to develop EV charging infrastructure proposals with more regulatory clarity would serve as a practical and useful first step.

Siemens Digital Grid

Siemens stated in their post-roundtable comments that the Commission has a critical role to play in facilitating the efficient deployment of EV charging infrastructure and ensuring that all segments of the population are adequately served as PEVs move into the mainstream. PEV sales still represent less than one percent of all vehicle sales in the United States. There are several important institutional and market barriers that stand in the way of these vehicles reaching the large-scale deployment levels that will drive broad public benefits. Siemens recommends that the Commission approach PEV regulations with an eye towards addressing a few key barriers to PEV deployment. In addressing these issues, the Commission should keep in mind that there are significant opportunities available, not only for light duty vehicles, but for all classes of vehicles, including low speed, medium-duty, and heavy-duty vehicles.

Siemens believes that given the wide-ranging benefits of expanded PEV adoption for utility ratepayers and the broader public, there is ample reason for the Commission to consider direct utility participation and the provision of incentives for accelerated charging infrastructure deployment. Siemens recommends the Commission establish PEV-only rates and encourage cost-effective metering of PEV charging, including the use of smart meters with sub-metering capabilities. Since utilities need to carefully plan for any major changes in the grid, both in terms of generation and distribution, Siemens states that the Commission and any electric vehicle supply equipment providers should work closely with the utility on deployment to maximize the benefits that PEVs provide to the grid, and to ensure successful integration of the additional loads from PEV charging. This might include, but is not limited to, identifying preferred sites for electric vehicle supply equipment to be located.

According to Siemens, the goals of utility participation should be to eliminate underlying market barriers in order to facilitate the development of an expanded competitive market while simultaneously ensuring service provision in areas that are outside the reach of the competitive market. Given the widespread benefit to the public, Siemens' primary interest is in reducing barriers to growth of the PEV market by lowering the total cost of ownership. Allowing for both third-party and utility infrastructure ownership/operation harnesses the power of the competitive market in a way that ultimately benefits all customer classes, uses, and geographies.

Florida Tesla Enthusiasts Group

Larry Chanin, president of the group, wrote to the Commission offering the group's service in answering surveys concerning electric infrastructure issues, and potential concerns of future owners of long-distance EVs. The Florida Tesla Enthusiasts Group is an independent organization that meets, exchanges information, educates, and advocates for various electric vehicle related causes.

Mr. Chanin relayed a story concerning one of their club members who was without power for 6 days due to Hurricane Irma. Mr. Chanin stated that the member had purchased an inflatable mattress that fit perfectly in the back of her Model S with the rear seat folded flat. According to Mr. Chanin she spent 6 nights sleeping in the air conditioned comfort of the car without running out of charge or having to worry about carbon monoxide poisoning. Mr. Chanin also discussed problems/challenges of home charging at multi-unit dwellings.

Mr. Steve Ryland (a private EV owner)

Mr. Ryland suggested that only "quick charge" stations should be built going forward since the standard 240v charging takes too long. He believes that these types of chargers should be installed near major roads and highways, and at all rest stops to help minimize EV ownership range anxiety. Mr. Ryland thinks that until adoption becomes more common, quick charges should be offered for free. Mr. Ryland also believes that the State or FPL should offer an incentive to purchase or adopt EV usage. He suggests that the incentive could take the form of a possible credit on the electric bill or underwrite the installation of a home charger. He thinks that the State should require new and existing multi-unit housing to install stations on the property and that all new homes should be wired with outlets for future installation of a charger.