

# Electric Vehicle Cost-Benefit Analysis

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Plug-in Electric Vehicle Cost-Benefit Analysis: New York



## Acknowledgements

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### About this Study

This study was conducted by M.J. Bradley & Associates for the Natural Resources Defense Council. It is one of five state-level analyses of plug-in electric vehicle costs and benefits for different states in the Northeast, including Connecticut, Maryland, Massachusetts, New York, and Pennsylvania. These studies are intended to provide input to state policy discussions about actions required to promote further adoption of electric vehicles.

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M.J. Bradley & Associates LLC (MJB&A) provides strategic and technical advisory services to address critical energy and environmental matters including: energy policy, regulatory compliance, emission markets, energy efficiency, renewable energy, and advanced technologies.

Our multi-national client base includes electric and natural gas utilities, major transportation fleet operators, clean technology firms, environmental groups and government agencies.

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## Executive Summary

This study estimated the costs and benefits of increased penetration of plug-in electric vehicles (PEV) in the State of New York, for two different penetration levels between 2030 and 2050.<sup>1</sup> Scenario 1 is based on the state's short-term goal to have 850,000 electric vehicles on the roads of New York by 2025 (8-state ZEV MOU). Scenario 2 is based on the PEV penetration that would be required to achieve the state's long-term goals for economy wide greenhouse gas (GHG) reduction of 80 percent from 1990 levels by 2050 (80x50).

Compared to a business as usual baseline of continued gasoline car use the study estimated the total reductions in GHG emissions that could be achieved by turning the light duty fleet (cars and light trucks) over to PEVs, and the value of these GHG reductions to society. There are opportunities for additional GHG emission reductions from electrification of nonroad equipment and heavy-duty trucks and buses, but evaluation of these applications was beyond the scope of this study.

The study also estimated the benefits that would accrue to all electric utility customers in New York due to increased utility revenues from PEV charging. This revenue could be used to support operation and maintenance of the existing distribution infrastructure, thus reducing the need for future electricity rate increases. These benefits were estimated for a baseline scenario in which PEV owners plug in and start to charge their vehicles as soon as they arrive at home or work. The study also evaluated the additional benefits that could be achieved by providing PEV owners with price signals or incentives to delay the start of PEV charging until after the daily peak in electricity demand (off-peak charging). Increased peak hour load increases a utility's cost of providing electricity, and may result in the need to upgrade distribution infrastructure. As such, off-peak PEV charging can provide net benefits to all utility customers by shifting PEV charging to hours when the grid is underutilized and the cost of electricity is low. In addition, the study estimated the annual financial benefits to New York PEV owners – from fuel and maintenance cost savings compared to owning gasoline vehicles.

As shown in Figure 1 (8-state ZEV MOU penetration scenario), if New York meets its short term (2025) goals for PEV penetration and the increase in percent PEV penetration then continues at the same annual rate in later years, the net present value of **cumulative net benefits from greater PEV use in New York will exceed \$17.8 billion state-wide by 2050.**<sup>2</sup> Of these total net benefits:

- 48 percent (\$8.6 billion) will accrue directly to PEV owners in the form of reduced annual vehicle operating costs
- 31 percent (\$5.5 billion) will accrue to electric utility customers in the form of reduced electric bills, and
- 21 percent (\$3.8 billion) will accrue to society at large, as the value of reduced GHG emissions.

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<sup>1</sup> PEVs include battery-electric vehicles (BEV) and plug-in hybrid vehicles (PHEV).

<sup>2</sup> Using a 3% discount rate

Figure 1 NPV Cumulative Societal Net Benefits from NY PEVs – 8-state ZEV MOU Penetration

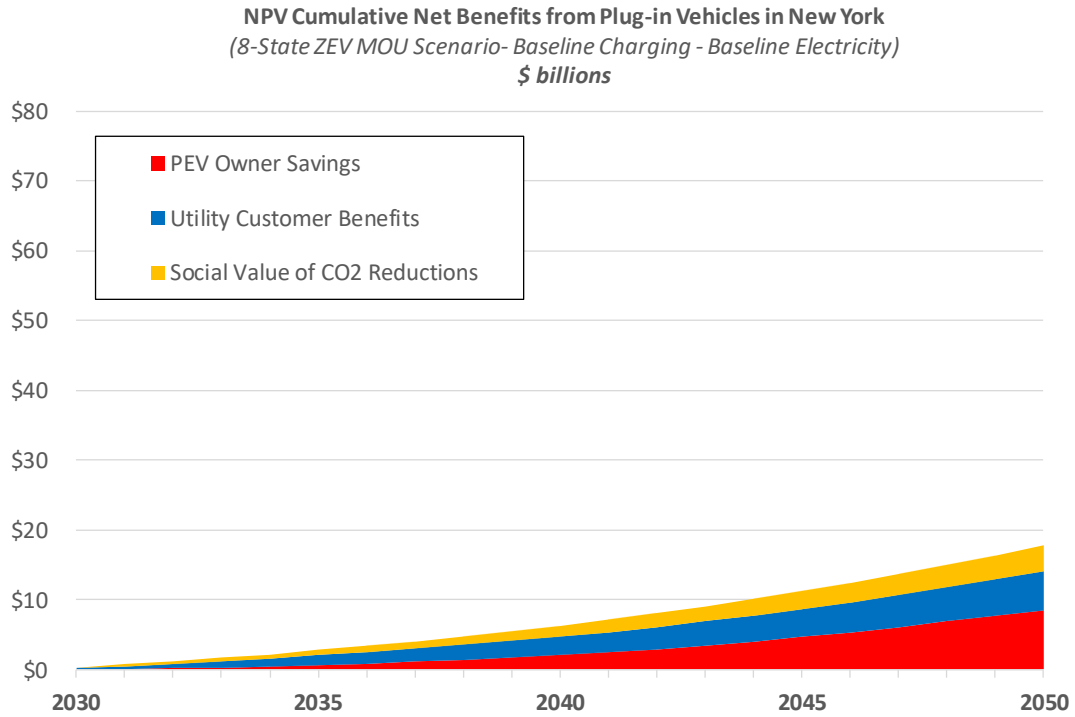
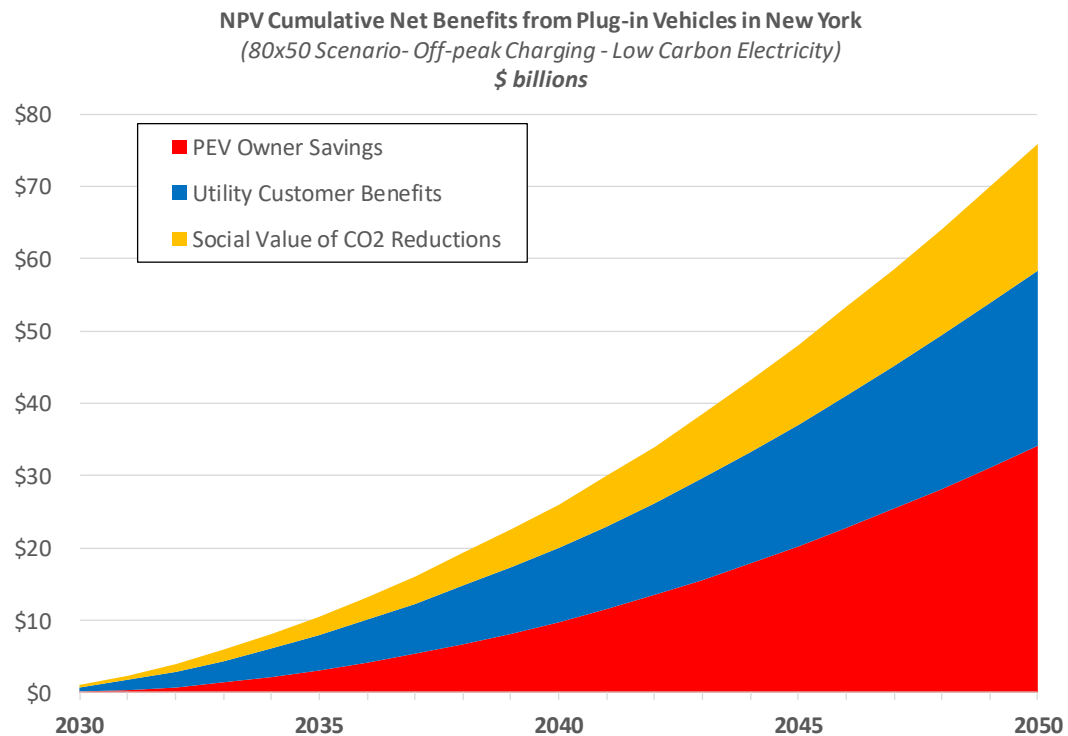


Figure 2 NPV Cumulative Societal Net Benefits from NY PEVs – 80x50 Penetration



As shown in Figure 2 (80x50 penetration scenario), if the state meets its long-term goals to reduce light-duty fleet GHG emissions by 80 percent from 1990 levels by 2050, which requires even greater PEV penetration, the net present value of **cumulative net benefits from greater PEV use in New York could exceed \$75 billion state-wide by 2050**. Of these total net benefits:

- 45 percent (\$34.1 billion) will accrue directly to PEV owners in the form of reduced annual vehicle operating costs
- 32 percent (\$24.3 billion) will accrue to electric utility customers in the form of reduced electric bills, and
- 23 percent (\$17.5 billion) will accrue to society at large, as the value of reduced GHG emissions.

