

# Electric Vehicle Cost-Benefit Analysis

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



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## About M.J. Bradley & Associates

M.J. Bradley & Associates, LLC (MJB&A), founded in 1994, is a strategic consulting firm focused on energy and environmental issues. The firm includes a multi-disciplinary team of experts with backgrounds in economics, law, engineering, and policy. The company works with private companies, public agencies, and non-profit organizations to understand and evaluate environmental regulations and policy, facilitate multi-stakeholder initiatives, shape business strategies, and deploy clean energy technologies.

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

We bring insights to executives, operating managers, and advocates. We help you find opportunity in environmental markets, anticipate and respond smartly to changes in administrative law and policy at federal and state levels. We emphasize both vision and implementation and offer timely access to information along with ideas for using it to the best advantage.

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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 Mexico, for two different penetration levels between 2030 and 2050.<sup>1</sup> The “ZEV Goal” scenario is based upon near-term (2025) Zero Emission Vehicle goals adopted by states that together comprise about a third of the automotive market, goals Governor Lujan Grisham has indicated New Mexico will soon adopt.<sup>2</sup> The “80x50” scenario is based on the PEV penetration that would be required to achieve New Mexico’s long-term goals for economy wide greenhouse gas (GHG) reduction of 80 percent below 2005 levels by 2050.

This study focused on passenger vehicles and trucks; there are additional opportunities for electrification of non-road equipment and medium- and heavy-duty trucks and buses, but evaluation of these applications was beyond the scope of this study.

The study estimated the benefits that would accrue to all electric utility customers in New Mexico due to increased utility revenues from PEV charging. This revenue could be used to support operation and maintenance of the electrical grid, thus reducing the need for future electricity rate increases. These benefits were estimated for a baseline scenario in which New Mexico drivers 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 New Mexico drivers with price signals or incentives to delay the start of PEV charging until after the daily peak in electricity demand (managed 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, managed 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 lower.

See Figure 1 for a summary of how the projected potential utility net revenue from PEV charging might affect average residential electricity bills for all New Mexico electric utility customers.<sup>3</sup> As shown in the figure, under the 80x50 scenario with managed off-peak charging the average New Mexico household could realize approximately \$133 in annual utility bill savings in 2050 (nominal dollars).

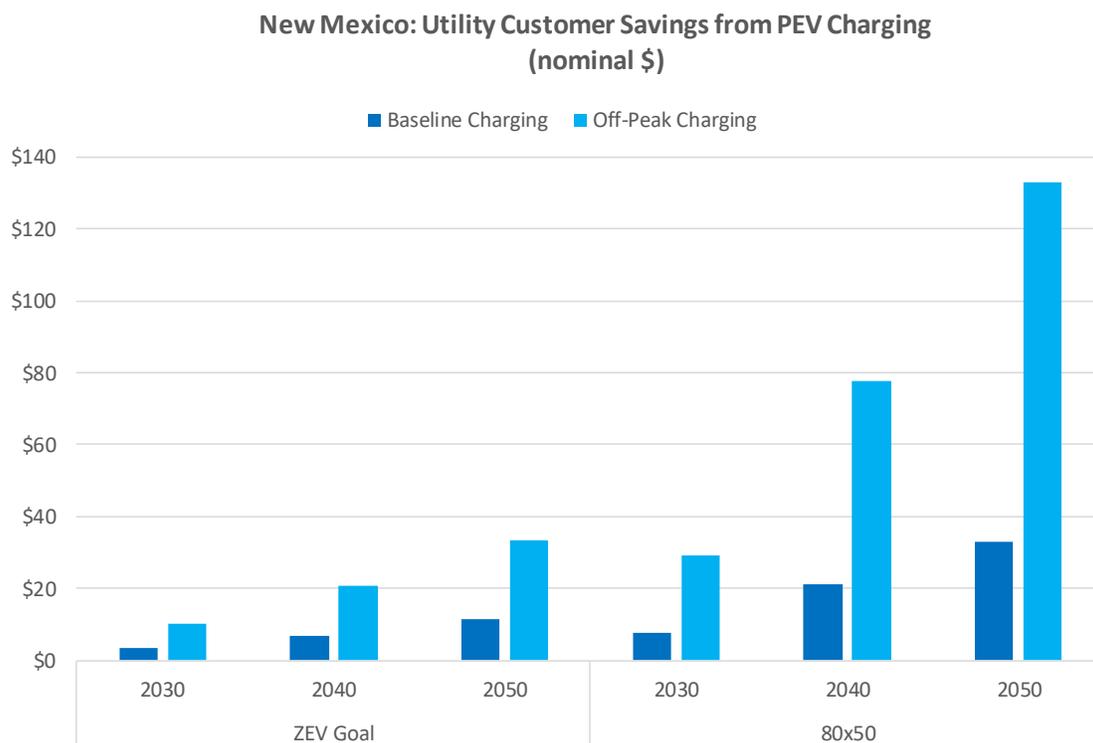
In addition, the study estimated the potential annual financial benefits to New Mexico drivers – from fuel and maintenance cost savings compared to owning gasoline vehicles, and societal benefits that could result from avoided emissions.

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

<sup>2</sup> In 2013, six Northeast/Mid-Atlantic states (MD, MA, NY, CT, RI, VT) and two Pacific coast states (CA, OR) joined in a Zero Emission Vehicle Memorandum of Understanding to enact policies that will ensure the deployment of 3.3 million ZEVs by 2025.

<sup>3</sup> Based on 2018 average electricity use of 7,116 kWh per housing unit in New Mexico.

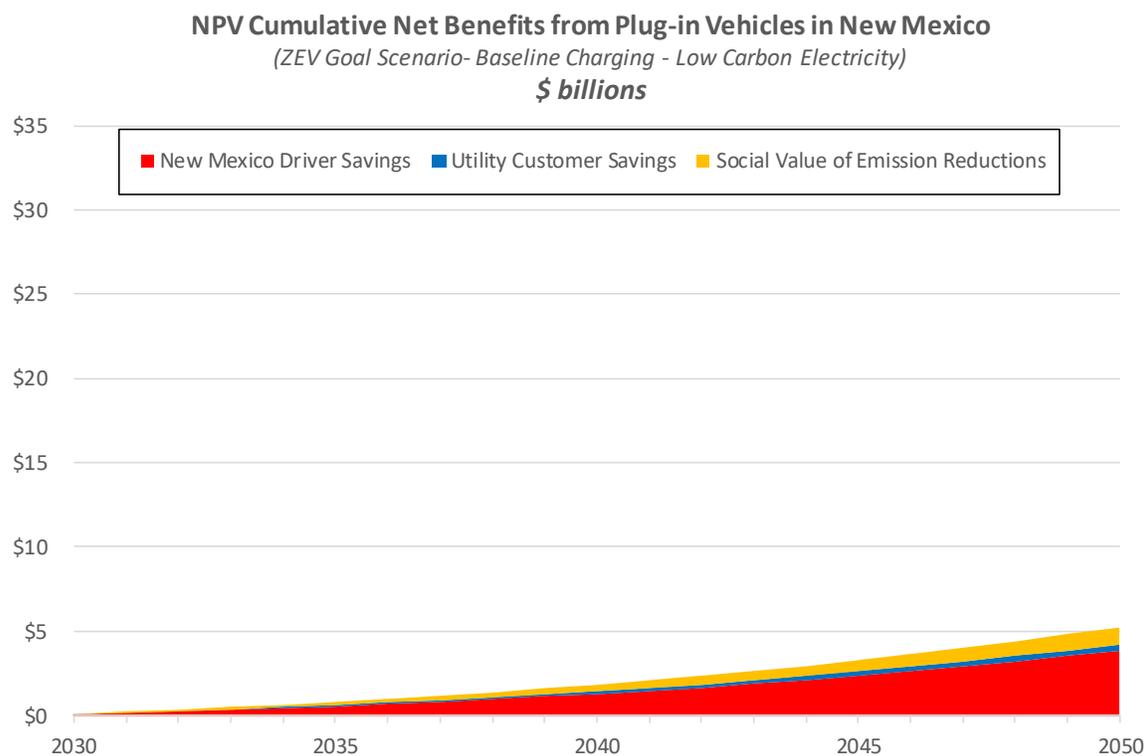


As shown in Figure 2 (ZEV Goal scenario), if New Mexico meets short term (2025) goals for PEV penetration, and the increase in percent PEV penetration then continues at the same annual rate in later years, the net present value of **cumulative net benefits from greater PEV use in New Mexico will exceed \$5.3 billion state-wide by 2050.**<sup>4</sup> Of these total net benefits:

- At least \$0.4 billion will accrue to electric utility customers in the form of reduced electric bills<sup>5</sup>,
- \$3.8 billion will accrue directly to New Mexico drivers in the form of reduced annual vehicle operating costs, and
- \$1.0 billion will accrue to society at large, as the value of reduced emissions.

<sup>4</sup> Using a 3 percent discount rate

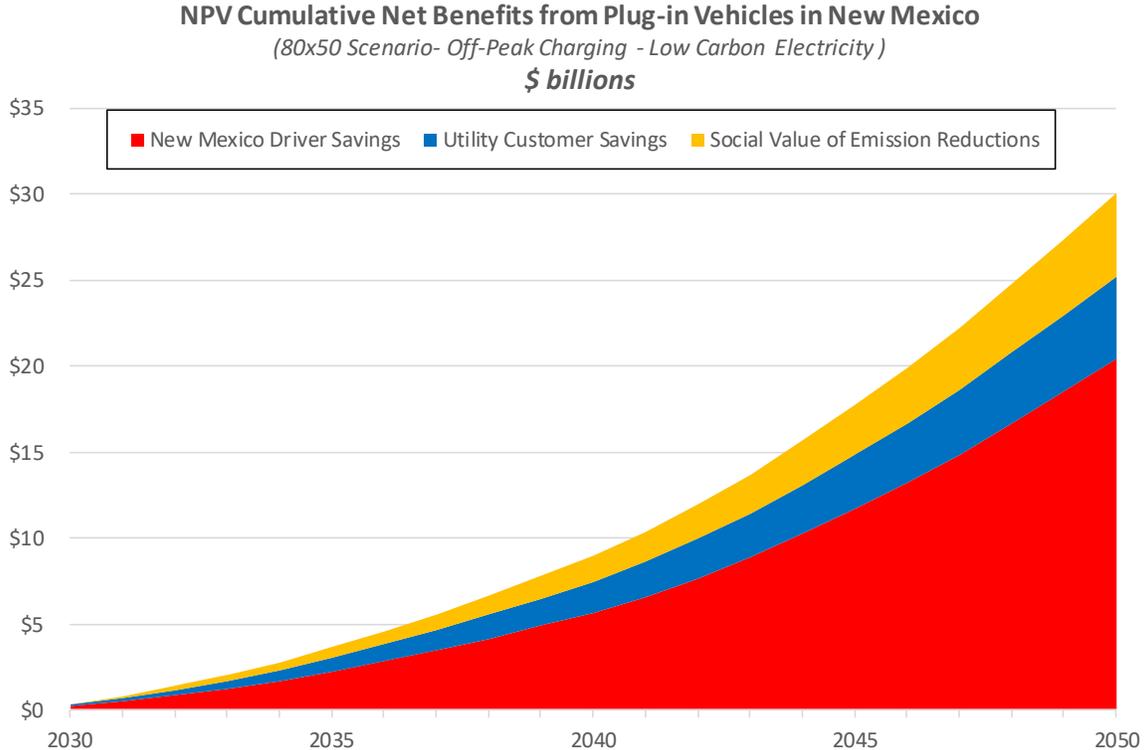
<sup>5</sup> Figure 2 includes utility customer savings under the baseline charging scenario; savings would be higher under the managed off-peak charging scenario.



