DUKE ENERGY OHIO EXHIBIT ______

BEFORE

THE PUBLIC UTILITIES COMMISSION OF OHIO

In the Matter of the Application of Duke Energy Ohio, Inc., for Authority to Adjust its Power Forward Rider.	)))	Case No. 19-1750-EL-UNC
In the Matter of the Application of Duke Energy Ohio, Inc., for Approval to Change Accounting Methods.	)))	Case No. 19-1751-GE-AAM

DIRECT TESTIMONY OF

LANG W. REYNOLDS

ON BEHALF OF

DUKE ENERGY OHIO, INC.

September 24, 2019

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I. INTRODUCTION AND PURPOSE OF TESTIMONY

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Lang W. Reynolds, and my business address is 550 South Tryon Street, Charlotte, North Carolina.

Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT CAPACITY?

A. I am employed as Director Electric Transportation for Duke Energy Carolinas, LLC, a utility affiliate of Duke Energy Ohio, LLC (Duke Energy Ohio, or Company) and an direct subsidiary of Duke Energy Corporation (Duke Energy).

Q. PLEASE BRIEFLY DESCRIBE YOUR EDUCATIONAL AND PROFESSIONAL BACKGROUND.

A. I hold a Bachelor of Arts from Swarthmore College and Masters of Business Administration from the University of Colorado. I have been employed by Duke Energy since July of 2015 and worked previously for Morgan Stanley. During my time at Duke Energy I have worked within the Distributed Energy Technology organization and also Duke Energy Renewables before assuming the role of Electric Transportation Manager in January of 2017, Manager of Electric Transportation in December of 2017, and Director of Electric Transportation in March of 2019.

Q. PLEASE DESCRIBE YOUR DUTIES AND RESPONSIBILITIES AS DIRECTOR OF ELECTRIC TRANSPORTATION.

A. My responsibility as Director of Electric Transportation has been to establish a team at Duke Energy tasked with developing and implementing projects and programs to facilitate broader adoption of electric transportation in a manner that drives economic and utility customer benefits across all of our utility service territories. Specifically, I oversee the design and implementation of Pilot Electric Vehicle (EV) Programs for the various Duke Energy jurisdictions, including Ohio. Members of my team are located throughout Duke Energy's various service territories.

Q. HAVE YOU PREVIOUSLY TESTIFIED BEFORE THE PUBLIC UTILITIES COMMISSION OF OHIO?

A. No, I have not.

Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?

A. The purpose of my testimony is to describe a component of Duke Energy Ohio's Infrastructure Modernization Plan consisting of Electric Transportation Pilot Programs (Pilot or Pilot Programs) and how these Pilot Programs are consistent with the Public Utility Commission of Ohio's (Commission) PowerForward Initiative. Specifically, I will provide details of each Pilot, including a program description, the benefits to customers and communities, what the Company hopes to learn from the Pilot, and the estimated cost for each program.

II. DISCUSSION

A. EV PILOT PROGRAM OVERVIEW

Q. PLEASE GENERALLY DESCRIBE DUKE ENERGY OHIO'S ELECTRIC TRANSPORTATION PILOT PROGRAM PROPOSAL.

A. Based on the research conducted by MJ Bradley statewide for Ohio, Attachment LWR-1, Duke Energy Ohio believes that increasing adoption of electric transportation can provide strong economic and utility customer benefits over the long term. At the same time, new electric vehicles (EV) are entering the market and strong year-over-year sales growth continues nationwide, including in Ohio.

Duke Energy Ohio is proposing a 36-month Electric Transportation Pilot Program that will support Ohio in joining other states to advance deployment of EV infrastructure to meet growing market needs. Duke Energy Ohio's proposal consists of five distinct programs. The proposed programs are designed to deploy a foundational level of fast charging infrastructure, research the effects of increasing adoption of different types of electric vehicles on the electric system, research customer EV charging behavior, and ascertain the potential financial and environmental benefits to the state of Ohio.

The five programs, which I describe in more detail below, are as follows:

- EV Fast Charge Program;
- Electric School Bus Rebate Program;
- Electric Transit Bus Program;
- Residential EV Charging Rebate Program; and
- Commercial EV Charging Program.

Q. PLEASE SUMMARIZE WHY THESE AREAS FOR DEVELOPMENT WERE TARGETED IN THIS PILOT.

A. The Pilot targets several highlighted segments in the Commission's previously issued PowerForward Roadmap (Roadmap)[1] that need to be studied, such as residential and corridor travel charging, public level II daytime charging, and electric school and transit buses. The residential charging program will study home charging behaviors, help identify where EVs are located, and incentivize

[1] Ohio Public Utilities Commission, *PowerForward: A Roadmap to Ohio's Electricity Future* (Aug. 29, 2018) (PowerForward Roadmap), *available at* https://www.puco.ohio.gov/industry-information/industry-topics/powerforward/powerforward-a-roadmap-to-ohios-electricity-future/.

off-peak charging. The Pilot's plan for corridor travel charging, or DC Fast Charging, will invest in the foundational infrastructure that is needed to realize significant growth of EV adoption across our service territory and throughout the state of Ohio. Investments in this program will be protected by collaborating with the local governments of the cities we serve, including but not limited to, the City of Cincinnati, as well as regional planning agencies, customers, and other valuable stakeholders to determine the best locations. Ultimately, this Pilot will give us new and valuable information to help us guide the adaptation of our grid to meet anticipated EV energy needs in the future.

Q. PLEASE EXPLAIN HOW THE EV PILOT SUPPORTS THE COMPANY'S INFRASTRUCTURE MODERNIZATION GOALS AND PROVIDES IMPROVEMENTS FOR CUSTOMERS CONSISTENT WITH THE COMMISSION'S VISION IN ITS POWERFORWARD ROADMAP.

A. The proposed Pilot is an achievable, real-life opportunity that is intended to provide the foundation to help modernize the Company's electric delivery infrastructure to support public and private EV charging development in the various communities within the Company's service territory. The Company's Pilot Programs are consistent with the Commission's Roadmap. At a high level, the Pilot effectively supports the Roadmap's objectives such as creating a strong and modern grid and cultivating a robust marketplace by following PowerForward principles, especially by providing net value to customers and creating an environment that fosters innovation.[2]

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[2] Id.

The Pilot Program is presented in a structure that allows for adaptability by various communities and municipalities within the Company's service territory to create a framework for partnership to meet shared goals of providing a reliable structure for supporting EV infrastructure.

Q. WHY IS DUKE ENERGY OHIO PROPOSING TO DO THIS AS PART OF ITS INFRASTRUCTURE MODERNIZATION PLAN?

A. The speed at which these objectives can be achieved through EV adoption depends on the local environment that is created. As an electric utility, we believe it is our responsibility to prepare for and expedite the value of EVs for all customers in our service territory. This Pilot Program not only allows for great data collection and grid studies of current EV technology, but it will also simultaneously help increase the number of electric vehicles in our service territory (further leveraging our pilot investment) and allow for the construction of infrastructure in the communities we serve.