## 1 Background – New York

In 2009, Governor David Paterson issued Executive Order 24, establishing a goal to reduce greenhouse gas (GHG) emissions 80 percent from 1990 levels by 2050 in order to protect against the potential impacts of climate change [1]. This action also established a Climate Action Council tasked with creating a Climate Action Plan and overseeing ongoing efforts to address climate change mitigation strategies for the state. In 2014, Governor Andrew Cuomo launched Reforming the Energy Vision (REV), a strategy to develop a clean energy system in the state and achieve New York's 80 by 50 goal, making the state a leader in climate action. Specifically, by 2030, REV will reduce GHG emissions 40 percent from 1990 levels, generate 50 percent of the state's electricity needs from renewable energy sources, and achieve a 23 percent reduction in building energy consumption from 2012 levels [2]. The 2015 New York State Energy Plan provides a roadmap for achieving REV goals through comprehensive actions and initiatives in renewable energy, building and energy efficiency, clean energy financing, sustainable community development, innovative R&D, and transportation, such as ChargeNY which establishes a target to put 30,000-40,000 EVs on the road by 2018 [3]. In 2005 New York adopted California vehicle emission standards, effective in the 2009 model year [4]. These standards include a zero-emission vehicle (ZEV) mandate that requires auto manufacturers to sell increasing numbers of ZEVs each year between 2018 and 2025. New York is also a signatory to the 8-state ZEV Memorandum of Understanding (ZEV MOU), which pledges participating states to enact policies that will ensure the deployment of 3.3 million ZEVs and supporting charging infrastructure in participating states by 2025. New York's share of the ZEV MOU commitment is 850,000 ZEVs on state roads by 2025.

In the state's 2016-2017 budget, legislators approved a program providing funding to offer rebates up to \$2,000 for the purchase of new BEVs, PHEVs, or fuel-cell EVs [5]. Additionally, on September 8, 2016, the New York State Department of Environmental Conservation announced \$3 million in available grants for electric vehicles and charging station purchases. A total of \$750,000 is available for clean vehicle rebates through the end of 2016. Municipalities will be eligible for rebates of \$2,500 for vehicles with a 10-50 mile electric range, and \$5,000 for vehicles with an electric range over 50 miles [6]

As of January 2016 there were about 16,000 PEVs (including battery-electric and plug-in hybrid vehicles) registered in New York and they comprised about 0.14 percent of the 11 million cars and light trucks registered in the State. In 2014 and 2015, sales of new PEVs in the state were 0.4 percent of new vehicle sales. [7]

## 2 Study Methodology

This section briefly describes the methodology used for this study. For more information on how this study was conducted, including a complete discussion of the assumptions used and their sources, see the report: *Mid-Atlantic and Northeast Plug-in Electric Vehicle Cost-Benefit Analysis, Methodology & Assumptions* (October 2016). This report can be found at:

[http://mjbradley.com/sites/default/files/NE\\_PEV\\_CB\\_Analysis\\_Methodology.pdf](http://mjbradley.com/sites/default/files/NE_PEV_CB_Analysis_Methodology.pdf)

This study evaluated the costs and benefits of two different levels of PEV penetration in New York between 2030 and 2050. These PEV penetration scenarios bracket the state's short and long-term policy goals for ZEV adoption and GHG reduction, as discussed in Section 1.

**SCENARIO 1 – 8 State ZEV MOU:** Penetration of PEVs equivalent to New York's commitment under the *8-state ZEV Memorandum of Understanding*. Compliance with this commitment will require approximately 8 percent of in-use light duty vehicles in New York to be ZEV by 2025.

Assuming that the increase in percent PEV penetration then continues at the same annual rate in later years, PEV penetration is assumed to be 10.9 percent in 2030, 18.0 percent in 2040, and 25.2 percent in 2050.<sup>3</sup>

**SCENARIO 2 – 80 x 50 Goal:** The level of PEV penetration required to reduce total light-duty GHG emissions in New York in 2050 by 80 percent from 1990 levels with 80 percent carbon free electricity. This will require PEV penetration of 27 percent in 2030, 62 percent in 2040 and 92 percent in 2050.

Each of these scenarios is compared to a baseline scenario with very little PEV penetration, and continued use of gasoline vehicles. The baseline scenario is based on future annual vehicle miles traveled (VMT) and fleet characteristics (e.g., cars versus light trucks) as projected by the Energy Information Administration.

Based on assumed future PEV characteristics and usage, the analysis projects annual electricity use for PEV charging at each level of penetration, as well as the average load from PEV charging by time of day. The analysis then projects the total revenue that New York's electric distribution utilities would realize from sale of this electricity, their costs of providing the electricity to their customers, and the potential net revenue (revenue in excess of costs) that could be used to support maintenance of the distribution system.

The costs of serving PEV load include the cost of electricity generation, the cost of transmission, incremental peak generation capacity costs for the additional peak load resulting from PEV charging, and annual infrastructure upgrade costs for increasing the capacity of the secondary distribution system to handle the additional load.

For each PEV penetration scenario this analysis calculates utility revenue, costs, and net revenue for two different PEV charging scenarios: 1) a baseline scenario in which all PEVs are plugged in and start to charge as soon as they arrive at home each day, and 2) an off-peak charging scenario in which a significant portion of PEVs that arrive home between noon and 11 PM each day delay the start of charging until after midnight.

Real world experience from the EV Project demonstrates that, without a “nudge”, drivers will generally plug in and start charging immediately upon arriving home after work (scenario 1), exacerbating system-wide evening peak demand.<sup>4</sup> However, if given a “nudge” - in the form of a properly designed and marketed financial incentive - many PEV owners will choose to delay the start of charging until off-peak times, thus reducing the effect of PEV charging on evening peak electricity demand (scenario 2). [8]

For each PEV penetration scenario, this analysis also calculates the total incremental annual cost of purchase and operation for all PEVs in the state, compared to “baseline” purchase and operation of gasoline cars and light trucks. For both PEVs and baseline vehicles annual costs include the amortized cost of purchasing the vehicle, annual costs for gasoline and electricity, and annual maintenance costs. For PEVs it also includes the amortized annual cost of the necessary home charger. This analysis is used to estimate average annual financial benefits to New York PEV owners.

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<sup>3</sup> While the 8-state MOU counts fuel cell vehicles and PEVs as zero emission vehicles, this scenario assumes that all ZEVs will be PEV.

<sup>4</sup> The EV Project is a public/private partnership partially funded by the Department of Energy which has collected and analyzed operating and charging data from more than 8,300 enrolled plug-in electric vehicles and approximately 12,000 public and residential charging stations over a two year period.



Finally, for each PEV penetration scenario this analysis calculates annual greenhouse gas (GHG) emissions from electricity generation for PEV charging, and compares that to baseline emissions from operation of gasoline vehicles. For the baseline and PEV penetration scenarios GHG emissions are expressed as carbon dioxide equivalent emissions (CO<sub>2</sub>-e) in metric tons (MT). GHG emissions from gasoline vehicles include direct tailpipe emissions as well as “upstream” emissions from production and transport of gasoline.

For each PEV penetration scenario GHG emissions from PEV charging are calculated based on a baseline electricity scenario and a “low carbon electricity” scenario. The baseline scenario is consistent with the latest EIA projections for future average grid emissions in the Middle Atlantic region. The low carbon electricity scenario is based on New York reducing average GHG emissions from the electric grid to 80 percent below 1990 levels by 2050.

Net annual GHG reductions from the use of PEVs are calculated as baseline GHG emissions (emitted by gasoline vehicles) minus GHG emissions from each PEV penetration scenario. The monetary “social value” of these GHG reductions from PEV use are calculated using the Social Cost of Carbon (\$/MT), as calculated by the U.S. government’s Interagency Working Group on Social Cost of Greenhouse Gases.

## 3 Study Results

This section summarizes the results of this study, including the projected number of PEVs; electricity use and load from PEV charging; projected GHG reductions compared to continued use of gasoline vehicles; benefits to utility customers from increased electricity sales; and projected financial benefits to PEV owners compared to owning gasoline vehicles.

All costs and financial benefits are presented as net present value (NPV), using a 3 percent discount rate.

### 3.1 Plug-in Vehicles, Electricity Use, and Charging Load

#### 3.1.1 Vehicles and Miles Traveled

The projected number of PEVs and conventional gasoline vehicles in the New York light duty fleet<sup>5</sup> under each PEV penetration scenario is shown in Figure 3, and the projected annual miles driven by these vehicles is shown in Figure 4.