As shown in Figure 3 (80x50 scenario), if the state meets long-term goals to reduce light-duty fleet and economy-wide GHG emissions by 80 percent from 2005 levels by 2050, which requires even greater PEV penetration, the net present value of **cumulative net benefits from greater PEV use in New Mexico could exceed \$30 billion state-wide by 2050**. Of these total net benefits:

- \$4.8 billion will accrue to electric utility customers in the form of reduced electric bills
- Up to \$20.4 billion will accrue directly to New Mexico drivers in the form of reduced annual vehicle operating costs<sup>6</sup>
- \$4.8 billion will accrue to society at large, as the value of reduced emissions

<sup>6</sup> Figure 3 includes utility customer savings under the managed off-peak charging scenario; savings would be lower under the baseline charging scenario.



By 2050, PEV owners are projected to save nearly \$2,253 per vehicle (nominal \$) in annual operating costs, compared to owning gasoline vehicles. A large portion of this direct financial benefit to New Mexico drivers derives from reduced gasoline use—from purchase of lower cost, regionally produced electricity instead of gasoline imported to the state. Under the ZEV Goal scenario, PEVs will reduce cumulative gasoline use in the state by nearly 1.4 billion gallons through 2050 – this cumulative gasoline savings grows to almost 6 billion gallons through 2050 under the 80x50 scenario. In 2050, annual average gasoline savings will be approximately 187 gallons per PEV under the ZEV Goal scenario, while projected savings under the 80x50 scenario are 223 gallons per PEV.

This projected gasoline savings will help to promote energy security and independence and will keep more of vehicle owners’ money in the local economy, thus generating even greater economic impact. Studies in other states have shown that the switch to PEVs can generate up to \$570,000 in additional economic impact for every million dollars of direct savings, resulting in up to 25 additional jobs in the local economy for every 1,000 PEVs in the fleet [1].

In addition, this reduction in gasoline use will reduce cumulative net GHG emissions by nearly 14.5 million metric tons through 2050 under the ZEV Goal scenario, and over 62 million metric tons under the 80x50 scenario.<sup>7</sup> The switch from gasoline vehicles to PEVs is also projected to reduce annual NO<sub>x</sub> emissions in the state by over 246 tons in 2050 under the ZEV Goal scenario, and by over 1,100 tons under the 80x50 scenario.

<sup>7</sup> Net of emissions from electricity generation

## Background - New Mexico

In January 2019, New Mexico's Governor Michelle Lujan Grisham signed an executive order committing the state to the Paris Climate Accord, requiring significant reductions in carbon pollution, approximately 45% by 2030 compared against 2005 levels. The EO also identified key market areas where reductions should take place, including power generation, oil and gas production as well as light duty vehicle sales. For LDVs, New Mexico will join Colorado as well as other states to require clean car standards and a ZEV goal of 9 percent of new vehicles being zero-emitting electric drive by 2025. [2]

In March 2019, New Mexico's legislature passed the Energy Transition Act, which was supported by Governor Michelle Lujan Grisham. The bill is a direct response to the declining economic viability of coal power in the state. The bill requires that New Mexico utilities have 50 percent renewable energy by 2030 and 100 percent carbon free electricity generation by 2045. [3]

Shortly after the Energy Transition Act, bipartisan legislature passed House Bill 521 with backing from Gov. Grisham. HB521 focuses on expanding EV charging infrastructure in New Mexico. The bill's two main goals were 1) to clarify to independent EV charging companies that they would not be regulated like utilities and 2) require regulated utilities to develop charging infrastructure incentive programs and partnerships with charging manufacturers to assist in accelerated EV adoption. [4]

### *PEV Vehicles in New Mexico*

As of December 2018, there were approximately 2,100 PEVs (including battery-electric and plug-in hybrid vehicles) registered in New Mexico and they comprised about 0.11 percent of the 1.9 million cars and light trucks registered in the State. In 2016 and 2017, sales of new PEVs in the state were less than one half of one percent of new vehicle sales. For 2018, this percentage rose to 0.8%, while limited data for 2019 shows a further increase to just over 1 percent market share in New Mexico<sup>8</sup>. [5]

### *Public PEV Charging Stations in New Mexico*

In New Mexico, there are currently 80 public charging stations, with a total of 245 charging outlets. Of these 80 stations, 22 are considered DC fast chargers (DCFC) and include 98 charging outlets. Nearly all of the DCFCs are accessible from major highways, with a significant clustering between Albuquerque and Santa Fe, NM. [6]

Public Service of New Mexico (PNM) offers free charging at 2 locations, one in Santa Fe and one in Silver City. [7]

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<sup>8</sup> Estimate is through June 2019.

## Study Methodology

This section briefly describes the methodology used for this study. For more information on how this study was conducted, including a general 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).<sup>9</sup> 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 Mexico between 2030 and 2050. These PEV penetration scenarios bracket short and long-term policy goals for ZEV adoption and GHG reduction which have been adopted by other states, and localities.<sup>10</sup>

**ZEV Goal Scenario:** Penetration of PEVs equivalent to New Mexico's participation in a program similar to the *8-state ZEV Memorandum of Understanding*. Compliance with this MOU would require approximately 6 percent of in-use light duty vehicles in New Mexico to be ZEV by 2025. Assuming the increase in percent PEV penetration then continues at the same annual rate in later years, PEV penetration is assumed to be 8.9 percent in 2030, 14.7 percent in 2040, and 20.6 percent in 2050.<sup>11</sup>

**80x50 Scenario:** The level of PEV penetration required to reduce total light-duty GHG emissions in New Mexico in 2050 by 80 percent from 2005 levels with 100 percent carbon free electricity, to meet the goals specified in the Energy Transition Act. This will require PEV penetration of 25 percent in 2030, 58 percent in 2040 and 90 percent in 2050.

Both of these scenarios are 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 New Mexico Department of Transportation.

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 Mexico'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.

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) a managed off-peak charging scenario in which a significant portion of PEVs delay the start of charging until non-peak periods each day.

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<sup>9</sup> This analysis used the same methodology as described in the referenced report, but used different PEV penetration scenarios, as described here. In addition, for this analysis fuel costs and other assumptions taken from the Energy Information Administration (EIA) were updated from EIA's Annual Energy Outlook 2016 to those in the Annual Energy Outlook 2019. For projections of future PEV costs, this analysis also used updated assumptions from a 2019 study by the International Council on Clean Transportation [8]. In addition, as further described in this section, this analysis used a modified methodology to calculate incremental energy, generation capacity and transmission/distribution costs associated with PEV charging. This analysis also includes an estimate of NOx reductions resulting from transportation electrification; the methodology used is not included in the cited report but is described here.

<sup>10</sup> The states of CA, CT, FL, MA, MD, ME, MN, NH, NJ, NY, OR, RI, and VT have all set economy-wide goals of 75-80 percent GHG reduction by 2050. The starting point for the target 2050 GHG reduction percentage varies by state, from 1990 to 2006. The District of Columbia has also adopted a goal to reduce GHG emissions by 80 percent from 2006 levels by 2050.

<sup>11</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 given that fact fuel cell technology lags behind battery technology and fuel cell vehicles face a greater infrastructure challenge.

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 afternoon/evening peak demand.<sup>12</sup> However, if given a “nudge” - in the form of a properly designed and marketed financial incentive - many New Mexico drivers 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). [9]

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 transmission and secondary distribution systems, to handle the additional load.

This analysis calculates average system-wide electricity generation costs based on projections by the Energy Information Administration, but then adds incremental costs associated specifically with PEV charging load under each charging scenario, based on timing of the charging load. This was done using forecast data from Tri-State Generation and Transmission Association, Inc. This data shows that the cost for New Mexico utilities to purchase bulk electricity varies by year and time of day, with average annual costs (\$/MWh) about 11 percent higher during the day (6 AM – 9 PM) than at night. As discussed below, compared to baseline charging managed off-peak charging shifts load from the late afternoon/early evening to the early morning hours, thus reducing the cost to utilities to purchase the necessary electricity.

To calculate the costs associated with adding generation and transmission/distribution capacity to handle the incremental PEV charging load, this analysis uses a value of \$96/kW-year in 2019 (nominal dollars). This value is increased by 2.5 percent per year in later years to account for inflation.<sup>13</sup> For each scenario in each year, this value is multiplied by the estimated incremental load (kW) imposed by EV charging during the late afternoon peak load period (4 p.m. – 8 p.m.), to calculate incremental capacity costs resulting from PEV charging.

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 Mexico drivers.

For each PEV penetration scenario this analysis also 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 “low carbon electricity” scenario. This low carbon electricity scenario is based on New Mexico achieving 50 percent renewable energy by 2030 and 100 percent carbon free electricity generation by 2045, in accordance with goals established under the Energy Transition Act.

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 monetized “social value” of these GHG reductions from PEV use are calculated using the Social Cost of Carbon (\$/MT), as calculated by the U.S.

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<sup>12</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.

<sup>13</sup> Based on data provided by PNM’s Resource team and MJB&A’s inflation adjustment. [10]

government's Interagency Working Group on Social Cost of Greenhouse Gases. The Interagency Working Group calculated GHG social values based on discount rates of 2.5 percent, 3 percent, and 5 percent; for this analysis we used the average values generated with a 3 percent discount rate, which is in the middle of the range of reported values. The values used are \$41 per metric ton in 2015, rising to \$79/MT in 2050 (constant 2015\$).