Q. PLEASE EXPLAIN WHY DUKE ENERGY OHIO'S PROPOSED EV PILOT PROGRAMS WILL BENEFIT ALL CUSTOMERS, DESPITE THE FACT THAT INDIVIDUAL CUSTOMER PARTICIPATION MAY BE LIMITED.

A. At the most basic level, to the extent that the Company's electric customer base grows through the implementation of broader public and private EV charging facilities, a larger base is created through which to spread utility costs. Savings to all customers are an anticipated result from increasing EV adoption due to incremental net revenue received by increasing distribution grid utilization to charge EVs in excess of any increases in costs of service related to the additional load. Significant state-wide financial benefits are possible from increased EV adoption as shown in Attachment LWR-1. Growth to five percent light duty vehicle market share is estimated to provide cumulative net benefits of more than $5 billion state-wide by 2050 ($600 million will accrue to electric utility customers in the form of reduced electric bills and $4.4 billion will accrue directly to Ohio EV drivers in the form of reduced annual vehicle operating costs). High growth (95 percent market share) is estimated to provide more than $43.3 billion in cumulative net benefits state-wide by 2050 ($7.6 billion to electric utility customers and $35.7 billion to Ohio EV drivers). Similar benefits of this study have been replicated in other states as well.

Increasing the rate of EV adoption in the Company's service territory is the pathway for its customers to realize their share in these anticipated benefits. Duke Energy Ohio believes it has an opportunity and obligation to help customers achieve these potential benefits associated with higher EV adoption by investing in programs that deploy foundational electric vehicle infrastructure and EV load management methods in the near term. Unfortunately, the full potential value of EV adoption for everyone will not be achieved until reliable, convenient, and widespread charging infrastructure is deployed. Duke Energy Ohio is well-suited to support expansion of EV infrastructure to provide a platform for its customers to realize these potential benefits in south-western Ohio over the long term. Lastly, the Pilot Programs will provide the Company with valuable EV charging information that will be utilized to help Duke Energy Ohio develop the appropriate product offerings for the forthcoming future of electric vehicle transportation.

Q. PLEASE DESCRIBE THE EV MARKET IN OHIO AND WHAT IS CHANGING IN THE MARKETPLACE.

A. As of November 2018, there were 12,700 Plug-In Electric Vehicles registered in Ohio. Approximately 3,000 (24%) of those vehicles are registered in the Duke Energy Ohio service territory, with 950 purchased in 2018. Currently, the market for public Direct Current Fast Charging (DCFC) in Southwest Ohio is limited, with only five operators, 20 locations, and 60 DCFC charging plugs. 30 of the DCFC units are exclusive to Tesla drivers. As the EV market evolves, the Company anticipates accelerated deployment of EV technology and the potential customer benefits of increased EV adoption in the State of Ohio. A Duke Energy study shown in Attachment LWR-2 suggests that by 2030, nearly 150,000 EVs could be registered in the Duke Energy Ohio service territory. At this modest growth rate, approximately 250 DCFC and 5,000 Level II (L2) workplace and public charging plugs would be needed to provide adequate EV infrastructure support, according to the U.S. Department of Energy's EVI-Pro Lite calculator. For comparison, a high growth rate of 25% would bring 650,000 EVs to the Duke Energy Ohio service territory and require approximately 1,400 DCFC and 25,000 L2 charging plugs to provide adequate support.

Q. WHAT IS HAPPENING WITH RESPECT TO EV CHARGING IN THE UNITED STATES THAT HAS RELEVANCE FOR OHIO?

A. In the United States, utilities are investing in EV charging infrastructure as new vehicles enter the market and strong sales growth continues nationwide. According to the Edison Electric Institute (EEI), as of October 2018, there were 1 million EVs in the United States. The EEI estimates the next 1 million EVs will be on the road by early 2021. The availability of charging infrastructure is fundamental to that growth. The EEI also notes that, as of September 2018, electric utilities have received state regulatory approval for nearly $1.1 billion for electric transportation investments. These investments are primarily in EV charging infrastructure deployment, but could also include charging infrastructure for other applications such as medium to heavy duty trucks and buses.[3]

With the anticipated growth in the EV market, the time is now to ensure the infrastructure needed to support the growth is in place. Utilities will also need to ensure that the infrastructure is safe, reliable and cost-effective. To support these goals, Duke Energy Ohio needs to better understand the grid impacts of serving EV charging equipment, customer charging behaviors and the viability of managed charging methods.

Q. PLEASE EXPLAIN HOW DUKE ENERGY OHIO'S PROPOSED PILOT ADVANCES STATE POLICY.

A. Among others, it is the policy of the state of Ohio to "encourage innovation" and "facilitate the state's effectiveness in the global economy."[4] With the increased adoption of electric vehicles in the state of Ohio, electric transportation infrastructure must grow with it. The Pilot advances this goal by enabling the deployment of modern-day technologies intended to benefit Duke Energy Ohio customers and the bulk electric system. Further, with the rollout of key statewide initiatives, such as PUCO's PowerForward and Ohio House Bill 202, this pilot

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[3] Edison Electric Institute, *"Electric Vehicles Sales Forecast and the Charging Infrastructure Required through 2030,"* November 2018.
[4] Ohio Revised Code. State Policy. R.C. 4928.02(D) and (N). Accessible at http://codes.ohio.gov/orc/4928.02,

represents an ideal application of the concepts of advancing the grid to meet customer's needs and encouraging economic growth while providing environmental benefits.

Q. WHAT IS THE TOTAL COST OF THIS PILOT AND WHAT DOES DUKE ENERGY OHIO PROPOSE TO INCLUDE IN CUSTOMER RATES AS COST RECOVERY?

A. Please see Table 1 for a breakdown of estimated costs per program and a total Pilot Program cost. Duke Energy Ohio proposes to use the Power Forward Rider to recover costs associated with this Pilot as part of its Infrastructure Modernization Plan. Duke Energy Ohio witness Jay P. Brown, discusses the recovery of these costs as part of this case in his direct testimony. The programs include "make-ready" investments for infrastructure designed to bring power to the charging equipment; company owned infrastructure & equipment investments; and/or rebates to offset some or all of the cost of charging equipment and/or installation costs.