There are currently 5.503 million cars and 5.704 million light trucks registered in New York, and these vehicles travel 132.5 billion miles per year. Both the number of vehicles and total annual vehicle miles are projected to increase by 7 percent through 2050, to 11.961 million light duty vehicles traveling 141.4 billion miles annually<sup>6</sup>.

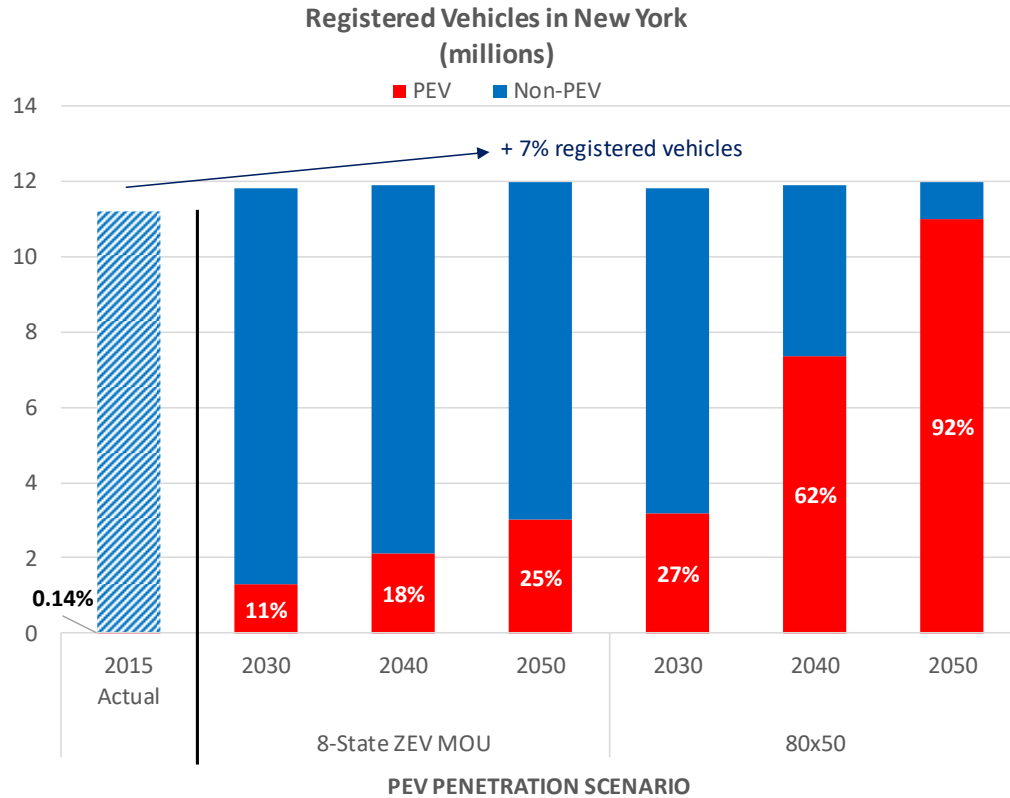
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<sup>5</sup> This analysis only includes cars and light trucks. It does not include medium- or heavy-duty trucks and buses.

<sup>6</sup> The New York State Department of Transportation projections for VMT growth are higher, mirroring national level VMT growth projections from the Federal Highway Administration (+24 percent through 2040). For conservatism this analysis uses EIA VMT growth assumptions for the Mid-Atlantic region (New York, New Jersey, and Pennsylvania), which reflect significantly lower projections for population growth in this region (2 percent through 2040) compared to the national average (18 percent through 2040). According to the US Census Bureau, the majority of US population growth through 2040 will occur in the south and west, with low growth in the northeast and mid-Atlantic states.

In order to meet the state’s goals under the 8-state ZEV MOU, the number of PEVs registered in New York would need to increase from approximately 16,000 today to 850,000 by 2025. Assuming the same annual increase in percent PEV penetration in later years, there would be 1.3 million PEVs in the state in 2030, 2.1 million in 2040, and 3.0 million in 2050 (8-state ZEV MOU penetration scenario).

Figure 3 Projected New York Light Duty Fleet

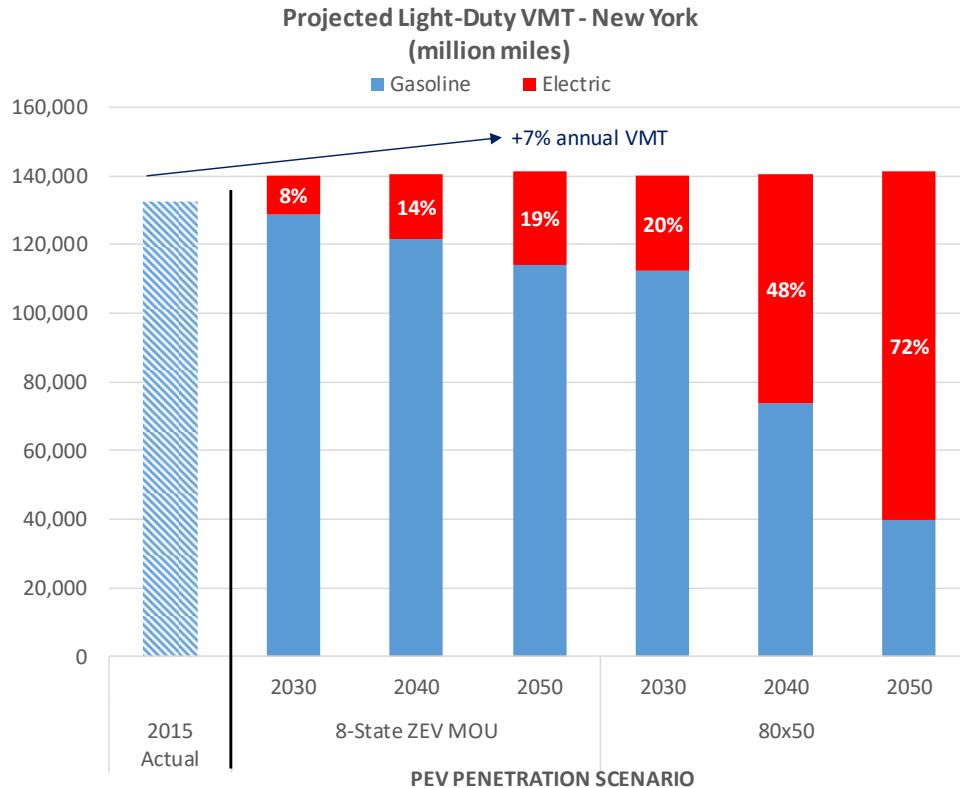


In order to put the state on a path to achieve an 80 percent reduction in light-duty GHG emissions from 1990 levels by 2050 (80x50 penetration scenario) there would need to be approximately 3.2 million PEVs in New York by 2030, rising to 7.4 million in 2040, and 11.0 million in 2050.

Note that under both PEV penetration scenarios the percentage of total VMT driven by PEVs each year is lower than the percentage of plug-in vehicles in the fleet. This is because PEVs are assumed to have a “utility factor” less than one – i.e., due to range restrictions neither a battery-electric nor a plug-in hybrid vehicle can convert 100 percent of the miles driven annually by a baseline gasoline vehicle into miles powered by grid electricity. In this analysis BEVs with 200 mile range per charge are conservatively assumed to have a utility factor of 87 percent, while PHEVs are assumed to have an average utility factor of 72 percent in 2030, rising to 79 percent in 2050. This analysis estimates that New York could reduce light-duty fleet GHG in 2050 by 80 percent from 1990 levels if 72 percent of miles were driven by PEVs

on electricity (Figure 4). However, in order to achieve this level of electric miles 92 percent of light-duty vehicles would need to be PEVs (Figure 3).

Figure 4 Projected New York Light Duty Fleet Vehicle Miles Traveled



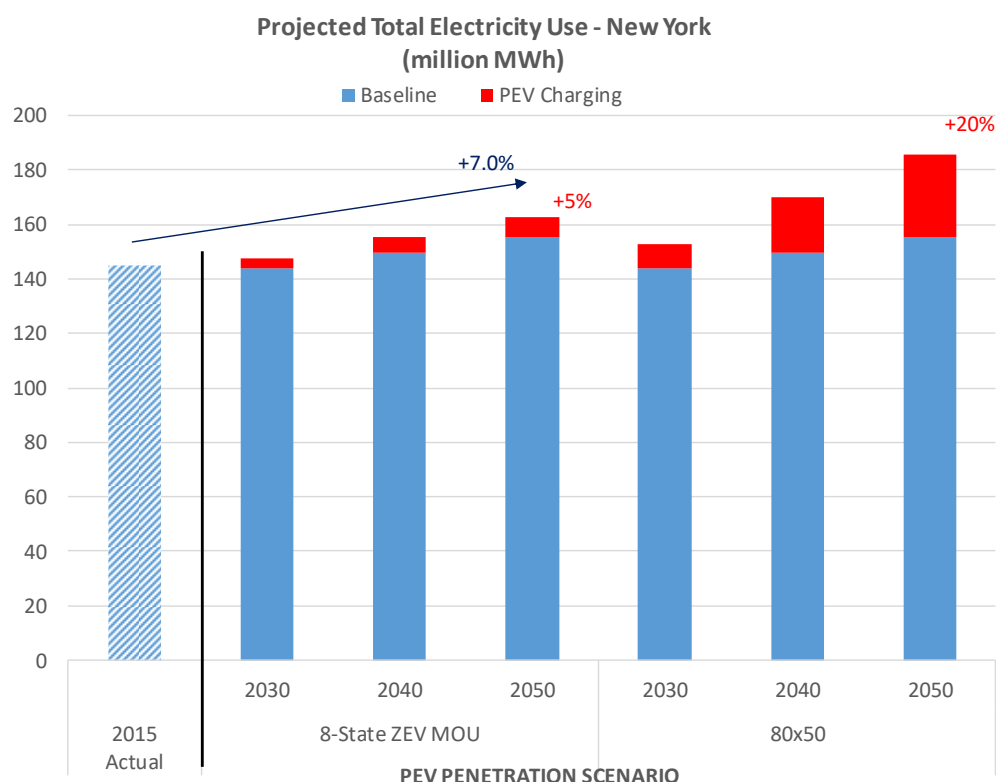
### 3.1.2 PEV charging Electricity Use

The estimated total PEV charging electricity used in New York each year under the PEV penetration scenarios is shown in Figure 5.