Finally, this analysis projected annual net reductions in nitrogen oxide (NOx) emissions under each PEV penetration scenario that would result from the use of electric vehicles instead of gasoline vehicles.<sup>14</sup> To do so the reduction in emissions due to reducing miles driven by conventional vehicles was estimated, then subtracted the emissions resulting from generation of the electricity required to charge the electric vehicles that replaced them. To calculate the reduction in emissions from conventional vehicles, for each year in the analysis the authors used emission factors (grams/mile) for new conventional vehicles purchased in that year. These emission factors were derived from the United States Environmental Protection Agency's (EPA) MOTO Vehicle Emissions Simulator (MOVES) model [11].

The monetized social value of these NOx reductions was calculated using a national average value of \$15,909 per ton of NOx in 2018, escalated in future years using EIA inflation assumptions. The 2018 value was derived from modeling done by the Environmental Protection Agency using their Response Surface Model [12]; this value represents a national average for mobile source NOx.

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<sup>14</sup> These reductions are net of projected NOx emissions from production of electricity required to charge the PEVs.

## 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 New Mexico drivers compared to owning gasoline vehicles.

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

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

#### Vehicles and Miles Traveled

The projected number of PEVs and conventional gasoline vehicles in the New Mexico light duty fleet under each PEV penetration scenario is shown in Figure 4, and the projected annual miles driven by these vehicles is shown in Figure 5.<sup>15</sup>

There are currently 1.0 million cars and 0.9 million light trucks registered in New Mexico, and these vehicles travel 30 billion miles per year. Both the number of vehicles and total annual vehicle miles are projected to increase by 22 percent through 2050, to 2.3 million light duty vehicles traveling 36.3 billion miles annually<sup>16</sup>.

In order to meet the ZEV Goal scenario, the number of PEVs registered in New Mexico would need to increase from approximately 2,100 today, to 110,278 by 2025. Assuming the same annual increase in percent PEV penetration in later years, there would be 187,500 PEVs in the state in 2030, 325,000 in 2040, and 477,000 in 2050 (ZEV Goal penetration scenario).

In order to put the state on a path to achieve an 80 percent reduction in light-duty GHG emissions from 2005 levels by 2050 (80x50 scenario) there would need to be approximately 527,000 PEVs in New Mexico by 2030, rising to 1.3 million in 2040, and 2.0 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 90 percent in 2030 increasing to 95 percent in 2050, while PHEVs are assumed to have an average utility factor of 75 percent in 2030, rising to 85 percent in 2050. This analysis estimates that New Mexico could reduce light-duty fleet GHG in 2050 by 80 percent from 2005 levels if 84 percent of miles were driven by PEVs on electricity (Figure 5). However, in order to achieve this level of electric miles 90 percent of light-duty vehicles would need to be PEVs (Figure 4).

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<sup>15</sup> This analysis only includes cars and light trucks. It does not include medium- or heavy-duty trucks and buses.

<sup>16</sup> Vehicle fleet and VMT growth is assumed to mirror projected population growth.

Figure 4 Projected New Mexico Light Duty Fleet

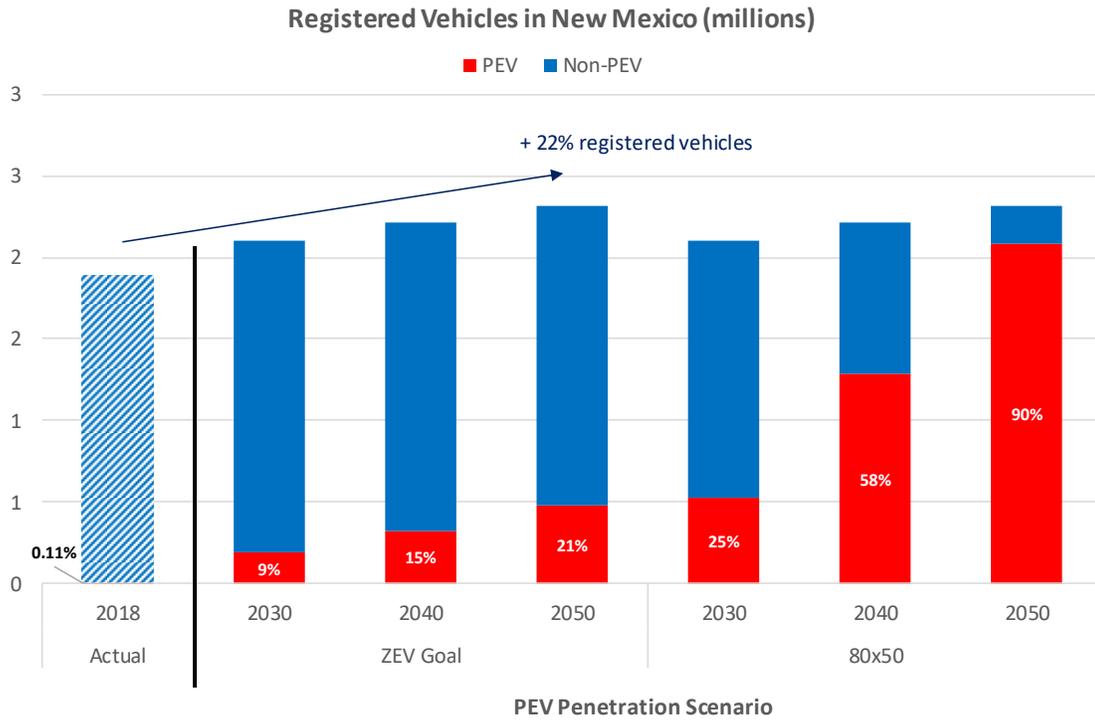
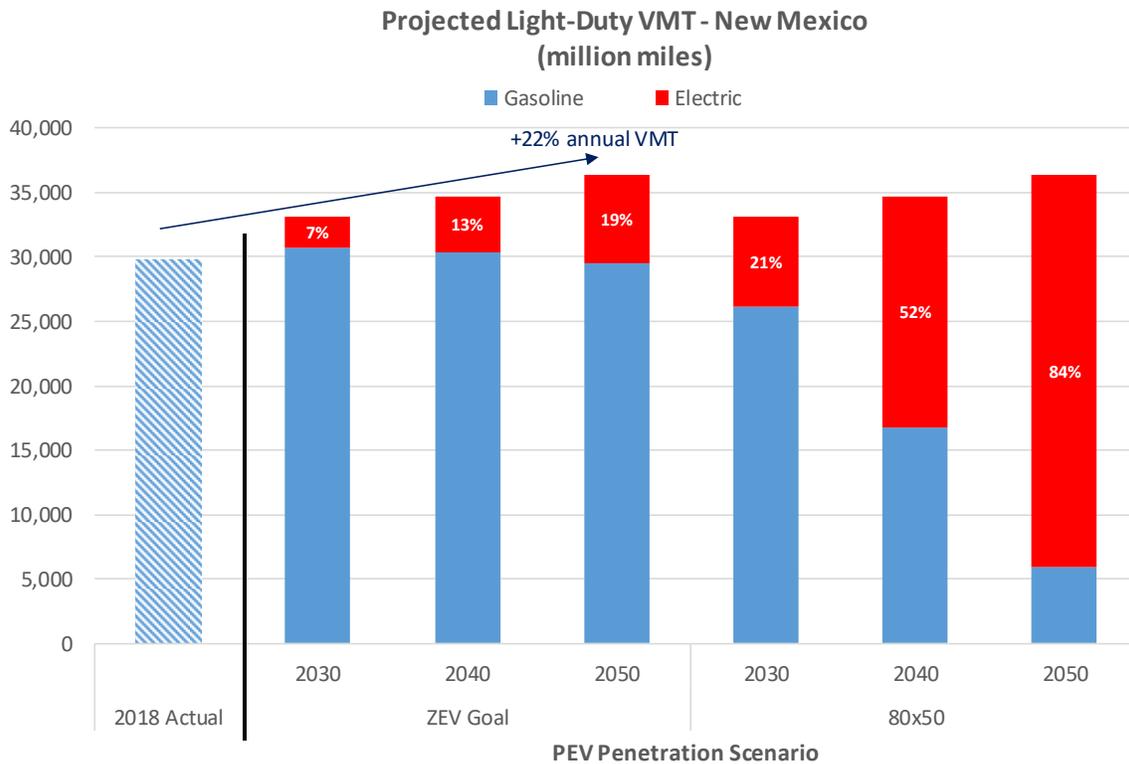


Figure 5 Projected New Mexico Light Duty Fleet Vehicle Miles Traveled

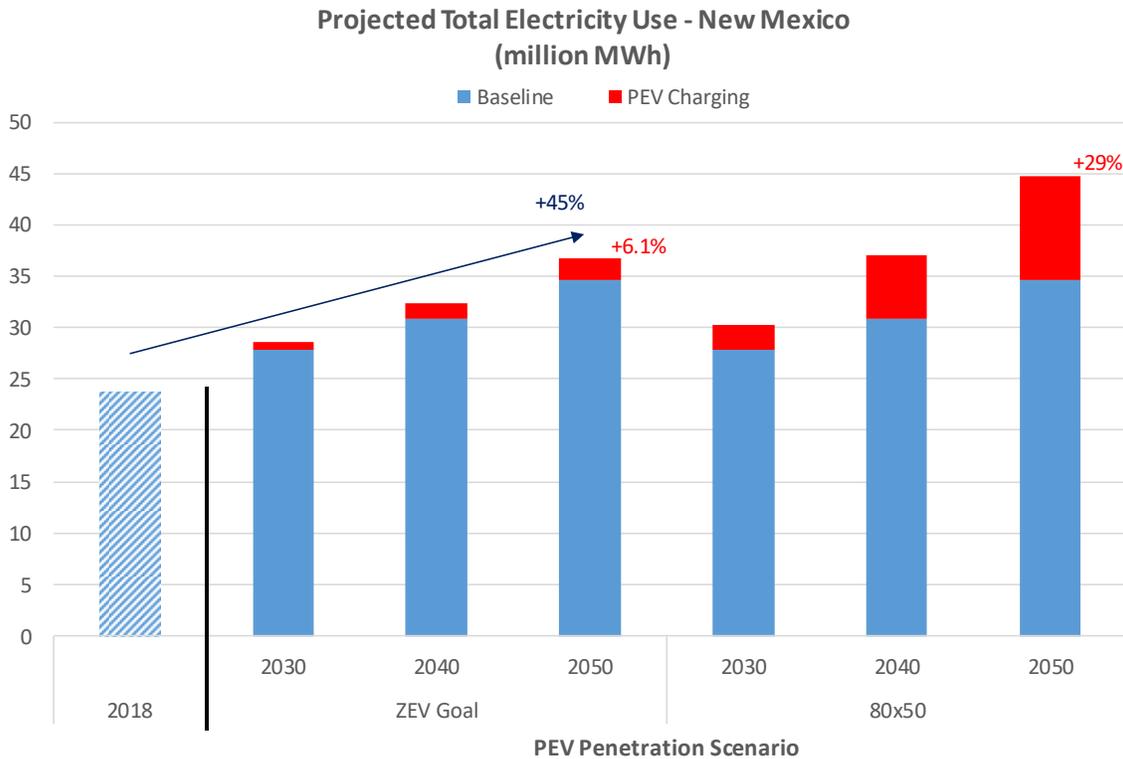


### PEV Charging Electricity Use

The estimated total PEV charging electricity used in New Mexico each year under the PEV penetration scenarios is shown in Figure 6.