Table 1. EV Pilot Program Summary			
Program	**Incentive Style**	**Units and Cost**	**Total Budget**
EV Fast Charge	"Make-Ready"	25 location minimum (50 unit minimum) Up to $50,000 per "Make-Ready" location	Maximum of $5,000,000 Capital $63,000 O&M
Electric School Bus	Rebate	10 buses $215,000 per bus	$2,150,000 O&M
Electric Transit Bus	"Make-Ready"	10 units Up to $30,000 per unit	$300,000 Capital
Residential Level II	Rebate	1000 customers $1,000 incentive per customer $511 company cost per customer (AMI load detection & mgmt costs)	$1,511,000 O&M
Commercial Level II	"Make-Ready"	1200 Total Ports 600 public 200 MUD 200 Workplace 200 Fleet Up to $5,000/port	Maximum $6,000,000 Capital
G&A, Marketing, and Network Fees		Program Marketing Education and Outreach G&A Network Fees	$814,000 O&M
		Total Capital Total O&M **OVERALL TOTAL**	$11,300,000 $4,538,000 **$15,838,000**

Q. DOES THE PROPOSED PILOT PROGRAM ALIGN WITH ANY VOLKSWAGEN MITIGATION SETTLEMENT FUNDING OPPORTUNITIES?

A. Yes. According to the Ohio EPA Beneficiary Mitigation Plan, the Ohio EPA has allocated approximately $40 million for on-road fleet and equipment projects. This includes Class 4-8 school buses, shuttle buses and transit buses, among others. Duke Energy Ohio's proposed pilot program includes an allocation of $300 thousand for the infrastructure to support ten electric transit buses. Also included in the Ohio EPA's plan is an allocation of up to $3 million for small pilot school bus replacement projects in VW priority counties to demonstrate the viability of battery-electric school bus technology that produces no direct NOx emissions and no particulate matter emissions under all possible operational conditions. Duke Energy Ohio's proposed pilot program includes an allocation of $2.15 million for the deployment of ten electric school buses and associated charging infrastructure. The Ohio EPA plans to have a September 2020 request for application period for EV school buses with awards being announced in October 2020.

Lastly, Duke Energy Ohio is watching the Light Duty Electric Vehicle Supple Equipment (EVSE) infrastructure funding segment of the Beneficiary Mitigation Plan as it develops. The Pilot was developed to help Pilot applicants leverage Beneficiary Mitigation Plan funding for the installation of DCFC and L2 units. Duke Energy Ohio is also considering a submission to recover any eligible Fast Charging infrastructure costs that would occur in the potential contingency phase of the EV Fast Charge program. Any award that Duke Energy Ohio receives from the VW Trust will be used to offset the amount requested in this pilot within the Fast Charging program. Budgeted amounts requested in this pilot do not include any relief from the VW Trust. The Ohio EPA plans to have an October 2019 and March 2020 request for application period for EV infrastructure with awards being announced one month later [5].

B. EV FAST CHARGE PROGRAM

Q. PLEASE DESCRIBE THE EV FAST CHARGING PILOT PROGRAM.

A. Duke Energy Ohio is proposing to implement an EV Fast Charging pilot designed to advance the EV market in Ohio to help meet the fast charging needs associated with the anticipated growth in EVs. Today, if a customer, such as a municipality, wishes to install a DCFC station, the customer would be required to pay for not only the cost of the station, but the utility infrastructure to bring service to that station. In order to help defray these costs for the customer and spur their investment decisions, the first step of the proposed EV Fast Charging Pilot will offer funding of a minimum of twenty-five (25) "make-ready" investments of up to $50 thousand each where the Company will install, own, and operate necessary electric infrastructure facilities to the customer's DCFC stub out point as illustrated in Figure 1. Customers will install, own, and operate the actual and eligible DCFC units. Through this "make-ready" incentive, there could be up to 100 different DCFC locations in the Company's service territory. The "make-ready" incentive cannot be used by the customer for purchasing and installing

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[5] Ohio Environmental Protection Agency. Office of Environmental Education. VW Mitigation Grants, *available at*: https://epa.ohio.gov/oeef/#131365122-vw-mitigation-grants.

DCFC EVSE units. The incentive will be available to customers for three years or until the budgeted amount is fully utilized, whichever occurs first.

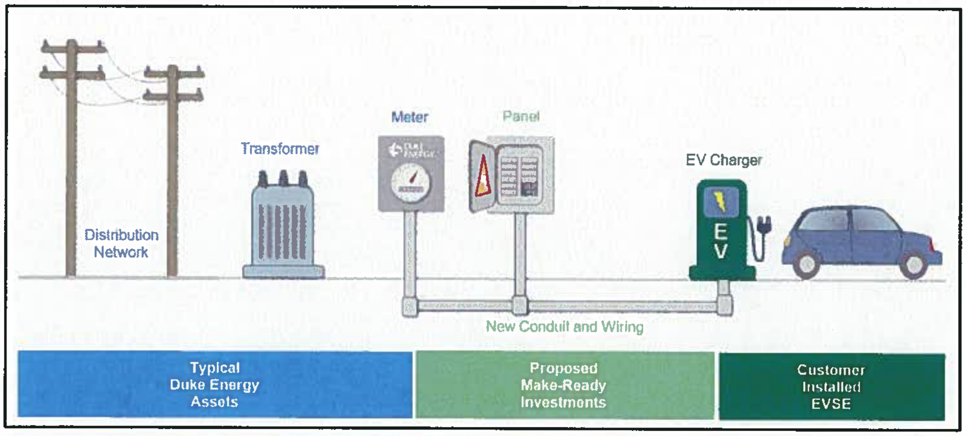

Figure 1. Illustration of Proposed "Make-Ready" Investments.

While the company has sized the "make-ready" incentive to defray a significant portion of site upgrade costs, it is possible that customers may not take advantage of the incentive due to other cost and technology considerations related to deploying DCFC stations. In order to ensure that the full number of proposed DCFC stations are installed under this program within the three year pilot period, the Company is also proposing to provide the Commission with a mid-term reporting, after the first eighteen months, discussing pilot status, lessons learned and potential enhancements to the pilot program to ensure full deployment is achieved. Such enhancements may include additional incentive opportunities or a request for Duke Energy Ohio to install, own, and maintain DCFC locations (up to 25) if the initial phase of the Pilot is not fully subscribed after the first eighteen months of the Pilot. This step may be proposed to ensure all stations are completely installed if the "make-ready" incentive is not fully utilized in a timely manner. Any funding remaining within the EV Fast Charge program will be used to cover this contingency phase. No additional dollars will be added to the pilot.

Q. WHO WILL BE ELIGIBLE FOR THE EV FAST CHARGE "MAKE-READY" INCENTIVE PROGRAM?

A. Eligible customers must provide proof of ability to purchase, install, and operate eligible DCFC locations for the 36-month Pilot term. Participation will be available on a first-come-first-served basis to non-residential customers receiving electric service from Duke Energy Ohio. There is a limit of 5 "make-ready" incentives per customer regardless of location.

