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.

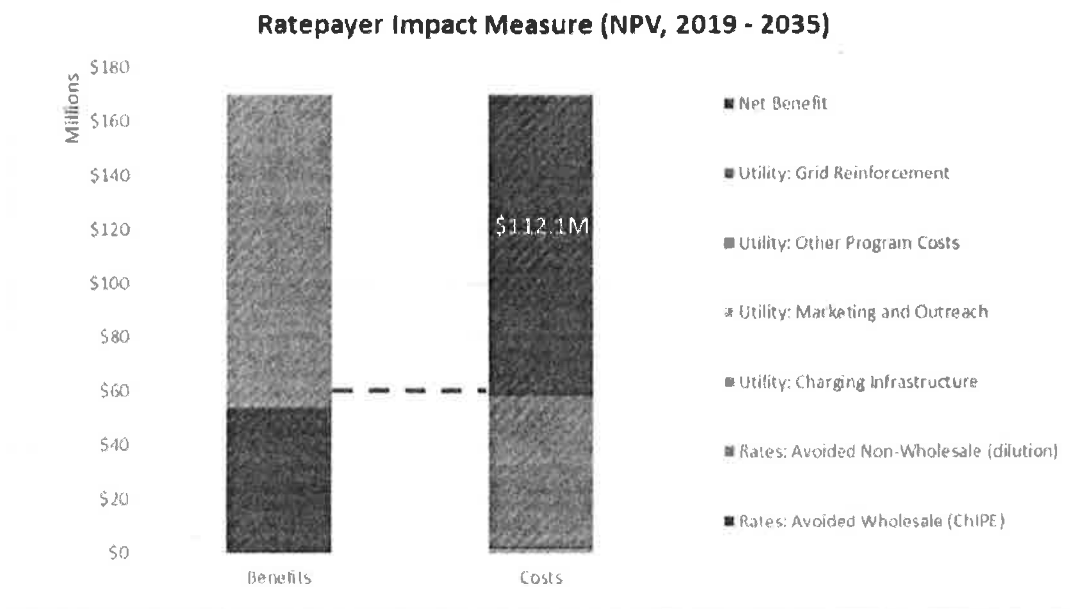
## 7.1 Key Result: The Adapted Rate Impact Measure (RIM)

**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.

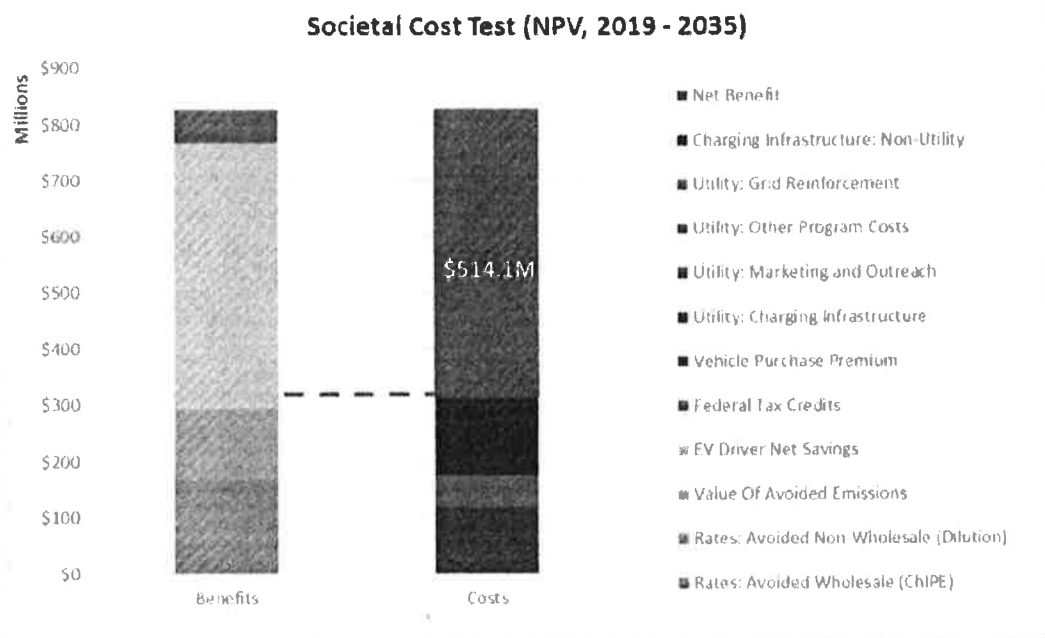



## 7.2 Key Result: The Adapted Societal Cost Test (SCT)

**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.

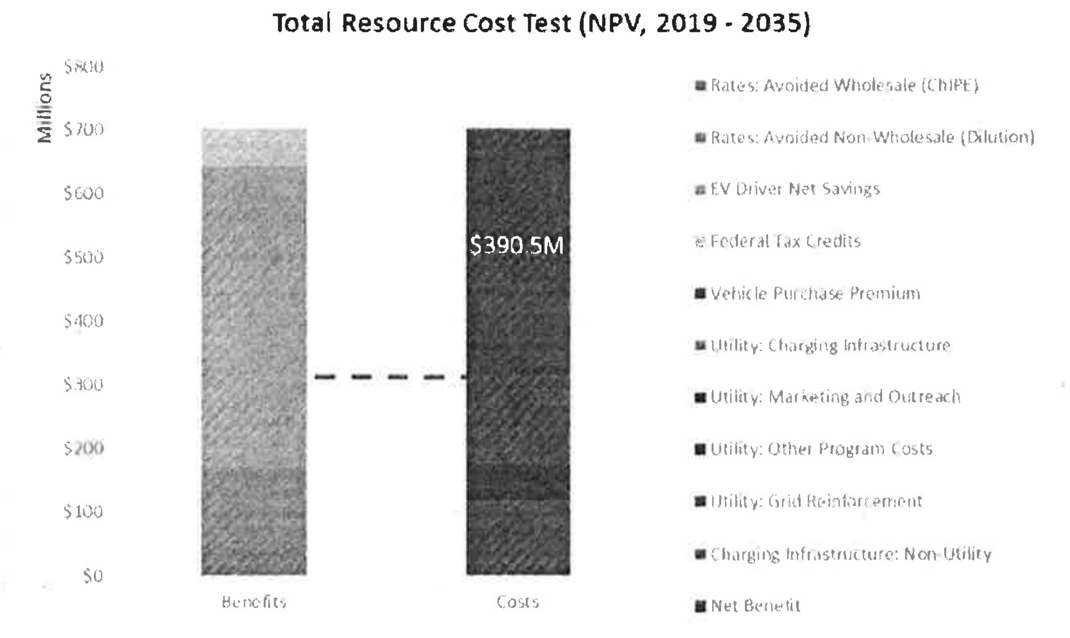



## 7.3 Key Result: The Adapted Total Resource Cost (TRC)

**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 generatiốn 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 $CO_2$ 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,