In Figure 6, 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 Mexico is currently 24 million MWh per year. Annual electricity use is projected to increase to 27.8 million MWh in 2030 and continue to grow after that, reaching 35 million MWh in 2050 (45 percent greater than 2018 level).

Figure 6 Estimated Total Electricity Use in New Mexico



Under the ZEV Goal penetration scenario, electricity used for PEV charging is projected to be 0.8 million MWh in 2030 – an increase of 2.9 percent over baseline electricity use. By 2050, electricity for PEV charging is projected to grow to 2.1 million MWh – an increase of 6.1 percent over baseline electricity use. Under the 80x50 scenario electricity used for PEV charging is projected to be 2.4 million MWh in 2030, growing to 10.1 million MWh and adding 29 percent to baseline electricity use in 2050.

### PEV Charging Load

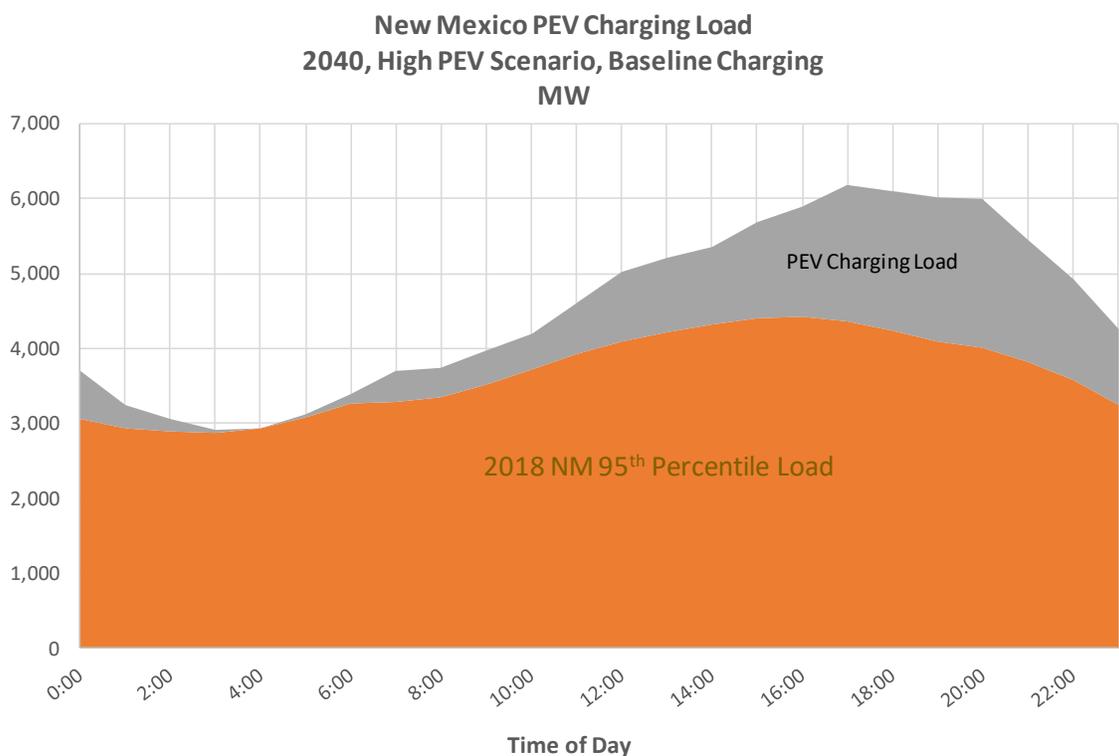
This analysis evaluated the effect of PEV charging on the New Mexico electric grid under two different charging scenarios. Under both scenarios, 78 percent of all PEVs are assumed to charge exclusively at home and 22 percent are assumed to charge both at home and at work. Under the baseline charging scenario, all New Mexico drivers 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 managed off-peak charging scenario 90 percent of New Mexico drivers who arrive at home after noon each day are assumed to delay the start of home charging until after 9 PM – in response to a price

signal or incentive provided by their utility.<sup>17</sup> Further, this scenario assumes that off-peak charging will be managed by staggering charge start times between 10 PM and 5 AM for individual PEVs, to avoid a sharp secondary peak at 10 PM.<sup>18</sup>

See Figure 7 (baseline) and Figure 8 (managed off-peak) for a comparison of PEV charging load under the baseline and managed off-peak charging scenarios, using the 2040 80x50 penetration scenario as an example. In each of these figures, the 2018 New Mexico 95<sup>th</sup> percentile load (MW) by time of day is plotted in orange, and the projected incremental load due to PEV charging is plotted in grey.<sup>19</sup>

In 2018 daily electric load in New Mexico was generally in the range of 2,800 – 3,000 MW from midnight to 5 AM, ramping up through the morning and early afternoon to peak at approximately 4,400 MW between 3 PM and 5 PM, and then falling off through the late afternoon and evening hours.

**Figure 7** 2040 Projected New Mexico PEV Charging Load, Baseline Charging (80x50 scenario)



As shown in Figure 7, baseline PEV charging is projected to add load primarily between 7 AM and midnight, 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 3 PM and 5 PM. As shown in Figure 8, off-peak charging significantly reduces the incremental PEV charging load during the afternoon peak load period but distributes load through the late evening and continuing into the early morning hours, between 10 PM and 6 AM. The shape of this late evening/early morning peak can potentially be controlled based on the design of off-peak charging

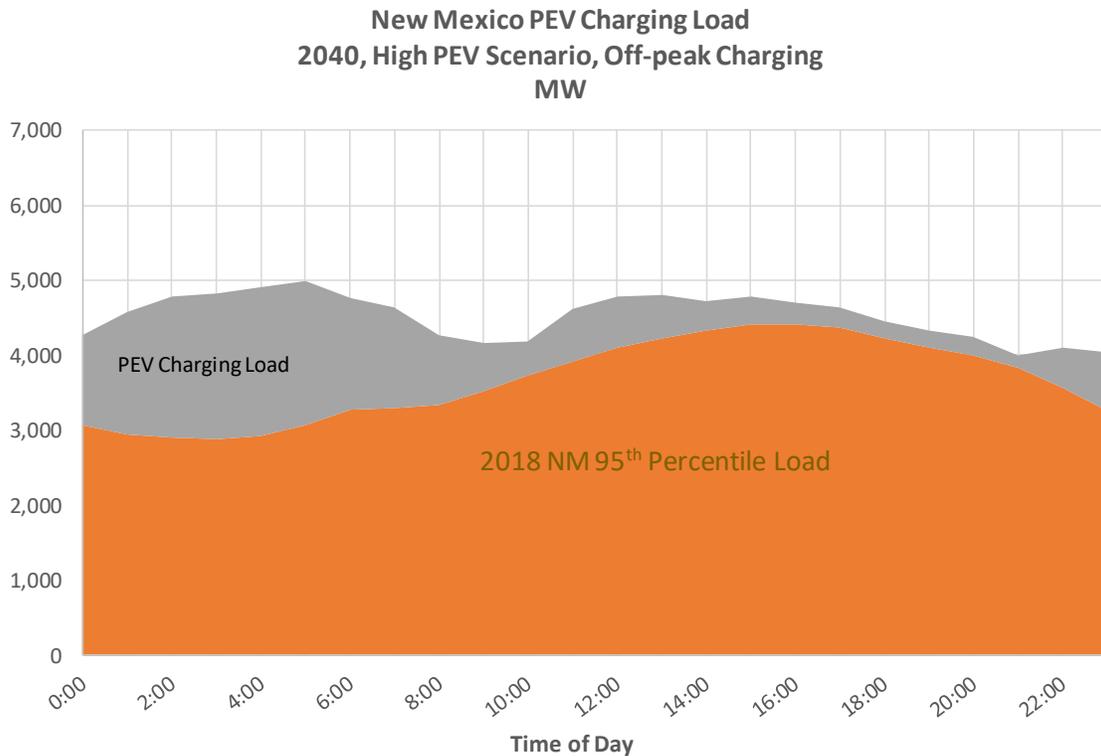
<sup>17</sup> Utilities have many policy options to incentivize off-peak PEV charging. This analysis does not compare the efficacy of different options.

<sup>18</sup> Utilities have multiple policy and technical options for implementing managed charging. This analysis does not endorse any particular methodology.

<sup>19</sup> For each hour of the day actual load in 2018 was higher than the value shown on only 5 percent of days (18 days).

incentives<sup>20</sup>. It should also be noted that those early morning hours are often the hours of the day when wind generation peaks.