Q. WILL PARTICIPANTS BE SUBJECT TO ADDITIONAL TERMS AND CONDITIONS?

A. Yes. The EV Fast Charging locations shall include charging equipment with electrical demand requirements of 100 kW or greater, include both CHADeMO and CCS standard fast charge vehicle connectors, and Open Charge Point Protocol (OCPP) communication standard 1.6 or higher. Each location will include a minimum of two Fast Charging Electric Vehicle Supply Equipment (EV Supply Equipment or EVSE) capable of charging all mass-market plug-in electric vehicles intended for use on public streets and highways. Customers are required to provide DCFC utilization data to Duke Energy Ohio for annual commission reporting as described in Attachment LWR-3. Customers must also show a signed purchase order of eligible DCFC EVSE equipment to initiate the scheduling of any Company "make-ready" work. Prior to any "make-ready" site work commencing, the customer and Duke Energy Ohio will conduct a site visit and execute a Site Host Agreement to establish the terms and conditions of the installation.

Q. WHAT IS THE ESTIMATED SERVICE LIFE OF EV FAST CHARGING INFRASTRUCTURE?

A. Based on independent third-party analysis[6] and company experience, Duke Energy Ohio is currently projecting a ten (10) year useful life for Company-owned EV Fast Charging stations.

Q. HOW WILL DUKE ENERGY OHIO DETERMINE THE PLACEMENT OF THE FAST CHARGING STATIONS?

A. Duke Energy Ohio will work with the customers who wish to install these EV Fast Charging stations, including municipalities such as the City of Cincinnati, regional planning agencies, third-party operators, customers, and other valuable stakeholders to determine the best location for fast charging stations at key interstate and highway corridor locations throughout Duke Energy Ohio's service territory. The Company has initially collaborated with OKI (Ohio, Kentucky, and Indiana Regional Council of Governments) to prioritize the placement of EV Fast Charge stations. OKI is a council of local governments, business organizations, and community groups committed to developing collaborative strategies to improve the quality of life and the economic vitality of the region. OKI approves several million dollars in surface transportation projects each year.[7] The Company believes OKI is a valuable stakeholder in the site selection process. OKI has

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[6] *Electric Vehicles Sales Forecast and the Charging Infrastructure Required through 2030,"* November 2018, *available at* https://luskin.ucla.edu/sites/default/files/Non-Residential%20Charging%20Stations.pdf
[7] Ohio Kentucky Indiana Regional Council of Governments. About us. Accessed by: https://www.oki.org/about-oki/

identified locations that require minimal electric facility expansion, are within one and a half mile of a major highway or interstate interchange, have 24/7 public access with restrooms, appropriate site lighting, and nearby retail and restaurant options. These variables are widely accepted best practices when performing EV Fast Charging site selection. The high traffic volume at these locations will ensure EV Fast Charge stations are installed responsibly in useful locations. Attachment LWR-4 suggests a map of potential EV Fast Charge locations in the Greater Cincinnati area that will enable intra- and inter-state electric vehicle travel and build driver confidence in EV range. This Pilot will focus on stations located in Ohio, not OKI's suggested locations in northern Kentucky. Please note that these locations are not final, and other locations or corridors such as Oxford, Hamilton, Oakley, Delhi Township, Ronald Reagan Highway (SR 126), Butler County Veterans Highway (SR 129), Downtown Cincinnati Riverfront, and Batavia may be considered. The Company will work with customers to identify other areas along the corridor also. Charging services will be available to all electric vehicle drivers that travel through Duke Energy Ohio's service territory.

C. ELECTRIC SCHOOL BUS PROGRAM

Q. PLEASE DESCRIBE THE ELECTRIC SCHOOL BUS PILOT PROGRAM.

A. Duke Energy Ohio proposes a pilot rebate to support procurement of ten (10) Electric Vehicle School Buses (EV School Bus) by public school transportation systems. The rebate will be used to help install EVSE charging infrastructure, to facilitate market adoption, to collect utilization and other load characteristics to understand grid and utility impacts, and to explore potential for bi-directional power flow from EV School Bus batteries. Duke Energy Ohio is proposing to fund up to ten (10) electric school buses, up to $215 thousand per bus, for procurement, delivery, and installation of EV School Buses and associated EVSE. The School Corporation or its contractor will be responsible for installation, ownership, proper operation and maintenance of EVSE and EV School Bus according to manufacturer guidelines during the Pilot. The School Corporation will establish and maintain charging station network connectivity between the EVSE network provider and Duke Energy Ohio for load control capabilities during the full 36-month Pilot. At the conclusion of the Pilot, Duke Energy Ohio will retain ownership rights to the EV School Bus battery and may remove and repurpose it at the end of its useful life, which is typically 8-12 years.

Q. WHO WILL BE ELIGIBLE FOR THE ELECTRIC SCHOOL BUS PROGRAM?

A. The proposed EV School Bus Program will be available, on a first-come-first-served basis, to customers operating public school transportation systems in Duke Energy Ohio's electric service territory.

Q. WILL PARTICIPANTS BE SUBJECT TO ADDITIONAL TERMS AND CONDITIONS?

A. Yes. Participants must utilize one or more EV School Buses and provide transportation services to a public-school system. Overall, rebates will be available for 10 buses, with no more than three buses per school system. Participants must grant Duke Energy Ohio access to all vehicle charging data throughout the program term and allow implementation of load management capabilities to reduce charging speeds, up to and including full curtailment and bi-directional power flow, provided such control activities do not impact the necessary duty cycle of the EV School Bus. Prior to participation under this Program, the School Corporation and Duke Energy Ohio will execute an Electric Vehicle School Bus Supply Equipment Site Agreement to establish the terms and conditions of EV Supply Equipment and School Bus installation and ownership.

D. ELECTRIC TRANSIT BUS PROGRAM

Q. PLEASE EXPLAIN THE ELECTRIC TRANSIT BUS PROGRAM.

A. Duke Energy Ohio proposes a "make-ready" investment of up to $30 thousand per EVSE for up to ten (10) electric transit buses on a first-come, first-served basis to eligible transit agency customers electing to procure an electric transit bus. The Company will install, own, and operate the "make-ready" infrastructure up to the DCFC station stub out point where the bus will charge. The customer will install, own, and operate the DCFC unit and associated equipment. The Company believes significant operational cost savings upwards of over $500 thousand per bus lifetime are achievable as illustrated in Attachment LWR-5. This 36-month pilot program allows customers to leverage Volkswagen Settlement Trust funding and previously awarded Federal Transit Administration grant funding for the procurement of electric transit buses.

Q. WHO WILL BE ELIGIBLE FOR THE ELECTRIC TRANSIT BUS PROGRAM?

A. Participants must operate a transit bus system utilizing one or more EV Transit Buses, including but not limited to transit agencies, universities, airports, and non-profit/municipal entities. Participation will be available on a first-come-first-served basis to non-residential customers receiving electric service from Duke

Energy Ohio. Customers must show a signed purchase order of eligible transit bus(es) to initiate the scheduling of any Company "make-ready: work.