In Figure 5, projected baseline electricity use without PEVs is shown in blue and the estimated incremental electricity use for PEV charging is shown in red. State-wide electricity use in New York is currently 145 million MWh per year. Annual electricity use is projected to fall to 144.1 million MWh in 2030, but to grow after that, reaching 155.2 million MWh in 2050 (7.0 percent greater than 2015 level).

Under the 8-state ZEV MOU penetration scenario, electricity used for PEV charging is projected to be 3.5 million MWh in 2030 – an increase of 2.4 percent over baseline electricity use. By 2050, electricity for PEV charging is projected to grow to 7.6 million MWh – an increase of 5 percent over baseline electricity use. Under the 80x50 penetration scenario electricity used for PEV charging is projected to be 8.8 million MWh in 2030, growing to 30 million MWh and adding 20 percent to baseline electricity use in 2050.

Figure 5 Estimated Total Electricity Use in New York



### 3.1.3 PEV Charging Load

This analysis evaluated the effect of PEV charging on the New York electric grid under two different charging scenarios. Under both scenarios 80 percent of all PEVs are assumed to charge exclusively at home and 20 percent are assumed to charge both at home and at work. Under the baseline charging scenario all PEV owners are assumed to plug-in their vehicles and start charging as soon as they arrive at home or at work (if applicable) each day. Under the off-peak charging scenario 65 percent of PEV owners who arrive at home in the afternoon and early evening are assumed to delay the start of home charging until after midnight – in response to a price signal or incentive provided by their utility<sup>7</sup>.

See Figure 6 (baseline) and Figure 7 (off-peak) for a comparison of PEV charging load under the baseline and off-peak charging scenarios, using the 2040 80x50 PEV penetration scenario as an example. In each of these figures the 2015 New York 95<sup>th</sup> percentile load (MW)<sup>8</sup> by time of day is plotted in orange, and the projected incremental load due to PEV charging is plotted in grey.

In 2015 daily electric load in New York was generally in the range of 17,800 – 19,700 MW from midnight to 5 AM, ramping up through the morning and early afternoon to peak at approximately 27,800 MW between 2 PM and 4 PM, and then falling off through the late afternoon and evening hours.

<sup>7</sup> Utilities have many policy options to incentivize off-peak PEV charging. This analysis does not compare the efficacy of different options.

<sup>8</sup> For each hour of the day actual load in 2015 was higher than the value shown on only 5 percent of days (18 days).

Figure 6 2040 Projected New York PEV Charging Load, Baseline Charging (80x50 scenario)

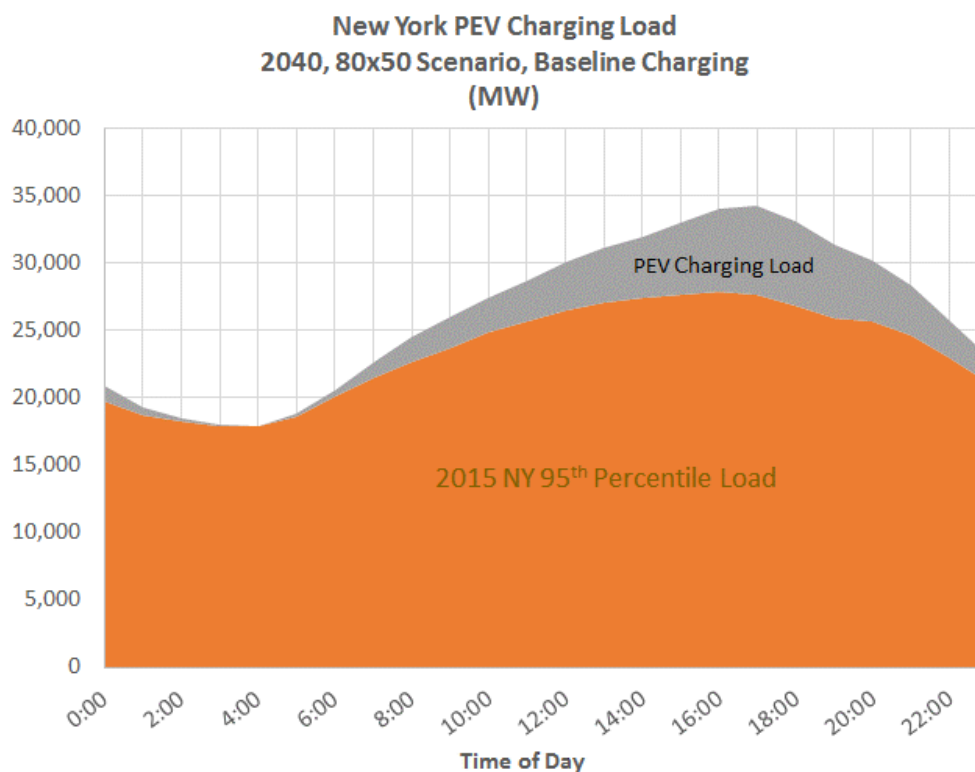
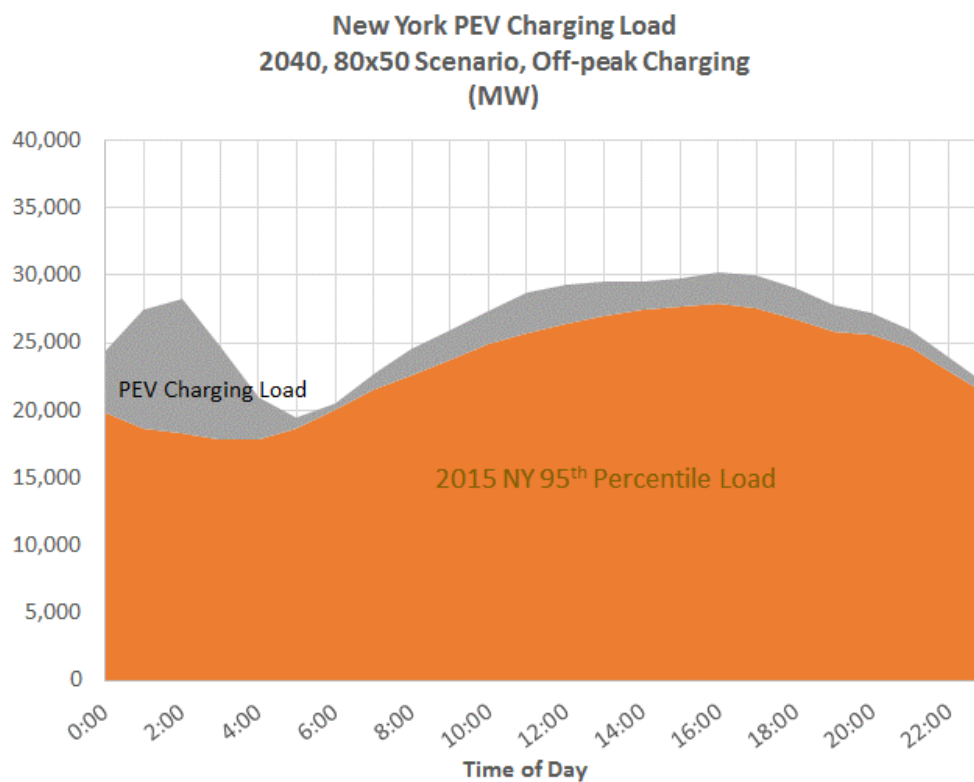