Figure 8 2040 Projected New Mexico PEV Charging Load, Off-peak Charging (80x50 scenario)



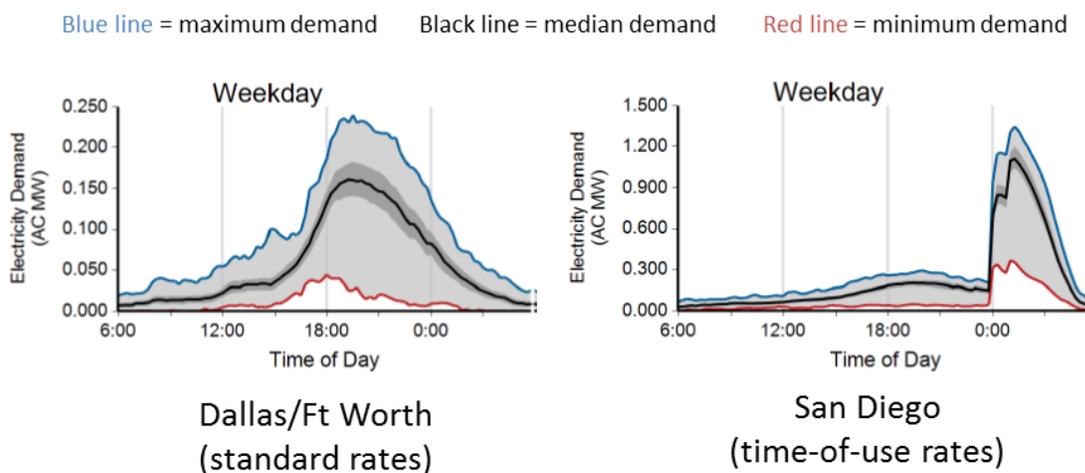
These baseline and off-peak load shapes are consistent with real world PEV charging data collected by the EV Project, as shown in Figure 9. In Figure 9 the graph on the left shows PEV charging load in the Dallas/Ft Worth area where no off-peak charging incentive was offered to drivers. The graph on the right shows PEV charging load in the San Diego region, where the local utility offered drivers a time-of-use rate with significantly lower costs (\$/kWh) for charging during the “super off-peak” period between midnight and 5 a.m. [9]<sup>21</sup>

<sup>20</sup> This analysis assumes off-peak charging will be managed, with individual vehicles starting to charge between 10 PM and 5 AM. Based on annual mileage per vehicle, and projected PEV energy use, the average over-night charge is projected to take less than 3 hours using Level 1 and level 2 home chargers.

<sup>21</sup> Off-peak charging start times in San Diego are not actively controlled based on the design of the incentive, so there is typically a sharp peak in load at midnight, the start of the ‘super off-peak’ period with lower energy costs.

Figure 9

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 Mexico, 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 2018 95<sup>th</sup> percentile peak hour load.

Under the ZEV Goal penetration scenario, PEV charging would add 246 MW load during the afternoon peak load period on a typical weekday in 2030, which would increase the 2018 baseline peak load by about 5 percent. By 2050, the afternoon incremental PEV charging load would increase to 627 MW, adding more than 14 percent to the 2018 baseline afternoon peak. By comparison the afternoon peak hour PEV charging load in 2030 would be only 35 MW for the off-peak charging scenario, increasing to 91 MW in 2050.

Under the 80x50 penetration scenario, baseline PEV charging would increase the total 2018 afternoon peak electric load by about 75 percent in 2050, while off-peak charging would only increase it by about 10 percent.<sup>22</sup>

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

		ZEV Goal			80x50		
		2030	2040	2050	2030	2040	2050
<b>Baseline Charging</b>	PEV Charging (MW)	246.3	427.2	627.4	783.5	1,986.9	3,333.6
	<i>Increase relative to 2018 Peak</i>	5.6%	9.7%	14.2%	17.7%	44.9%	75.4%
<b>Off-Peak Charging</b>	PEV Charging (MW)	34.8	61.1	90.9	102.1	282.5	454.2
	<i>Increase relative to 2018 Peak</i>	0.8%	1.4%	2.1%	2.3%	6.4%	10.3%

As discussed below, 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.

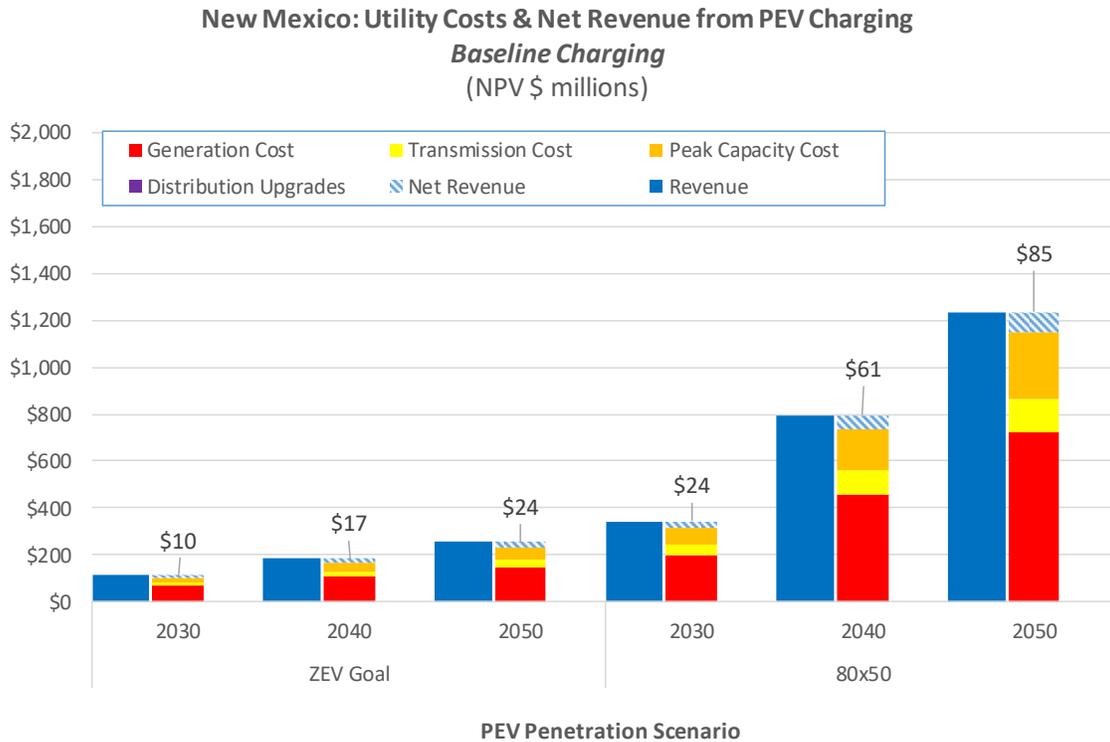
<sup>22</sup> Given projected significant increases in total state-wide electricity use through 2050, baseline peak load (without PEVs) is also likely to be higher in 2050 than 2018 peak load; as such the percentage increase in baseline peak load due to high levels of PEV penetration is likely to be lower than that shown in Table 1.

## Utility Customer Benefits

The estimated NPV of revenues and costs for New Mexico’ electric utilities to supply electricity to charge PEVs under each penetration scenario are shown in Figure 10, assuming the baseline PEV charging scenario.

In Figure 10, projected utility revenue is shown in dark blue. Under the ZEV Goal penetration scenario, the NPV of revenue from electricity sold for PEV charging in New Mexico is projected to total \$114 million in 2030, rising to \$257 million in 2050. Under the 80x50 scenario, the NPV of utility revenue from PEV charging is projected to total \$341 million in 2030, rising to \$1.2 billion in 2050.

Figure 10 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 (transmission and distribution upgrade cost). 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. Transmission and distribution upgrade costs are costs incurred by the utility to upgrade their own distribution infrastructure to handle the increased peak load imposed by PEV charging.

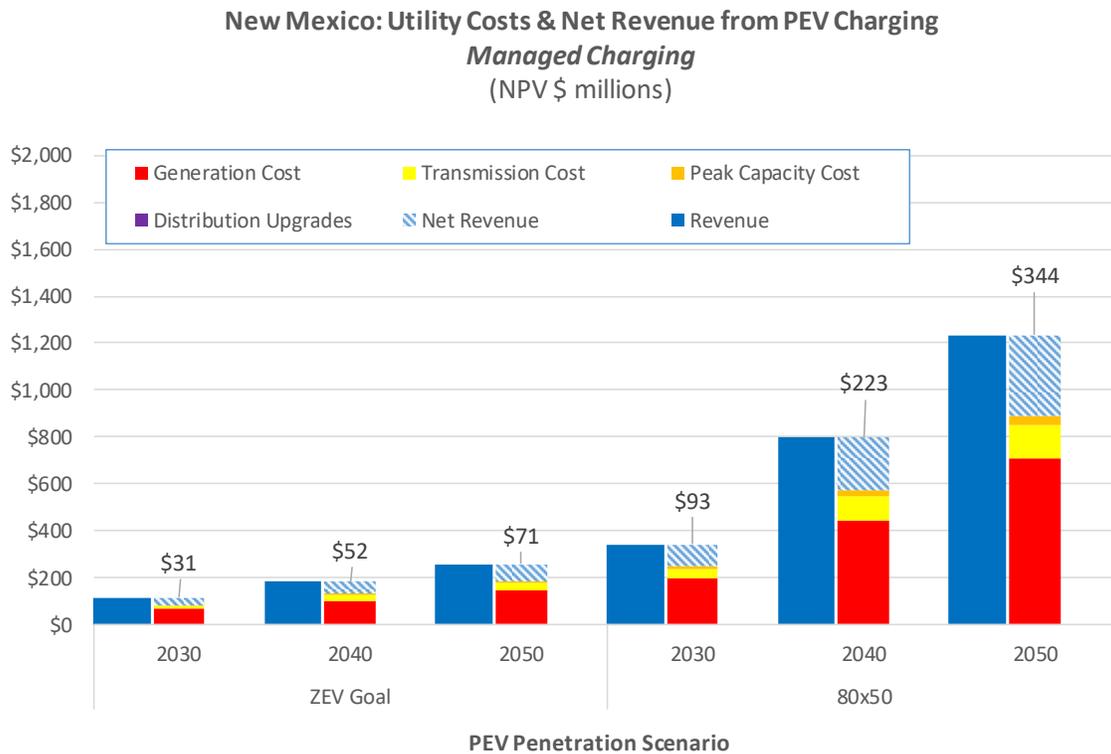
The striped light blue bars in Figure 10 represent the NPV of projected “net revenue” (revenue minus costs) that utilities would realize from selling additional electricity for PEV charging under each PEV penetration scenario. Under the ZEV Goal penetration scenario, the NPV of net revenue in New Mexico is projected to total \$10 million in 2030, rising to \$24 million in 2050. Under the 80x50 scenario, the NPV of utility net revenue from PEV charging is projected to total \$24 million in 2030, rising to \$85 million in 2050. The NPV of projected annual utility net revenue averages \$48 per PEV in 2030, and \$41 - \$50 per PEV in 2050.

Figure 11 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 10) projected revenue, and projected

transmission costs are the same, but projected generation, peak capacity and transmission and distribution upgrade costs are lower due to a smaller incremental peak load (see Table 1), and shifting of load to night-time hours when utilities' cost to purchase bulk electricity is lower.