Q. WILL PARTICIPANTS BE SUBJECT TO ADDITIONAL TERMS AND CONDITIONS?

A. Yes. Participants must allow Duke Energy Ohio to measure electrical charging values, behaviors and trends on an individual or collective basis, perform testing of utility-managed charging, and obtain any other data necessary to determine the operating characteristics of the customer's use of electricity. Customers will use their standard Duke Energy Ohio commercial rate. The "make-ready" incentive cannot be used by the Customer for purchasing and installing EVSE hardware. Limit five (5) "make-ready" incentives per customer regardless of location. Prior to participation, the customer and Duke Energy Ohio will conduct a site visit and execute a Site Host Agreement to establish the terms and conditions of the installation.

E. RESIDENTIAL EV CHARGING REBATE PROGRAM

Q. PLEASE EXPLAIN THE RESIDENTIAL EV CHARGING REBATE PROGRAM.

A. Duke Energy Ohio proposes an incentive/rebate Pilot Program to identify and manage residential EV charging behaviors for up to 1,000 eligible residential customers. Participating customers will receive a $500 incentive, upon verification of installation, for purchasing and installing a Level II electric vehicle charging station of their choice. A Level II EVSE is a 208/240V home charging station that can fully charge most EVs in half the time of a standard Level I 120V EVSE. Customers will also be eligible to receive up to an additional $500 utility

EV load-managed incentive in exchange for participating in monthly load management events. Usage will be billed under the customer's existing residential rate. The Company will collect usage characteristics of EV charging behavior, better understand potential grid and utility impacts from EV charging, and implement utility-managed charging. Company costs associated with networking, collecting, and additional management of this data are initially estimated at $511 per customer incentive for a total program cost of $1,511 per customer.

The first year will gather "unmanaged charging" data to achieve a baseline for comparison with "managed charging" events in years two and three. To implement managed charging, each month the Company will set and communicate specific time frames to avoid residential EV charging within 6-9 a.m. and 4-7 p.m. The customer is then responsible to avoid charging their EV within the set time frames to be eligible for the incentive. Participants can opt out of two (2) peak charging sessions per month and still be eligible for the incentive.

Q. WHO WILL BE ELIGIBLE FOR THE RESIDENTIAL EV CHARGING REBATE PROGRAM?

A. Eligible customers must own, lease, or otherwise operate on a regular basis, one or more plug-in EVs per installation. A plug-in vehicle includes plug-in hybrids (PHEV) and battery electric vehicles (BEV). Customers must also prove purchase and installation of eligible Level II EV Supply Equipment at their residence. Applications will be considered on a first-come-first-served basis from the date and time of submittal, up to 1,000 total customers. Customers will be eligible for only one rebate per residence.

Q. WILL PARTICIPANTS BE SUBJECT TO ADDITIONAL TERMS AND CONDITIONS?

A. Yes. Customers are not eligible for each month's incentive if the customer opts out of three or more events per month. Note that earned incentives will be remitted to the participating customer on a quarterly basis.

F. <u>COMMERCIAL EV CHARGING PROGRAM</u>

Q. PLEASE EXPLAIN THE COMMERICAL EV CHARGING PROGRAM?

A. Duke Energy proposes a Commercial EV Charging Program consisting of a "make-ready" investment to help public, fleet, workplace, and Multi-Unit Dwelling (MUD) entities install Level II EVSE. The Pilot consists of 1,200 units at a maximum of $5 thousand per unit. Each site must meet a 5-port minimum and there is a 20-port maximum limit per customer, regardless of the number of sites. The Company is allocating 200 ports for each of the following segments that do not require public access: fleet operations, private workplaces and MUD. The remaining 600 ports will be allocated for publicly accessible locations, including workplaces, throughout the Duke Energy Ohio service territory. Duke Energy will install, own, and operate the "make-ready" infrastructure up to the customer's Level II EVSE stub out points. The customer will install, own, and operate the Level II electric vehicle supply equipment. The "make-ready" incentive cannot be used by the Customer for purchasing and installing DCFC EVSE units.

Q. WILL THE COMMERCIAL EV CHARGING REBATE PROGRAM HELP THE CITY OF CINCINNATI REACH ITS OWN EV-RELATED GOALS?

A. The Commercial EV Charging program aligns well with the following EV-related goals that the City of Cincinnati has set forward as part of its Green Cincinnati

Plan and Bloomberg American Cities Climate Challenge goals. According to the Green Cincinnati Plan, Duke Energy Ohio has already been identified as a key implementation partner to help increase the availability of city-wide EV infrastructure[8].

1) 162 public charging units installed by 2020.

2) 100 percent of city fleet vehicles electrified by 2035.

3) Purchasing 20 electric city fleet vehicles by 2020.

4) EV education for 10,000 individuals.

5) Register 1,000 EVs in the parking program.

6) 20 percent reduction in use of fossil based fuels by 2023.

Q. WHO WILL BE ELIGIBLE FOR THE COMMERCIAL EV CHARGING REBATE PROGRAM?

A. Applications will be considered on a first-come-first-served basis from the date and time of submittal. Eligible public locations can be, but are not limited to city or government locations, street or curbside parking, parking garages, retail, restaurant, and other locations accessible 24/7 to the general public. Fleet customers, which includes public ride share companies, applying for the rebate must show proof of ownership or lease of an electric vehicle (PHEV or BEV) for each rebate given. Customers must show a signed purchase order of eligible Level II EVSE to initiate the scheduling of any Company "make-ready" work. There will be a 10 percent target (120 units) for commercial customers located in low-income areas. Low-income areas will be defined as neighborhoods where 50

[8] 2018 Green Cincinnati Plan, May 2018, *available at* https://www.cincinnati-oh.gov/oes/assets/File/2018%20Green%20Cincinnati%20Plan(1).pdf.

percent of the neighborhood is at the 200 percent poverty level as defined by Federal Poverty Guidelines.[9]

Q. WILL PARTICIPANTS BE SUBJECT TO ADDITIONAL TERMS AND CONDITIONS?

A. Yes. Participants must request new service to separately meter all EVSE that will be connected using Duke Energy Ohio "make-ready" investments. Standard Duke Energy Ohio commercial rates will apply. Customer must allow Duke Energy Ohio to analyze load characteristics and customer behavior in connection with the EV charging program. Prior to participation, the customer and Duke Energy Ohio will conduct a site visit and execute a Site Host Agreement to establish the terms and conditions of the installation. This program shall end on and after thirty-six (36) months following the initial effective date of the program, unless renewed or extended by the Company.