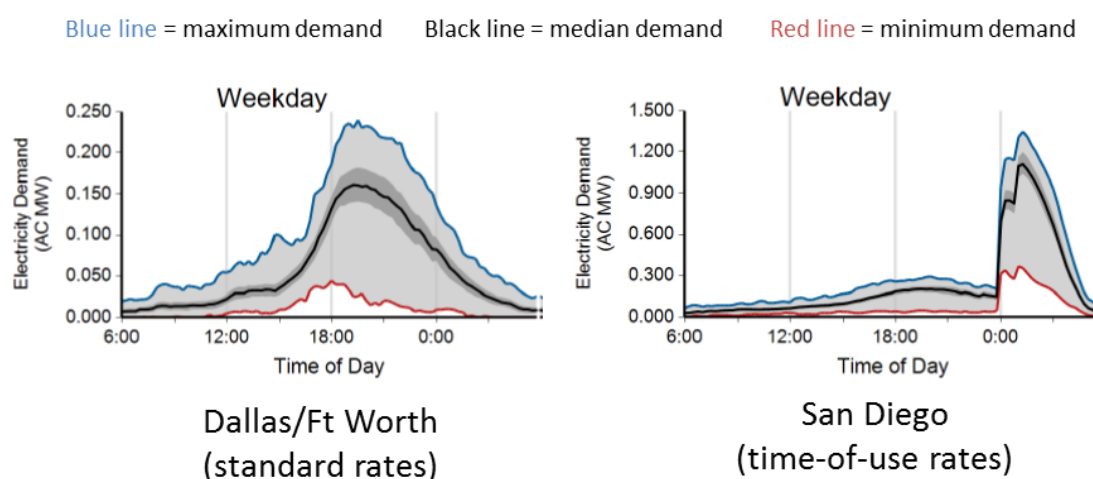
Figure 7 2040 Projected New York PEV Charging Load, Off-peak Charging (80x50 scenario)



As shown in Figure 6, baseline PEV charging is projected to add load primarily between 8 AM and 11 PM, as people charge at work early in the day and then at home later in the day. The PEV charging peak coincides with the existing afternoon peak load period between 2 PM and 4 PM. As shown in Figure 7, off-peak charging significantly reduces the incremental PEV charging load during the afternoon peak load period, but creates a secondary peak in the early morning hours, between midnight and 3 AM. The shape of this early morning peak can potentially be controlled based on the design of off-peak charging incentives.

These baseline and off-peak load shapes are consistent with real world PEV charging data collected by the EV Project, as shown in Figure 8. In Figure 8 the graph on the left shows PEV charging load in the Dallas/Ft Worth area where no off-peak charging incentive was offered to PEV owners. The graph on the right shows PEV charging load in the San Diego region, where the local utility offered PEV owners a time-of-use rate with significantly lower costs (\$/kWh) for charging during the “super off-peak” period between midnight and 5 a.m. [8]

Figure 8 PEV Charging Load in Dallas/Ft Worth and San Diego areas, EV Project



See Table 1 for a summary of the projected incremental afternoon peak hour load (MW) in New York, from PEV charging under each penetration and charging scenario. This table also includes a calculation of how much this incremental PEV charging load would add to the 2015 95<sup>th</sup> percentile peak hour load. Under the 8-state ZEV MOU penetration scenario, PEV charging would add 1,166 MW load during the afternoon peak load period on a typical weekday in 2030, which would increase the baseline peak load by about 4 percent. By 2050 the afternoon incremental PEV charging load would increase to 2,522 MW, adding 9 percent to the baseline afternoon peak. By comparison the afternoon peak hour PEV charging load in 2030 would be only 428 MW for the off-peak charging scenario, increasing to 918 MW in 2050.

Under the 80x50 PEV penetration scenario baseline PEV charging would increase the total afternoon peak electric load by about 36 percent in 2050, while off-peak charging would only increase it by about 13 percent<sup>9</sup>.

<sup>9</sup> If 2050 baseline peak load (without PEVs) is higher than 2015 peak load, the percentage increase in peak load due to PEV charging will be smaller. However, EIA currently estimates that total electricity use (MWh) in 2050 will only be 7 percent higher than 2015 use, so peak demand is not expected to grow significantly.

Table 1 Projected Incremental Afternoon Peak Hour PEV Charging Load (MW)

		8-state ZV MOU			80x50		
		2030	2040	2050	2030	2040	2050
<b>Baseline Charging</b>	PEV Charging (MW)	1,166	1,791	2,522	2,888	6,668	9,949
	<i>Increase relative to 2015 Peak</i>	4.2%	6.4%	9.0%	10.4%	23.9%	35.7%
<b>Off-Peak Charging</b>	PEV Charging (MW)	428	652	918	1,060	2,448	3,652
	<i>Increase relative to 2015 Peak</i>	1.5%	2.3%	3.3%	3.8%	8.8%	13.1%

As discussed below in Section 3.3, increased peak hour load increases a utility’s cost of providing electricity, and may result in the need to upgrade distribution infrastructure. As such, off-peak PEV charging can provide net benefits to all utility customers by bringing in significant new revenue in excess of associated costs.

### 3.2 GHG Reductions & Societal Benefits

The projected annual greenhouse gas (GHG) emissions (million metric tons carbon-dioxide equivalent, CO<sub>2</sub>-e million tons) from the New York light duty fleet under each PEV penetration scenario are shown in Figure 9. In this figure projected baseline emissions from a gasoline fleet with few PEVs are shown in red for each year; the values shown represent “wells-to-wheels” emissions, including direct tailpipe emissions and “upstream” emissions from production and transport of gasoline. Projected total fleet emissions for each PEV penetration scenario are shown in blue; this includes GHG emissions from generating electricity to charge PEVs, as well as GHG emissions from gasoline vehicles in the fleet.

Figure 9 Projected GHG Emissions from the Light Duty Fleet in New York

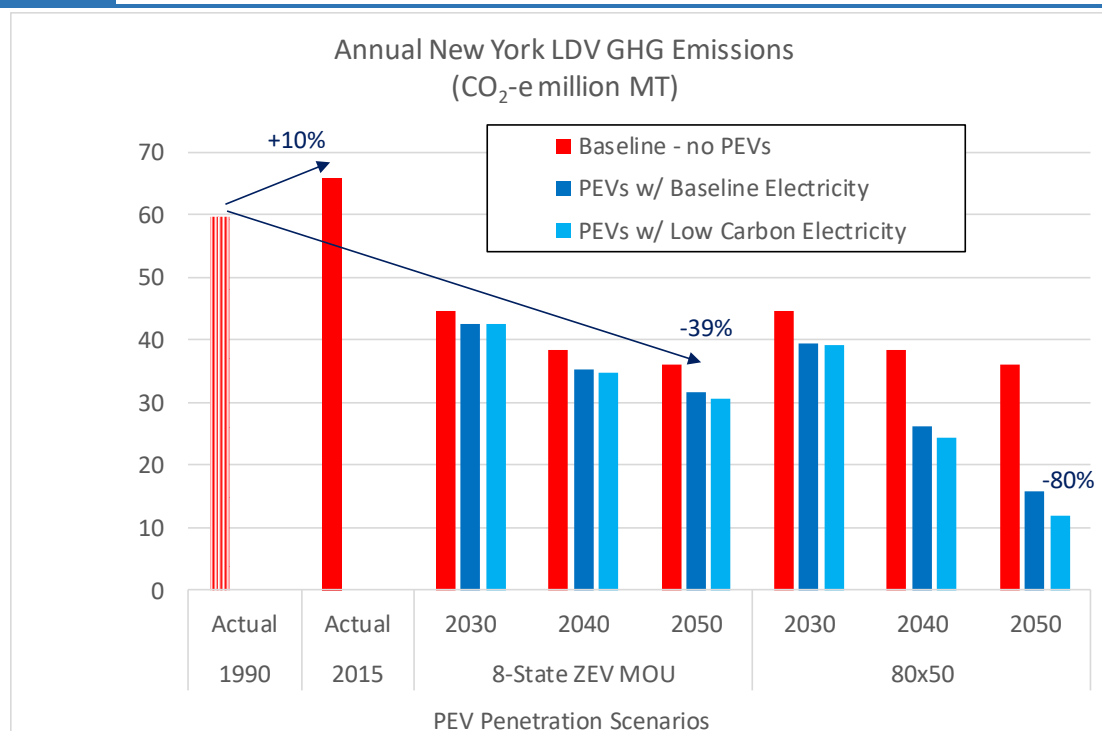
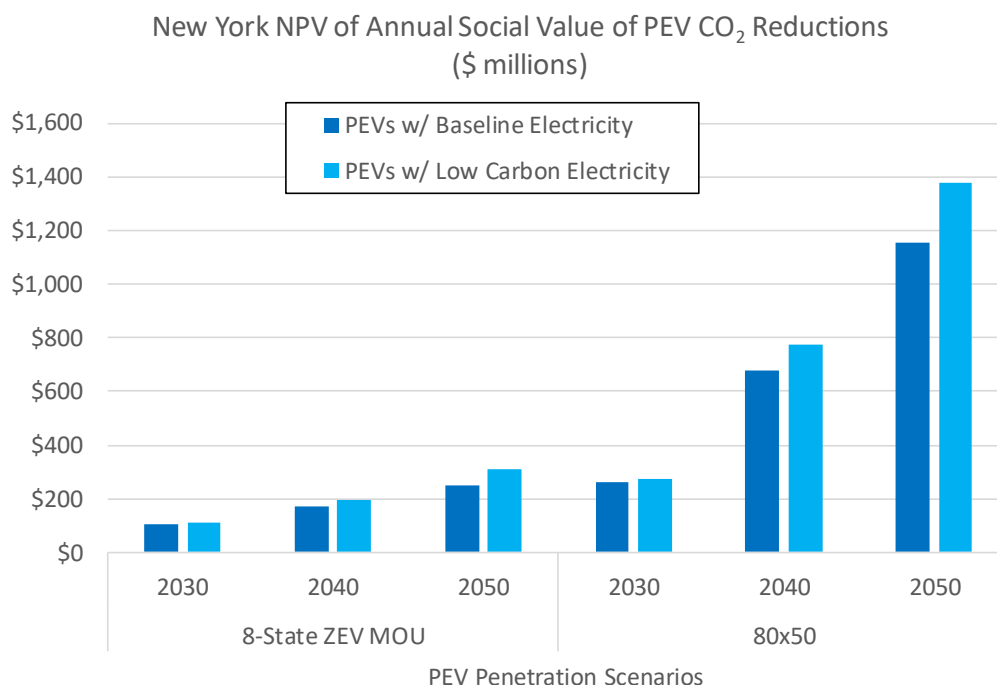