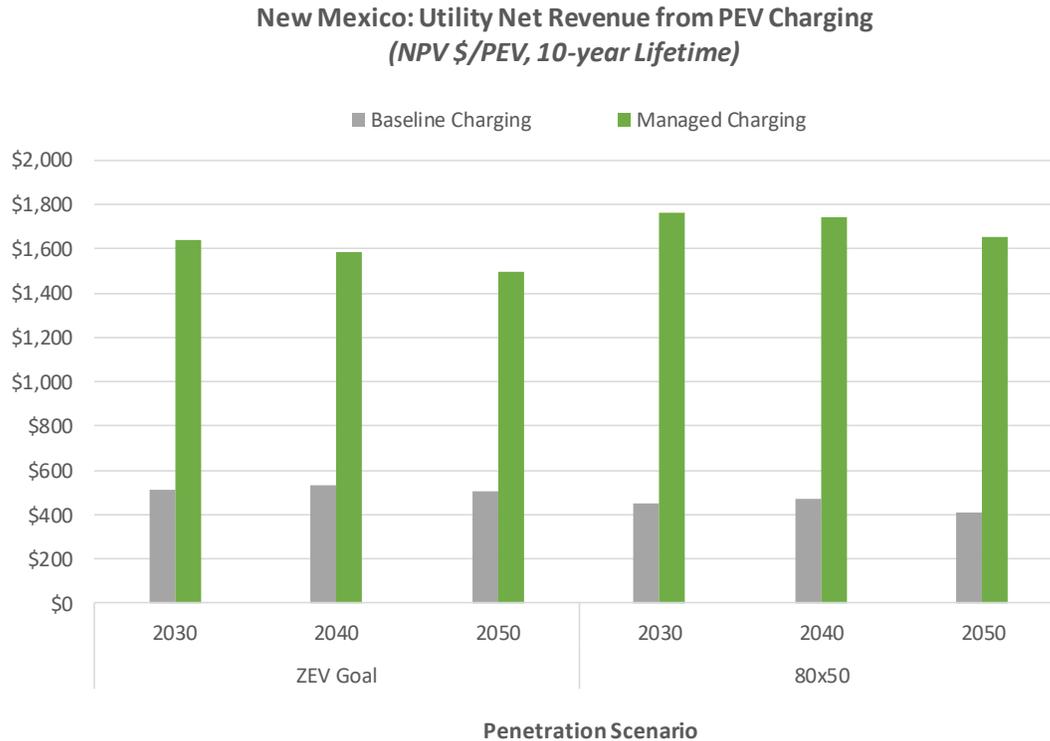
Compared to baseline charging, off-peak charging will increase the NPV of annual utility net revenue by \$21 million in 2030 and \$47 million in 2050 under the ZEV Goal penetration scenario, due to lower costs. Under the 80x50 scenario, off-peak charging will increase the NPV of annual utility net revenue by \$69 million in 2030 and \$259 million in 2050. This analysis estimates that compared to baseline charging, off-peak charging will increase the NPV of annual utility net revenue by \$122 per PEV in 2030 and \$112 per PEV in 2050.

**Figure 11** NPV of Projected Utility Revenue and Costs from Off-peak PEV Charging



Of note is the effect of managed off-peak charging on generation costs. Based on the 2018 daily load shape and forecasted marginal price data from PNM and Tri-State Generation and Transmission Association, Inc. [13], this analysis estimates that New Mexico utilities currently pay an average of approximately \$27/MWh for bulk power. Under the baseline charging scenario, the cost of the power needed to charge PEVs in 2030 would average almost \$31/MWh, approximately 12 percent more than the current average, due to the timing of the load, with a greater percentage during high-cost day-time hours. Under the managed off-peak charging scenario, load shifting to lower-cost night-time hours will reduce average bulk power costs for PEV charging to just over \$28/MWh, nearly a 8 percent reduction compared to the baseline scenario. This reduction is reflected in the net revenue figures shown in Figures 11 and 12.

The NPV of projected life-time utility net revenue per PEV is shown in Figure 12. Assuming a ten-year life, the average PEV in New Mexico in 2030 is projected to increase utility net revenue by about \$1,700 over its life-time, if charged off-peak. PEVs in service in 2050 are projected to increase utility net revenue by nearly \$1,600 over their life time (NPV) if charged off-peak.

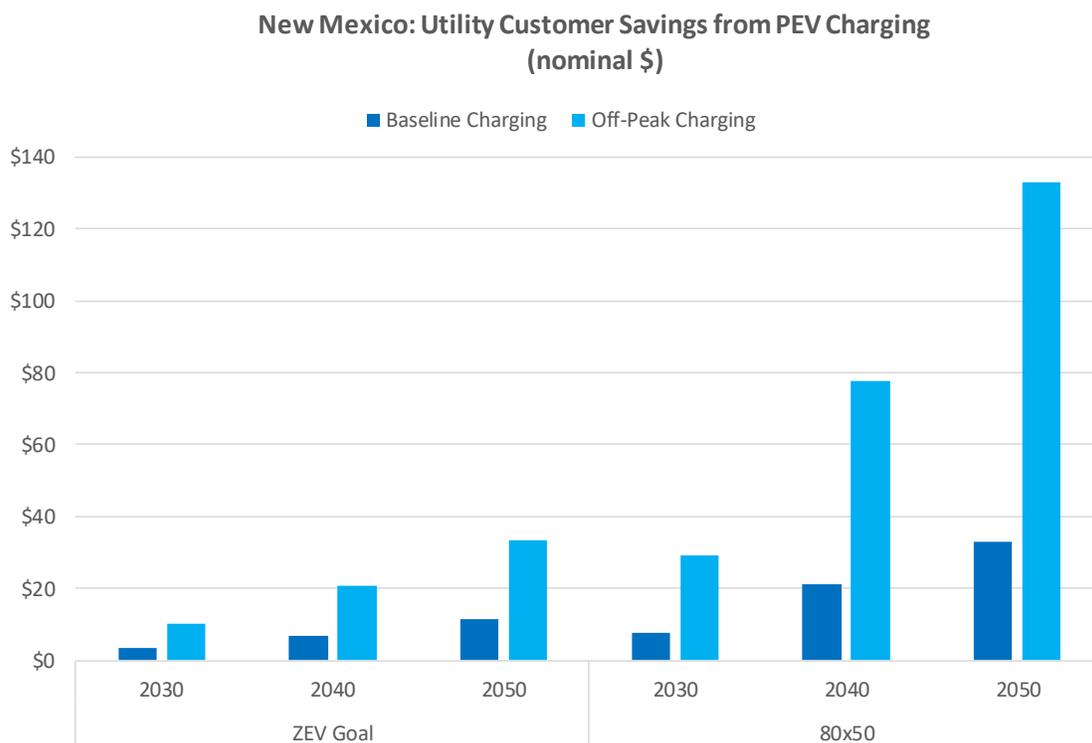


In general, a utility’s costs to maintain their distribution infrastructure increase each year with inflation, and these costs are passed on to utility customers in accordance with rules established by the state’s Public Regulation Commission (PRC), via periodic increases in residential and commercial electric rates. However, under the PRC’s “revenue decoupling” regulations, 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 Mexico, 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.<sup>23</sup> The revenue decoupling mechanism in statute in New Mexico would ensure this happens automatically.

See Figure 13 for a summary of how the projected utility net revenue from PEV charging might affect average residential electricity bills for all New Mexico electric utility customers.<sup>24</sup> As shown in the figure, under the 80x50 scenario, projected average electric rates in New Mexico could be reduced up to 7 percent by 2050, resulting in an annual savings of approximately \$133 (nominal dollars) per household in New Mexico in 2050.

<sup>23</sup> Some of this net revenue may also be passed directly to PEV owners as an incentive to charge off-peak, in recognition of the significant benefits this would provide.

<sup>24</sup> Based on 2018 average electricity use of 7,116 kWh per housing unit in New Mexico.



### New Mexico Driver 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. These incentives are important to spur an early market, but PEVs are projected to provide a total lower cost of ownership than conventional vehicles in New Mexico on an unsubsidized basis by 2030, as described below.

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 \$100/kWh by 2025. [14]

Based on these battery cost projections, this analysis projects that the average annual cost of owning a PEV in New Mexico will fall below the average cost of owning a gasoline vehicle by 2030, even without government purchase subsidies.<sup>25</sup> See Table 2 which summarizes the average projected annual cost of New Mexico 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.

<sup>25</sup> The analysis assumes that all battery electric vehicles in-use after 2030 will have 250-mile range per charge and that all plug-in hybrid vehicles will have 50-mile all-electric range.

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

GASOLINE VEHICLE		ZEV Goal			80x50		
		2030	2040	2050	2030	2040	2050
Vehicle Purchase	\$/yr	\$6,369	\$8,060	\$10,358	\$6,581	\$8,588	\$11,425
Gasoline	\$/yr	\$1,653	\$1,915	\$2,367	\$1,711	\$2,061	\$2,676
Maintenance	\$/yr	\$351	\$440	\$559	\$355	\$451	\$582
<b>TOTAL ANNUAL COST</b>	<b>\$/yr</b>	<b>\$8,373</b>	<b>\$10,415</b>	<b>\$13,284</b>	<b>\$8,648</b>	<b>\$11,099</b>	<b>\$14,683</b>

PEV -NM Baseline Charging/Standard Rate		ZEV Goal			80x50		
		2030	2040	2050	2030	2040	2050
Vehicle Purchase	\$/yr	\$6,556	\$7,952	\$9,752	\$6,784	\$8,355	\$10,384
Electricity	\$/yr	\$816	\$1,023	\$1,306	\$871	\$1,121	\$1,439
Gasoline	\$/yr	\$250	\$222	\$172	\$215	\$189	\$173
Personal Charger	\$/yr	\$81	\$101	\$128	\$81	\$101	\$128
Maintenance	\$/yr	\$190	\$242	\$310	\$196	\$246	\$306
<b>TOTAL ANNUAL COST</b>	<b>\$/yr</b>	<b>\$7,893</b>	<b>\$9,540</b>	<b>\$11,668</b>	<b>\$8,148</b>	<b>\$10,011</b>	<b>\$12,429</b>

<b>Savings per PEV</b>	<b>\$/yr</b>	<b>\$481</b>	<b>\$875</b>	<b>\$1,616</b>	<b>\$500</b>	<b>\$1,088</b>	<b>\$2,253</b>
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As shown in Table 2, 2030 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 New Mexico driver is projected to save \$481 – \$500 per year compared to the average gasoline vehicle owner, without government subsidies. These annual PEV savings are projected to increase to an average of \$875 - \$1,088 per PEV in 2040, and \$1,616 - \$2,253 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 Mexico is projected to be \$344 in 2030, rising to \$751 in 2050.