G. EDUCATION AND OUTREACH

Q. WILL THERE BE AN EDUCATION AND OUTREACH COMPONENT OF THE PROPOSED PILOT?

A. Yes. Duke Energy Ohio proposes to invest approximately $525 thousand or slightly over three (3) percent of total Pilot Program towards Marketing, Education and Outreach. Attachment LWR-6 illustrates the various components and costs associated with this investment.

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[9] United States Health and Human Services Poverty Guidelines for 2019, *available at* https://aspe.hhs.gov/poverty-guidelines .

H. LEARNING OPPORTUNITIES AND REPORTING METRICS

Q. PLEASE DESCRIBE WHAT DUKE ENERGY OHIO ANTICIPATES TO LEARN FROM THE EV PILOT PROGRAM?

A. As stated in the introduction, Duke Energy Ohio is proposing this pilot to study grid impacts of multiple EV charging segments as EV adoption increases. Additionally, a summarized report of the installation costs and revenue generated from the program will be created. Please see Attachment LWR-3, for a summary of what Duke Energy Ohio expects to learn from the different Pilot programs.

Q. HOW DOES DUKE ENERGY OHIO PROPOSE TO SHARE THIS INFORMATION WITH THE COMMISSION AND OTHER PARTIES TO THIS PROCEEDING?

A. To the extent possible in keeping with protecting customer privacy, aggregated data will be made available to the public through annual reports and stakeholder meetings every twelve months, for a three-year period, following the start of the Pilot and a final report filed with the Commission within 180 days after conclusion of the Pilot. Duke Energy Ohio will have a full, open stakeholder process at the end of the Pilot before proposing any permanent programs.

III. RATES AND CUSTOMER PROTECTIONS

Q. IS DUKE ENERGY OHIO PROPOSING ANY SPECIFIC RATE STRUCTURES TO ACCOMPANY ITS EV PILOT PROPOSAL?

A. No, not currently. One of the main goals of the Pilot Proposal is to evaluate charging behaviors associated with the different programs. Duke Energy Ohio will evaluate these behaviors at the conclusion of the Pilot and determine if a specific EV charging rate is suitable for the Company and the customer. Before or after the Pilot is concluded the Company may seek approval of newly developed EV customer offerings or continuation of EV pilot programs.

Q. WHAT TYPES OF CONSUMER PROTECTIONS DOES DUKE ENERGY OHIO PROPOSE TO BUILD INTO ITS PROGRAMS?

A. The Company has multiple consumer protections in place. First, the proposal is limited in time. The Pilot will cease after thirty-six (36) months, at which time Duke Energy Ohio may propose to extend certain program elements based on data gathered during the Pilot and the state of the marketplace at that time. Second, the Pilot is limited in scope. Each program is limited to a number of participants necessary to generate the data necessary to inform Duke Energy Ohio on customer EV behaviors. Finally, the Pilot is limited in costs. The Company's proposal for cost recovery through Rider PowerForward is capped at $15.9 million. The Company is not, at this time, seeking additional cost recovery or unlimited authority. Furthermore, all capital installations associated with the Pilot will be coordinated with other Company planned work to improve efficiencies.

IV. <u>OTHER UTILITY'S EV PILOT PROJECTS</u>

Q. HAS DUKE ENERGY OHIO CONDUCTED EV PROJECTS IN THE PAST?

A. No. This will be the first Duke Energy Ohio electric transportation pilot. However, Duke Energy Indiana offered Project Plug-In from 2010 to 2013. Project Plug-In was an EV charging station pilot funded by a U.S. Department of Energy grant where Duke Energy Indiana contracted the installation of charging stations and provided rebates of up to $1 thousand towards installation costs for 85 residential customers who bought or leased an EV in the Duke Energy Indiana service territory in exchange for collecting data about their charging behaviors for a two-year period. The Company also installed, owned, and operated 45 commercial charging stations at no cost to the site host.

The result of the project was that Duke Energy Indiana was able to analyze and understand the distribution impact of EVs; the technical capabilities that charging stations and when, where, how long, and how often a customer charges their EV. Additionally, when asked about their experience owning an EV, 80 percent of participants felt strongly that they saved money in fuel costs. However, only 32 percent of participants noted using their EV to travel distances greater than 100 miles.

Q. ARE YOU AWARE OF OTHER UTILITY EV PROPOSALS IN OTHER JURISDICTIONS?

A. Yes. Over $1 billion of utility EV programs has been approved in the US since 2010. Duke Energy Florida has an approved EV pilot in Florida[10] and has proposed pilots in Duke Energy Carolinas, in North Carolina[11] and South Carolina,[12] and in Indiana[13]. Duke Energy North Carolina implemented smaller pilot programs between 2012-2014. Additionally, as previously discussed in my testimony, Duke Energy Indiana offered Project Plug-In from 2010 to 2013.

External to Duke Energy, Puget Sound Energy in Washington has received approval for a five-year plan to increase EV charging accessibility by owning and operating eight (8) DC Fast Charging stations that include 32

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[10] Florida Public Service Commission Docket No. 20170783-EI.
[11] North Carolina Utilities Commission Docket Nos. E-2, Sub 1197 and E-7, Sub 1195.
[12] South Carolina Public Service Commission Docket Nos. 2018-321-E and 2018-322-E.
[13] Indiana Utility Regulatory Commission Cause No. 45253.

charging units. Puget Sound Energy is also helping customers install Level 2 charging stations for commercial fleet and residential charging programs. Consumers Energy in Michigan has proposed PowerMiDrive, a three-year pilot program that will provide rebates of up to $5 thousand to install up to 200 Level 2 public chargers, as well as incentives of up to $70 thousand for up to 24 DC Fast-Charging stations. Maryland's four electric utilities combined to propose a statewide electric vehicle portfolio consisting of residential, non-residential, and public charging solutions. Many of these solutions included utility ownership of EV Supply Equipment.

Q. HAVE ANY OF THOSE PROPOSALS BEEN APPROVED BY THE RESPECTIVE STATE COMMISSION?

A. Yes. Several state commissions have favorably ordered for utility-sponsored EV programs, creating a competitive market that attracts business and contributes to beneficial environmental stewardship. For example, on December 13, 2018, the Washington Utilities and Transportation Commission approved Puget Sound Energy's five new electric vehicle charging schedules that establish a portfolio of EV Supply Equipment programs and services over a five-year pilot term[14].

On January 9, 2019, the Michigan Public Service Commission issued an order approving Consumers Energy Company's request for a three-year pilot program to invest in EV charging infrastructure.[15]

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[14] https://www.utc.wa.gov/docs/Pages/DocketLookup.aspx?FilingID=180877

[15] *In the Matter of the Application of Consumers Energy Company for Authority to Increase Its Rates for the Generation and Distribution of Electricity and for Other Relief, Order*, Case No. U-20134, Mich. Pub. Serv. Comm'n., issued Jan. 9, 2019, *available at* https://www.michigan.gov/mpsc/0,4639,7-159-16400_17280-487034--,00.html.