Figure 10 NPV of Projected Social Value of PEV GHG Reductions



For the PEV penetration scenarios, projected GHG emissions are shown for a baseline electricity scenario (dark blue) and a “low carbon” electricity scenario (light blue). The baseline electricity scenario is based on projections of average carbon intensity for Middle Atlantic electricity generation from EIA. The low carbon electricity scenario is based on New York achieving its long-term goals to reduce total GHG emissions from electricity generation by 80 percent from 1990 levels by 2050.

As shown in Figure 9, GHG emissions from the light duty fleet were approximately 59.7 million tons in 1990, but they increased by 10 percent through 2015, to 65.9 million tons. However, even without significant PEV penetration, baseline annual fleet emissions are projected to fall to 36.1 million tons by 2050, a reduction of 39 percent from 1990 levels and 45 percent from current levels. This projected reduction is based on turnover of the existing vehicle fleet to more efficient vehicles that meet more stringent fuel economy and GHG standards issued by the Department of Transportation and Environmental Protection Agency. Under the 8-state ZEV MOU penetration scenario, PEVs are projected to reduce annual light duty fleet emissions by up to 5.4 million tons in 2050 compared to baseline emissions (-15 percent). Under the 80x50 penetration scenario annual GHG emissions in 2050 will be as much as 24.3 million tons lower than baseline emissions (-67 percent).

Figure 10 summarizes the NPV of the projected monetized “social value” of GHG reductions that will result from greater PEV use in New York. The social value of GHG reductions represents potential cost savings from avoiding the negative effects of climate change, if GHG emissions are reduced enough to keep long term warming below two degrees Celsius from pre-industrial levels. The values summarized in Figure 10 were developed using the Social Cost of CO<sub>2</sub> (\$/MT) as calculated by the U.S. government’s Interagency Working Group on Social Cost of Greenhouse Gases.

The NPV of the monetized social value of GHG reductions resulting from greater PEV use is projected to total \$104 million per year in 2030 under the 8-state ZEV MOU penetration scenario, rising to as much as



\$307 million per year in 2050. Under the 80x50 penetration scenario the NPV of the monetized social value of GHG reductions from greater PEV use is projected to be \$262 million per year in 2030, rising to as much as \$1.4 billion per year in 2050.

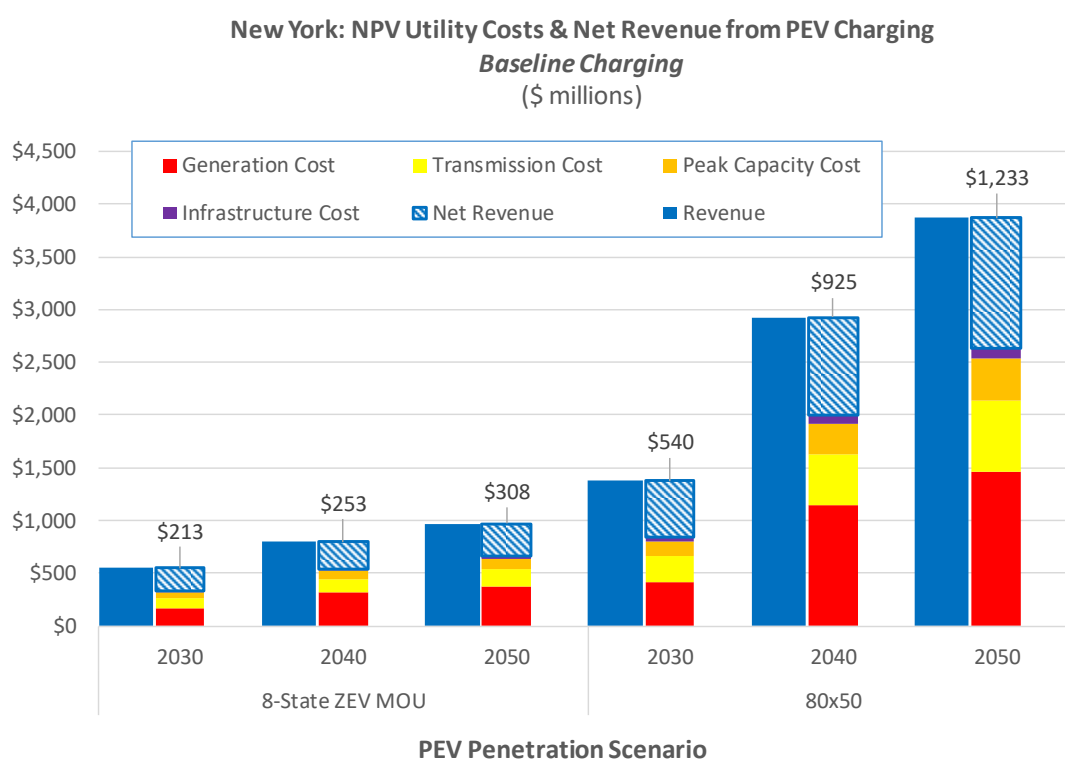
The NPV of the projected monetized social value of annual GHG reductions averages \$81 per PEV in 2030, and \$83 - \$125 per PEV in 2050.

### 3.3 Utility Customer Benefits

The estimated NPV of revenues and costs for New York's electric utilities to supply electricity to charge PEVs under each penetration scenario are shown in Figure 11, assuming the baseline PEV charging scenario.

In Figure 11, projected utility revenue is shown in dark blue. Under the 8-state ZEV MOU penetration scenario the NPV of revenue from electricity sold for PEV charging in New York is projected to total \$546 million in 2030, rising to \$969 million in 2050. Under the 80x50 penetration scenario the NPV of utility revenue from PEV charging is projected to total \$1.4 billion in 2030, rising to \$3.9 billion in 2050.

Figure 11 NPV of Projected Utility Revenue and Costs from Baseline PEV Charging



The different elements of incremental cost that utilities would incur to purchase and deliver additional electricity to support PEV charging are shown in red (generation), yellow (transmission), orange (peak capacity), and purple (infrastructure upgrade cost). Generation, transmission, and peak capacity costs generally represent payments made by distribution utilities to other companies to purchase and transmit power in Middle Atlantic's deregulated market. Generation and transmission costs are proportional to the total power (MWh) used for PEV charging, while peak capacity costs are proportional to the incremental peak load (MW) imposed by PEV charging. Infrastructure upgrade costs are costs incurred by the utility to upgrade their own infrastructure to handle the increased peak load imposed by PEV charging.

The striped light blue bars in Figure 11 represent the NPV of projected “net revenue” (revenue minus costs) that utilities would realize from selling additional electricity for PEV charging under each PEV penetration scenario. Under the 8-state ZEV MOU penetration scenario the NPV of net revenue in New York is projected to total \$213 million in 2030, rising to \$308 million in 2050. Under the 80x50 penetration scenario the NPV of utility net revenue from PEV charging is projected to total \$540 million in 2030, rising to \$1.2 billion in 2050. The NPV of projected annual utility net revenue averages \$166 per PEV in 2030, and \$102 - \$112 per PEV in 2050.