The NPV of total annual cost savings to New Mexico drivers from greater PEV ownership are projected to be \$46 million in 2030 under the ZEV Goal penetration scenario, rising to \$111 million in 2040 and \$229 million in 2050. Under the 80x50 scenario, the NPV of total annual cost savings to New Mexico drivers from greater PEV ownership are projected to be \$134 million in 2030, rising to \$551 million in 2040 and \$1.4 billion in 2050.

## Other Benefits

### Fuel and Emissions Reductions

Along with the financial benefits to electric utility customers and PEV owners described above, light-duty vehicle electrification can provide additional benefits, including significant reductions in gasoline fuel use and transportation sector emissions.

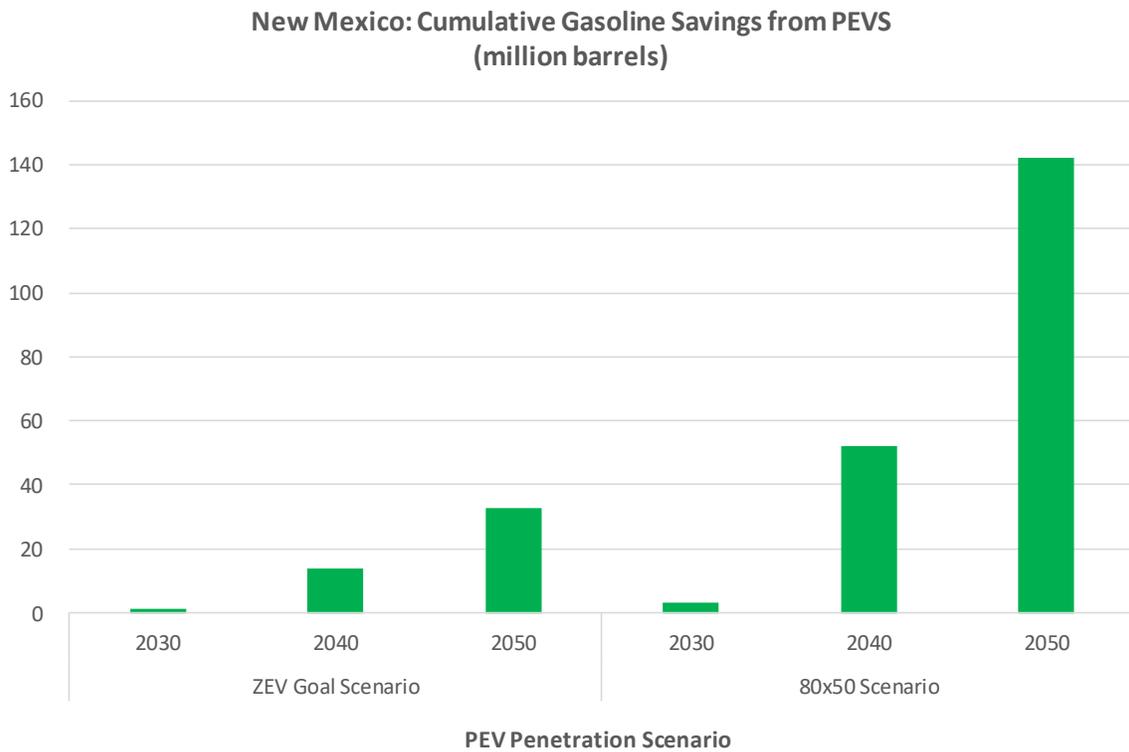
The estimated cumulative fuel savings (barrels of gasoline) from PEV use in New Mexico under each penetration scenario are shown in Figure 14.<sup>26</sup> Annual fuel savings under the ZEV Goal penetration scenario are projected to total 1.0 million barrels in 2030, with cumulative savings of nearly 33 million barrels by 2050. For the 80x50 scenario, annual fuel savings in 2030 are projected to be 3.0 million barrels, and by 2050 cumulative savings will exceed 142 million barrels.

<sup>26</sup> One barrel of gasoline equals 42 US gallons.

These fuel savings can help put the U.S. on a path toward energy independence, by reducing the need for imported petroleum. In addition, a number of studies have demonstrated that EVs can generate significantly greater local economic impact than gasoline vehicles - including generating additional local jobs - by keeping more of vehicle owners' money in the local economy rather than sending it out of state by purchasing gasoline.

Economic impact analyses for the states of California, Florida, Ohio and Oregon have estimated that for every million dollars in direct PEV owner savings, an additional \$0.29 - \$0.57 million in secondary economic benefits will be generated within the local economy, depending on PEV adoption scenario. These studies also estimated that between 13 and 25 additional in-state jobs will be generated for every 1,000 PEVs in the fleet. [1]

Figure 14 Cumulative Gasoline Savings from PEVs in New Mexico



The projected annual greenhouse gas (GHG) emissions (million metric tons carbon-dioxide equivalent, CO<sub>2</sub>-e million tons) from the New Mexico light duty fleet under each PEV penetration scenario are shown in Figure 15. 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.

For the PEV penetration scenarios, projected GHG emissions are shown for a “low carbon” electricity scenario (light blue). This low carbon electricity scenario is based on New Mexico achieving long-term goals to use 50 percent renewable energy by 2030 and 100 percent carbon free electricity generation by 2045, in accordance with goals established under the Energy Transition Act.

Figure 15

Projected GHG Emissions from the Light Duty Fleet in New Mexico

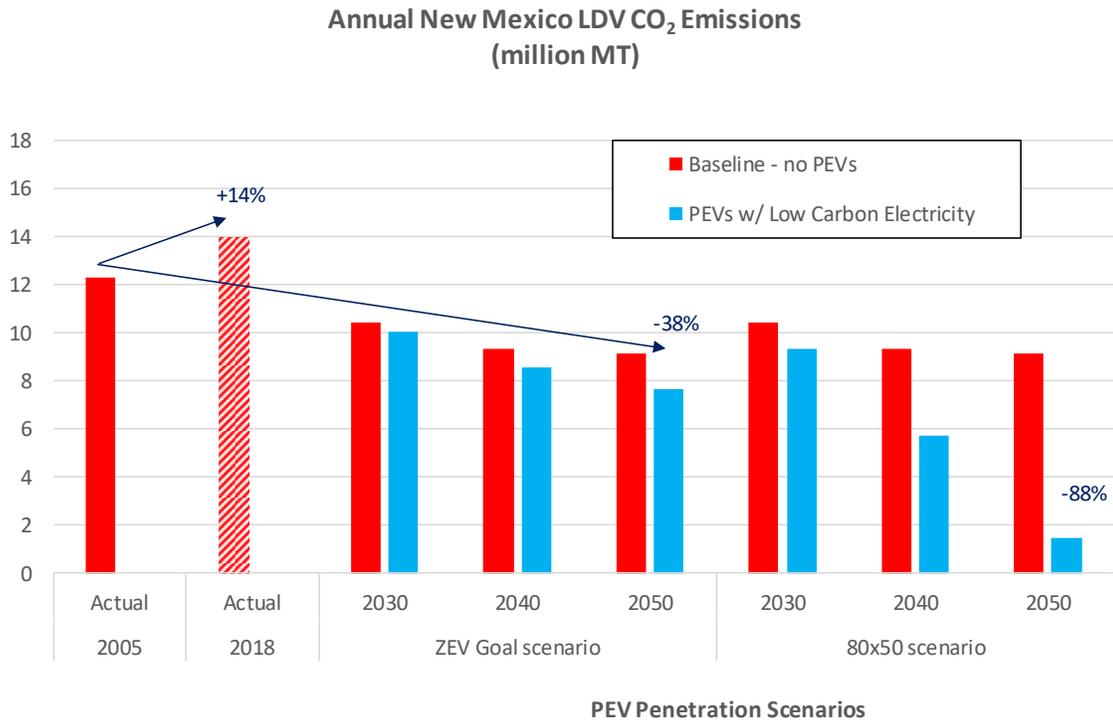
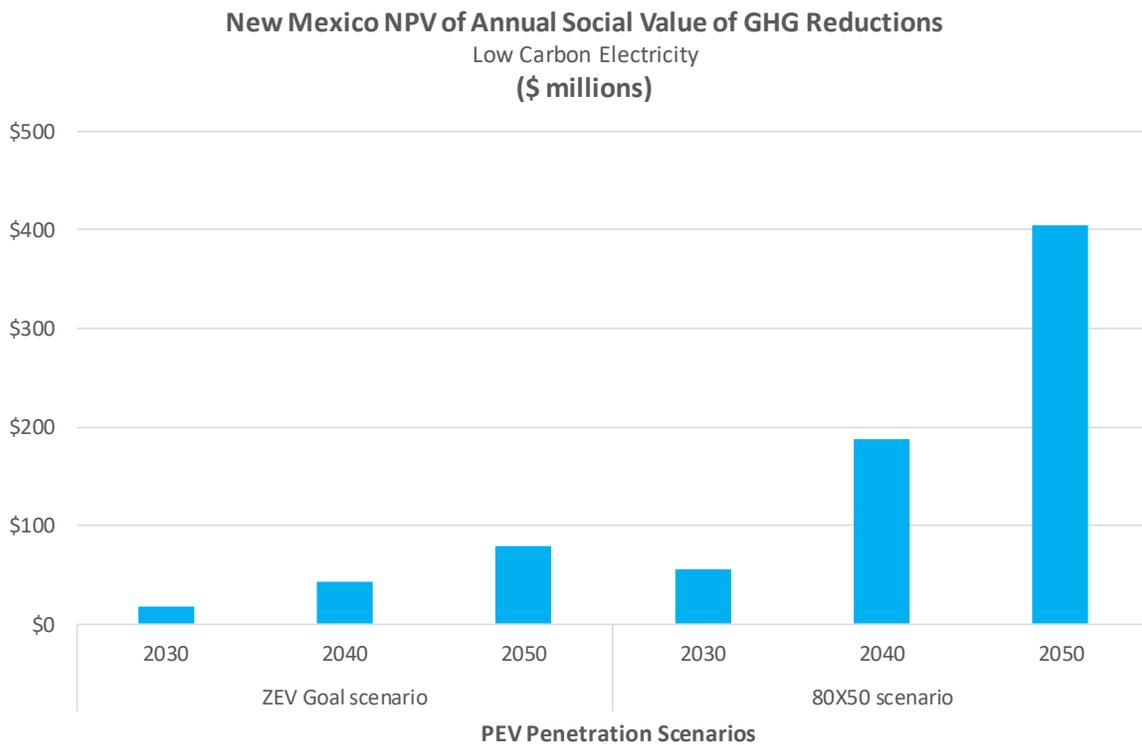


Figure 16

NPV of Projected Social Value of PEV GHG Reductions



As shown in Figure 15, GHG emissions from the light duty fleet were approximately 12.3 million tons in 2005, but they increased by 14 percent through 2018, to 13.9 million tons. However, even without significant PEV penetration, baseline annual fleet emissions are projected to fall to 9.2 million tons by 2050, a reduction of 25 percent from 2005 levels and 34 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<sup>27</sup>. Under the ZEV Goal penetration scenario, PEVs are projected to reduce annual light duty fleet emissions by up to 4.6 million tons in 2050 compared to 2005 baseline emissions (-38 percent). Under the 80x50 scenario, annual GHG emissions in 2050 will be as much as 10.8 million tons lower than 2005 baseline emissions (-88 percent).