On January 15, 2019, the Maryland Public Service Commission granted BGE, Potomac Electric Power Co., Delmarva Power, and Potomac Edison Co. authority to move forward with a modified, five-year pilot program of residential, workplace and public charging stations.[16]

Q. HAS THIS COMMISSION PREVIOUSLY APPROVED AN EV PILOT FOR ANY OHIO UTILITIES?

A. Yes. I am aware that the Commission recently approved an EV pilot program for AEP Ohio.

Q. PLEASE GENERALLY DESCRIBE HOW DUKE ENERGY OHIO'S ELECTRIC TRANSPORTATION PILOT PROGRAM PROPOSAL IS DIFFERENT THAN AEP OHIO'S ELECTRIC VEHICLE CHARGING PROGRAM?

A. AEP Ohio's $10 million Electric Vehicle Program offers various reimbursement incentives for up to 300 new Level 2 and 75 DC fast charging stations installed and operated by local government, other public charging entities, workplace charging entities, and multifamily complexes.[17] As I more fully explain below, in addition to DCFC and Commercial L2 charging, the proposed Duke Energy Ohio pilot is offering incentives for single family residential, transit bus, and school bus charging. The proposed pilot also includes a "make-ready" approach to DCFC, Transit bus, and Commercial L2 programs that provides necessary electrical site

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[16] *In the Matter of the Petition of the Electric Vehicle Work Group for Implementation of a Statewide Electric Vehicle Portfolio*, Order No. 88997, Pub. Serv. Comm'n. of Md., issued Jan. 14, 2019, *available at* https://www.psc.state.md.us/wp-content/uploads/Order-No.-88997-Case-No.-9478-EV-Portfolio-Order.pdf.

[17] AEP OHIO Electric Vehicle Program accessed from https://www.aepohio.com/save/business/ElectricVehicles/default.aspx. Public Utilities Commission of Ohio Case No#16-1852 accessed from http://dis.puc.state.oh.us/CaseRecord.aspx?Caseno=16-1852&link=DI.

work up the stub out point where the customer will install the charging equipment. Furthermore, the proposed pilot enables limited utility asset ownership of DCFC stations if not all DCFC incentives are accounted for after a certain time period. These differences in pilot programs will provide more data and support additional segments of transit vehicles which benefit a much broader cross-section of Duke Energy Ohio customers.

V. CONCLUSION

Q. ARE YOU SPONSORING ANY ATTACHMENTS IN THIS PROCEEDING?

A. Yes.

- Attachment LWR-1 MJB Ohio PEV Cost Benefit Analysis
- Attachment LWR-2 Duke Energy Ohio EV Forecast Study
- Attachment LWR-3 Duke Energy EV Pilot Reporting Metrics
- Attachment LWR-4 OKI EV Fast Charging Priority Areas
- Attachment LWR-5 E-bus Savings
- Attachment LWR-6 EV Marketing, Education, and Outreach Budget

Q. WERE THESE ATTACHMENTS PREPARED OR ASSEMBLED BY YOU OR UNDER YOUR SUPERVISION?

A. Yes.

Q. DOES THIS CONCLUDE YOUR PREFILED DIRECT TESTIMONY?

A. Yes, it does.

Electric Vehicle Cost-Benefit Analysis

Plug-in Electric Vehicle Cost-Benefit Analysis: Ohio

MJB & A

June 2018

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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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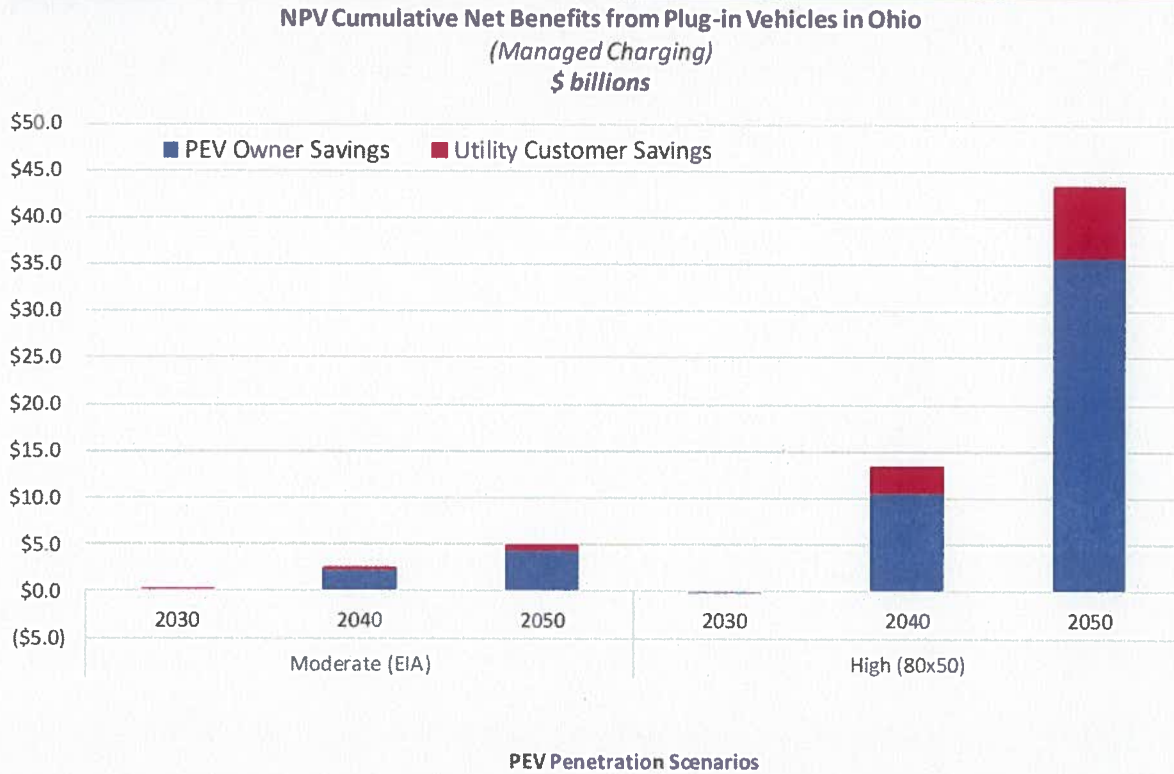
Executive Summary

This study estimated the costs and benefits of increased adoption of plug-in electric vehicles (PEVs) in the state of Ohio. The study estimated the financial benefits that would accrue to all electric utility customers in Ohio due to greater utilization of the electric grid during low load hours and resulting increased utility revenues from PEV charging. In addition, the study estimated the annual financial benefits to Ohio drivers from owning PEVs—from fuel and maintenance cost savings compared to owning gasoline vehicles. The study also estimated reductions in gasoline consumption, and associated greenhouse gas (GHG) and nitrogen oxide (NOx) emission reductions from greater use of PEVs instead of gasoline vehicles.