Figure 12 NPV of Projected Utility Revenue and Costs from Off-peak PEV Charging

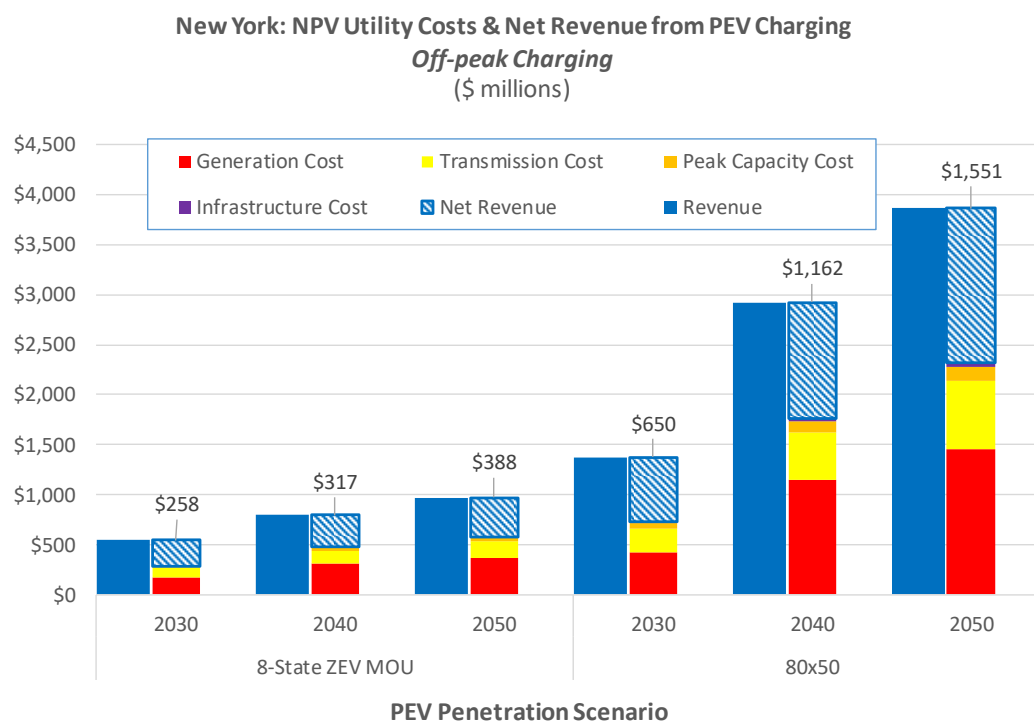


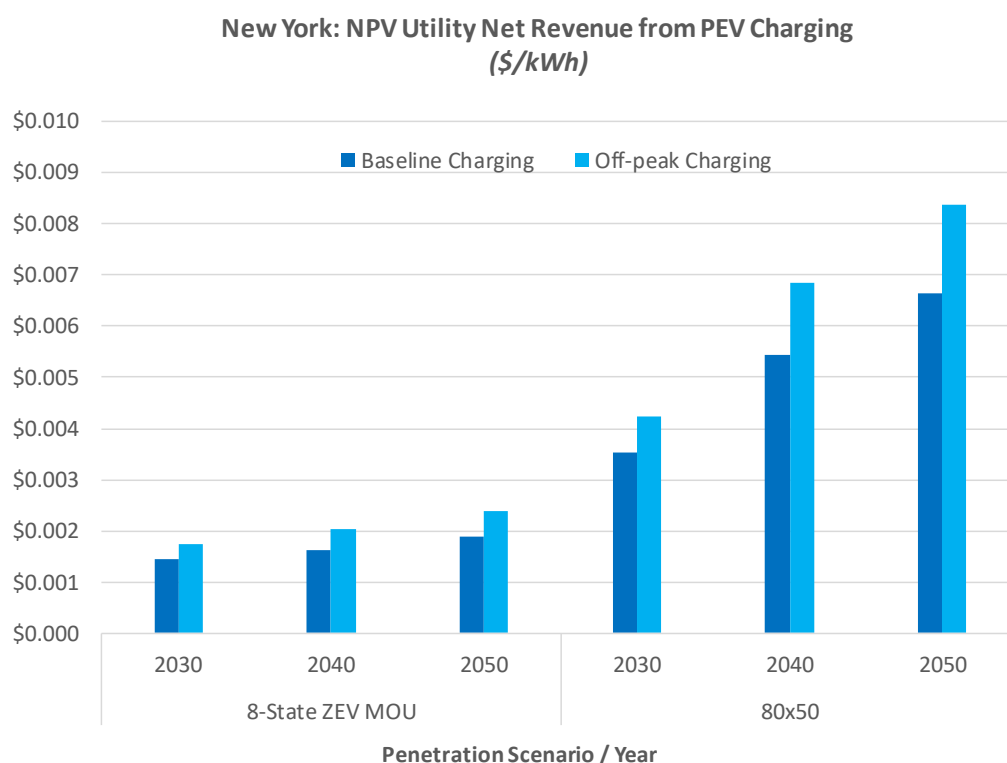
Figure 12 summarizes the NPV of projected utility revenue, costs, and net revenue for off-peak charging under each PEV penetration scenario. Compared to baseline charging (Figure 11) projected revenue, and projected generation and transmission costs are the same, but projected peak capacity and infrastructure costs are lower due to a smaller incremental peak load (see Table 1). Compared to baseline charging, off-peak charging will increase the NPV of annual utility net revenue by \$44 million in 2030 and \$81 million in 2050 under the 8-state ZEV MOU penetration scenario, due to lower costs. Under the 80x50 penetration scenario off-peak charging will increase the NPV of annual utility net revenue by \$110 million in 2030 and \$318 million in 2050. This analysis estimates that compared to baseline charging, off-peak charging will increase the NPV of annual utility net revenue by \$34 per PEV in 2030 and \$29 per PEV in 2050.

In general, a utility’s costs to maintain their distribution infrastructure increase each year with inflation, and these costs are passed on to rate payers in accordance with rules established by the state’s Public Service Commission (PSC), via periodic increases in residential and commercial electric rates. However, under PSC rules net revenue from additional electricity sales generally offsets the allowable costs that can be passed on via higher rates. As such, the majority of projected utility net revenue from increased electricity sales for PEV charging would in fact be passed on to utility customers in New York, not

retained by the utility companies. In effect this net revenue would put downward pressure on future rates, delaying or reducing future rate increases, thereby reducing customer bills.

See Figure 13 for a summary of how the NPV of projected utility net revenue from PEV charging might affect average residential and commercial electricity rates for all New York electric utility customers. By 2050 the NPV of utility net revenue from PEV charging could reduce electric rates in New York by as much as \$0.0024/kWh under the 8-state ZEV MOU penetration scenario, and by as much as \$0.0084/kWh under the 80x50 penetration scenario. Under the 80x50 penetration scenario this could reduce projected average electric rates in New York by up to 6.6 percent by 2050, resulting in an annual savings of approximately \$144 (nominal dollars) per household in New York<sup>10</sup> in 2050.

**Figure 13** Potential Effect of PEV Charging NPV of Net Revenue on Utility Rates (\$/kWh)



### 3.4 PEV Owner Benefits

Current PEVs are more expensive to purchase than similar sized gasoline vehicles, but they are eligible for various government purchase incentives, including up to a \$7,500 federal tax credit, and a \$2,000 state rebate in New York for all citizens, or up to a \$5,000 state rebate for PEVs purchased for municipal government fleets.

<sup>10</sup> Based on 2015 average electricity use of 5,980 kWh per housing unit in New York.

The largest contributor to incremental purchase costs for PEVs compared to gasoline vehicles is the cost of batteries. Battery costs for light-duty plug-in vehicles have fallen from over \$1,000/kWh to less than \$400/kWh in the last 5 years; many analysts and auto companies project that battery prices will continue to fall – to below \$125/kWh by 2025. [9]

**Table 2** Projected Fleet Average Vehicle Costs to Vehicle Owners (nominal \$)

GASOLINE VEHICLE		8-State ZEV MOU			80x50		
		2030	2040	2050	2030	2040	2050
Vehicle Purchase	\$/yr	\$4,374	\$5,589	\$7,082	\$4,493	\$6,332	\$8,154
Gasoline	\$/yr	\$1,306	\$1,687	\$2,167	\$1,328	\$1,851	\$2,434
Maintenance	\$/yr	\$264	\$330	\$402	\$265	\$340	\$417
<b>TOTAL ANNUAL COST</b>	<b>\$/yr</b>	<b>\$5,943</b>	<b>\$7,606</b>	<b>\$9,650</b>	<b>\$6,086</b>	<b>\$8,523</b>	<b>\$11,005</b>
PEV		8-State ZEV MOU			80x50		
		2030	2040	2050	2030	2040	2050
Vehicle Purchase	\$/yr	\$4,784	\$5,921	\$7,244	\$4,903	\$6,638	\$8,500
Electricity	\$/yr	\$689	\$813	\$946	\$701	\$867	\$1,034
Gasoline	\$/yr	\$228	\$261	\$319	\$232	\$284	\$354
Personal Charger	\$/yr	\$81	\$101	\$122	\$81	\$101	\$122
Maintenance	\$/yr	\$142	\$185	\$227	\$142	\$188	\$233
<b>TOTAL ANNUAL COST</b>	<b>\$/yr</b>	<b>\$5,925</b>	<b>\$7,280</b>	<b>\$8,857</b>	<b>\$6,059</b>	<b>\$8,078</b>	<b>\$10,242</b>
<b>Savings per PEV</b>	<b>\$/yr</b>	<b>\$18</b>	<b>\$326</b>	<b>\$793</b>	<b>\$27</b>	<b>\$445</b>	<b>\$764</b>

Based on these battery cost projections, this analysis projects that the average annual cost of owning a PEV<sup>11</sup> in New York will fall below the average cost of owning a gasoline vehicle by 2030, even without government purchase subsidies. See Table 2 which summarizes the average projected annual cost of New York PEVs and gasoline vehicles under each penetration scenario. All costs in Table 2 are in nominal dollars, which is the primary reason why costs for both gasoline vehicles and PEVs are higher in 2040 and 2050 than in 2030 (due to inflation). In addition, the penetration scenarios assume that the relative number of PEV cars and higher cost PEV light trucks will change over time; in particular the 80x50 scenario assumes that there will be a significantly higher percentage of PEV light trucks in the fleet in 2050 than in 2030, which further increases the average PEV purchase cost in 2050 compared to 2030.