Figure 16 summarizes the NPV of the projected monetized “social value” of GHG reductions that will result from greater PEV use in New Mexico. 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 16 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 \$18 million per year in 2030 under the ZEV Goal penetration scenario, rising to as much as \$79 million per year in 2050. Under the 80x50 scenario the NPV of the monetized social value of GHG reductions from greater PEV penetration is projected to be \$55 million per year in 2030, rising to as much as \$404 million per year in 2050.

The NPV of the projected monetized social value of annual GHG reductions averages \$101 per PEV in 2030, and \$167 - \$194 per PEV in 2050.

### NOx Emissions

Light-duty fleet electrification can reduce net nitrogen oxide (NOx) emissions from vehicles due to the switch from internal combustion engines used in conventional vehicles. Electric vehicles do not emit any tailpipe emissions, however; they are not necessarily zero emission vehicles. Depending on the electricity grid mix, NOx can be emitted when generating electricity for vehicle charging. PEVs in New Mexico charging with the existing grid mix already have lower NOx emissions (grams per mile) than new gasoline and diesel vehicles. This gap is projected to increase in future years, as zero-emission renewable generation (wind, solar) makes up a greater percentage of the new capacity required to meet rising electricity demand.

Under the low carbon electricity scenario modeled here and the ZEV Goal Scenario, by 2050 light-duty vehicle electrification in New Mexico could reduce annual NOx emissions by 247 tons. Under the 80x50 Scenario, total NOx reductions in 2050 could reach more than 1,105 tons per year.

Based on EPA’s national average damage value of \$15,909/ton of mobile source NOx<sup>28</sup>, these NOx reductions would have a social value of \$1.89 million in 2030 under the ZEV Goal Scenario, rising to \$8.2 million in 2050. Under the 80x50 Scenario the social value of these NOx reductions would be \$5.5 million in 2030, rising to \$37 million in 2050. Additional societal benefits would accrue from the electrification of medium and heavy-duty vehicles that are disproportionately responsible for NOx and other criteria emissions.

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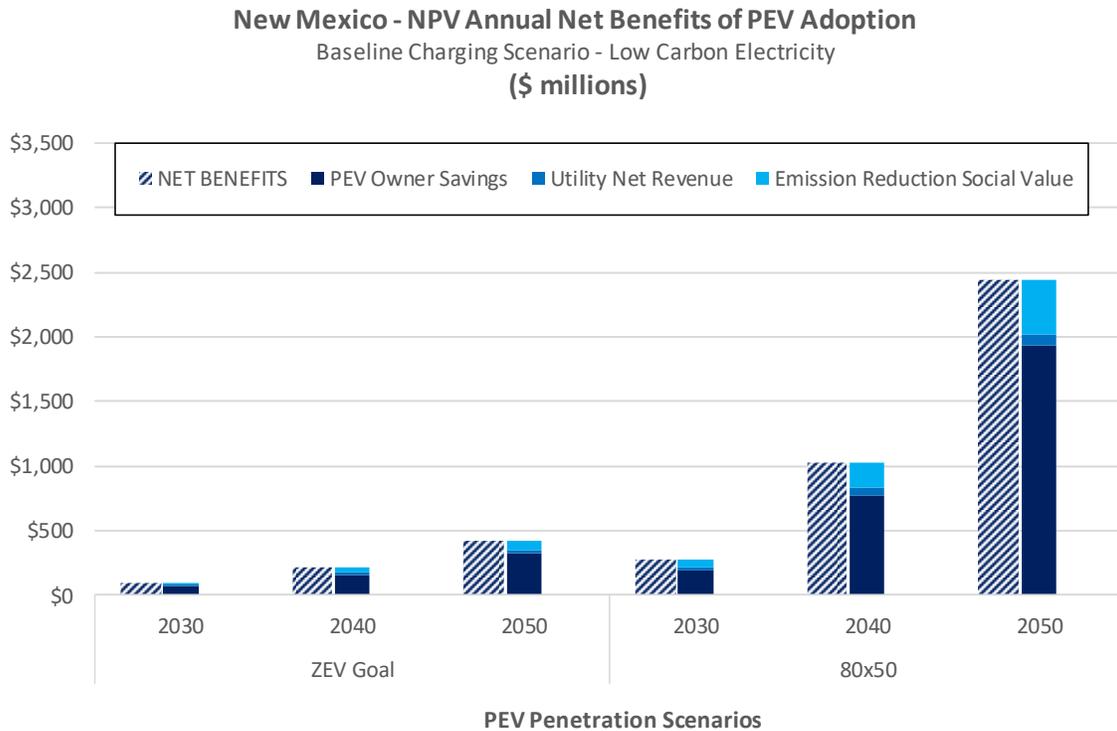
<sup>27</sup> This is based on current new car fuel efficiency standards still in effect, which mandate significant increases in fuel economy for new cars produced every year through model year 2025. This does not account for recent proposed rollbacks of these standards - which would cap fuel economy improvements at model year 2021 levels - that are under consideration by the Department of Transportation and the Environmental Protection Agency

<sup>28</sup> EPA’s damage value of \$15,909 was escalated to \$21,138 in 2030, \$26,314 in 2040 and \$33,270 in 2050 using inflation data from EIA’s Annual Energy Outlook for 2019.

## Total Societal Benefits

The NPV of total estimated societal benefits from increased PEV use in New Mexico under each PEV penetration scenario are summarized in Figures 17 and 18. These benefits include cost savings to New Mexico drivers, utility customer savings from reduced electric bills and the monetized benefit of reduced GHG and NOx emissions. Figure 17 shows the NPV of projected societal benefits if New Mexico drivers charge in accordance with the baseline charging scenario. Figure 18 shows the NPV of projected societal benefits if New Mexico drivers charge off-peak.

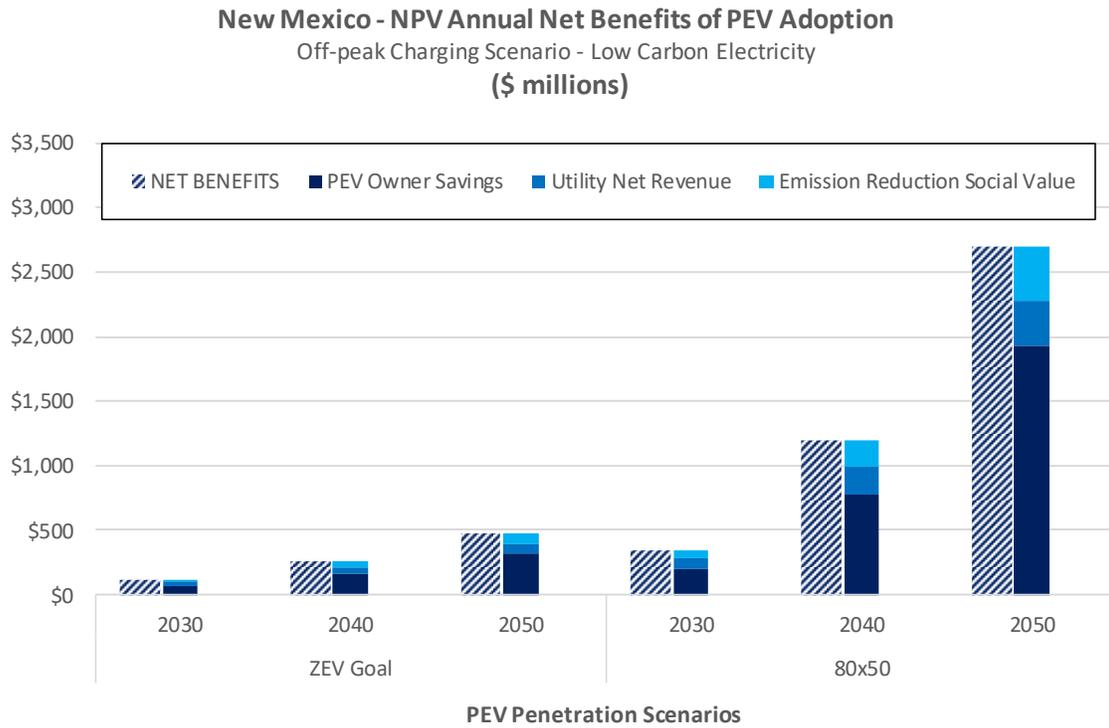
Figure 17 Projected NPV of Total Societal Benefits from Greater PEV use in NM – Baseline Charging



As shown in Figure 17, the NPV of annual societal benefits are projected to be a minimum of \$424 million per year in 2050 under the ZEV Goal penetration scenario and \$2.4 billion per year in 2050 under the 80x50 scenario. Approximately 79 percent of these annual benefits will accrue to New Mexico drivers as a cash savings in vehicle operating costs, 4 percent will accrue to electric utility customers as a reduction in annual electricity bills, and 18 percent will accrue to society at large in the form of reduced damage costs from NOx emissions and reduced pressure on climate change from GHG emissions.

Figure 18

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



As shown in Figure 18, the NPV of annual societal benefits in 2050 will increase by nearly \$47 million under the ZEV Goal penetration scenario, and \$259 million under the 80x50 scenario if New Mexico drivers charge off-peak. Of these increased benefits, all will accrue to electric utility customers as an additional reduction in their electricity bills.

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This study is one of seventeen state-level analyses of plug-in electric vehicle costs and benefits developed for different U.S. states, including Arizona, Colorado, Connecticut, Florida, Illinois, Indiana, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, New Mexico, New York, North Carolina, Ohio, South Carolina, and Pennsylvania.

These studies are intended to provide input to state policy discussions about actions required to promote further adoption of electric vehicles.

This report, and the other state reports, are available at [www.mjbradley.com](http://www.mjbradley.com).