As shown in Table 2, even in 2050 average PEV purchase costs are projected to be higher than average purchase costs for gasoline vehicles (with no government subsidies), but the annualized effect of this incremental purchase cost is outweighed by significant fuel cost savings, as well as savings in scheduled maintenance costs. In 2030 the average PEV owner in New York is projected to save \$18 – \$27 per year compared to the average gasoline vehicle owner, without government subsidies. These annual PEV savings are projected to increase to an average of \$326 - \$445 per PEV in 2040, and \$764 - \$793 per PEV in 2050, as relative PEV purchase costs continue to fall, and the projected price of gasoline continues to increase faster than projected electricity prices. The NPV of annual savings for the average PEV owner in New York is projected to be \$12 - \$18 in 2030, rising to \$271 - \$282 in 2050.

<sup>11</sup> The analysis assumes that all battery electric vehicles in-use after 2030 will have 200-mile range per charge and that all plug-in hybrid vehicles will have 50 mile all-electric range.

The NPV of total annual cost savings to New York drivers from greater PEV ownership are projected to be \$15 million in 2030 under the 8-state ZEV MOU penetration scenario, rising to \$333 million in 2040 and \$850 million in 2050. Under the 80x50 penetration scenario the NPV of total annual cost savings to New York drivers from greater PEV ownership are projected to be \$56 million in 2030, rising to \$1.6 billion in 2040 and \$3.0 billion in 2050.

### 3.5 Total Societal Benefits

The NPV of total estimated societal benefits from increased PEV use in New York under each PEV penetration scenario are summarized in Figures 14 and 15. These benefits include cost savings to PEV owners (section 3.4), utility customer savings from reduced electric bills (section 3.3) and the monetized benefit of reduced GHG emissions (section 3.2). Figure 14 shows the NPV of projected societal benefits if PEV owners charge in accordance with the baseline charging scenario, and if GHG emissions from electricity production follow EIA's current projections for carbon intensity. Figure 15 shows the NPV of projected societal benefits if PEV owners charge off-peak, and if New York meets its goals for grid decarbonization by 2050.

As shown in Figure 14, the NPV of annual societal benefits are projected to be a minimum of \$1.4 billion per year in 2050 under the 8-state ZEV MOU penetration scenario and \$5.4 billion per year in 2050 under the 80x50 penetration scenario. Approximately 56 percent of these annual benefits will accrue to PEV owners as a cash savings in vehicle operating costs, 23 percent will accrue to electric utility customers as a reduction in annual electricity bills, and 21 percent will accrue to society at large in the form of reduced pressure on climate change due to reduced GHG emissions.

As shown in Figure 15, the NPV of annual societal benefits in 2050 will increase by \$137 million under the 8-state ZEV MOU penetration scenario, and \$541 million under the 80x50 penetration scenario if PEV owners charge off peak and the state is successful in decarbonizing the electric grid. Of these increased benefits approximately 60 percent will accrue to electric utility customers as an additional reduction in their electricity bills, and 40 percent will accrue to society at large due to lower GHG emissions.

Figure 14 Projected NPV of Total Societal Benefits from Greater PEV use in NY – Baseline Charging

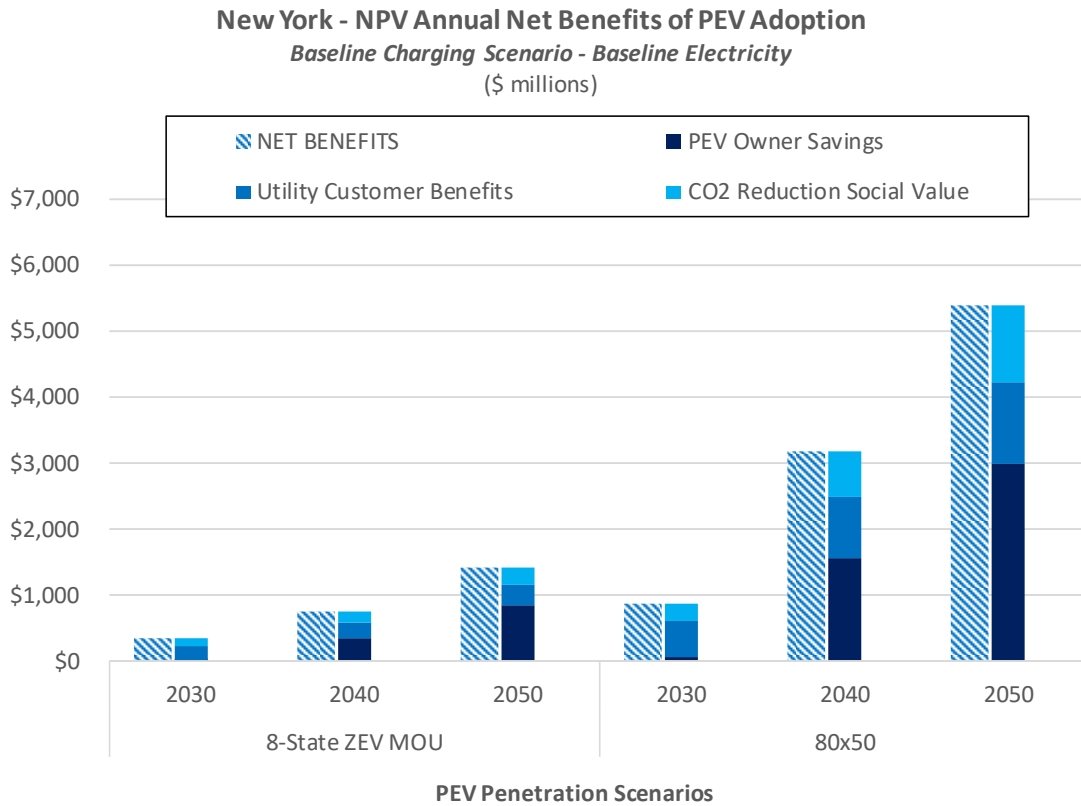
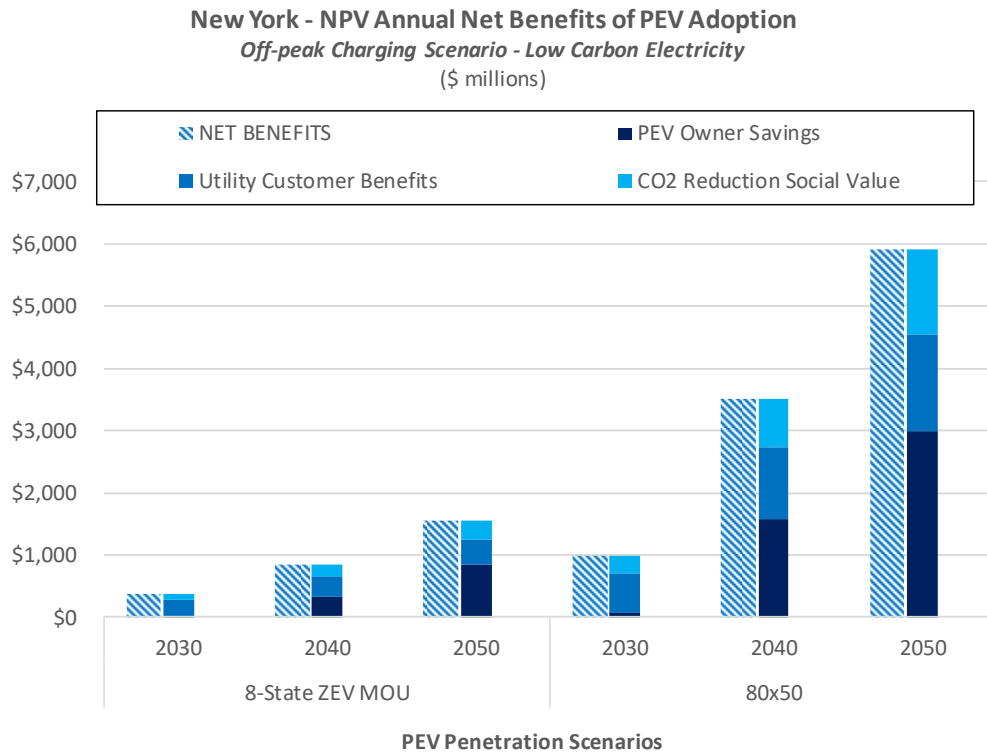


Figure 15 Projected NPV of Total Societal Benefits from Greater PEV use in NY – Off-peak Charging



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