Figure 1 NPV Cumulative Societal Net Benefits from OH PEVs



This study evaluated PEV costs and benefits for two distinct levels of PEV adoption – essentially a "business as usual" scenario of modest PEV penetration (EIA), and a much more aggressive scenario based on the PEV penetration that would be required to get the state onto a trajectory to reduce light-duty GHG emissions by 70 – 80 percent from current levels by 2050 (80x50). The levels of PEV penetration in the high 80x50 scenario are unlikely to be achieved without aggressive policy action at the state and local level, to incentivize individuals to purchase PEVs, and to support the necessary roll-out of PEV charging infrastructure.

As shown in Figure 1, if Ohio PEV adoption follows the moderate trajectory currently assumed by the Energy Information Administration (EIA), the net present value of **cumulative net benefits from greater PEV use in the state will exceed $5.0 billion state-wide by 2050.**[1] Of these total net benefits:

[1] Using a 3% discount rate

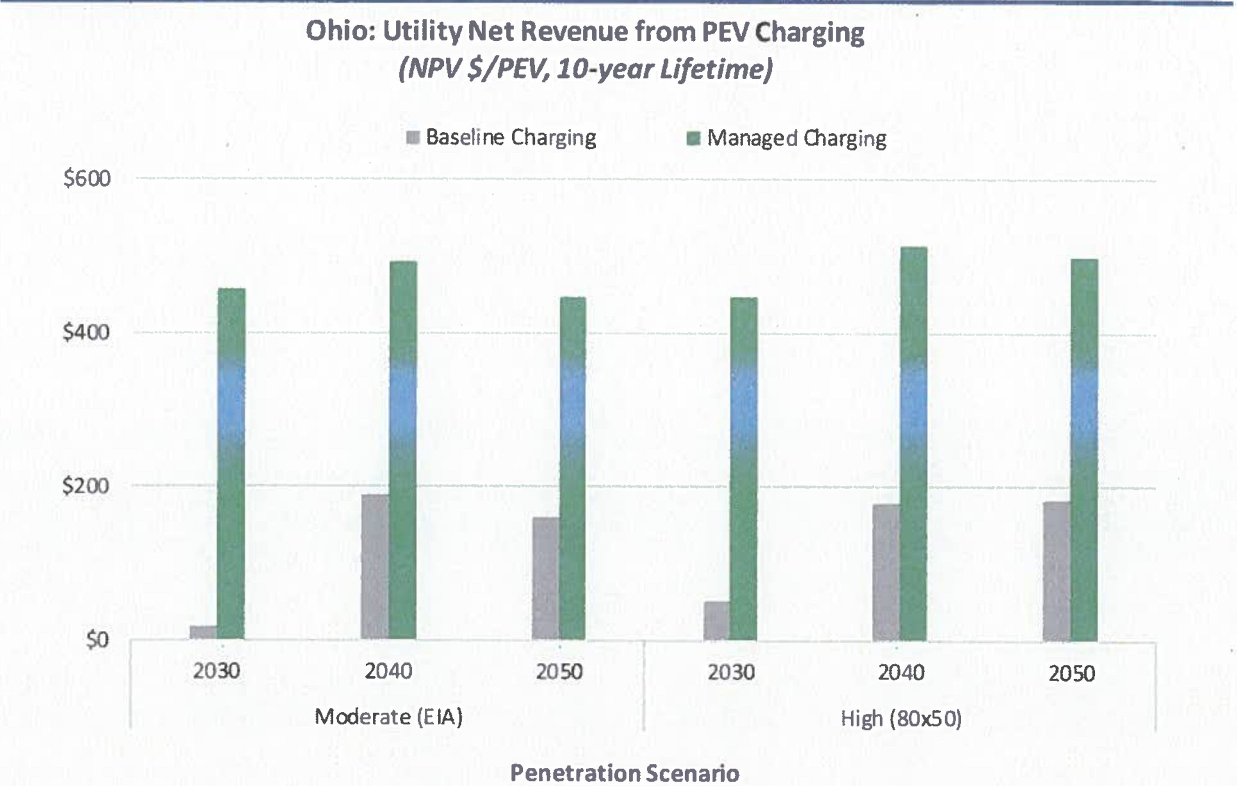
- $0.6 billion will accrue to electric utility customers in the form of reduced electric bills, and
- $4.4 billion will accrue directly to Ohio drivers in the form of reduced annual vehicle operating costs.

Also shown in Figure 1, if PEV sales in Ohio were high enough to get the state onto a trajectory to reduce light-duty GHG emissions by 70 – 80 percent from current levels by 2050 (80x50), the net present value of **cumulative net benefits from greater PEV use in Ohio could exceed $43.3 billion state-wide by 2050**. Of these total net benefits:

- $7.6 billion would accrue to electric utility customers in the form of reduced electric bills, and
- $35.7 billion would accrue directly to Ohio drivers in the form of reduced annual vehicle operating costs.

Utility customer savings result from net revenue received by the state's utilities, from selling electricity to charge PEVs. This net revenue is net of additional costs that would be incurred by utilities to secure additional generating capacity, and to upgrade distribution systems, to handle the incremental load from PEV charging. The NPV of projected life-time utility net revenue per PEV is shown in Figure 2. Assuming a ten-year life, the average PEV in Ohio in 2030 is projected to increase utility net revenue by about $450 over its life-time, if charging is managed. PEVs in service in 2050 are projected to increase utility net revenue on average by about $470 over their life time (NPV) if charging is managed.

Figure 2 NPV of Projected Life-time Utility Net Revenue per PEV



In addition, by 2050 PEV owners are projected to save more than $730 per vehicle (nominal $) in annual operating costs, compared to owning gasoline vehicles. A large portion of this direct financial benefit to Ohio drivers derives from reduced gasoline use—from purchase of lower cost, regionally produced electricity instead of gasoline imported to the state. Under the Moderate PEV (EIA) scenario, PEVs will reduce cumulative gasoline use in the state by more than 1.75 billion gallons through 2050 – this cumulative gasoline savings grows to 20.3 billion gallons through 2050 under the high PEV (80x50) scenario. In 2050, annual average gasoline savings will be approximately 120 gallons per PEV under the Moderate PEV (EIA) scenario, while projected savings under the High PEV (80x50) scenario are nearly 153 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 over 18 million metric tons[2] through 2050 under the moderate PEV scenario, and over 212 million metric tons under the high PEV scenario. The switch from gasoline vehicles to PEVs is also projected to reduce annual NOx emissions in the state by over 515 tons in 2050 under the moderate PEV (EIA) scenario, and by over 8,000 tons under the high PEV (80x50) scenario.

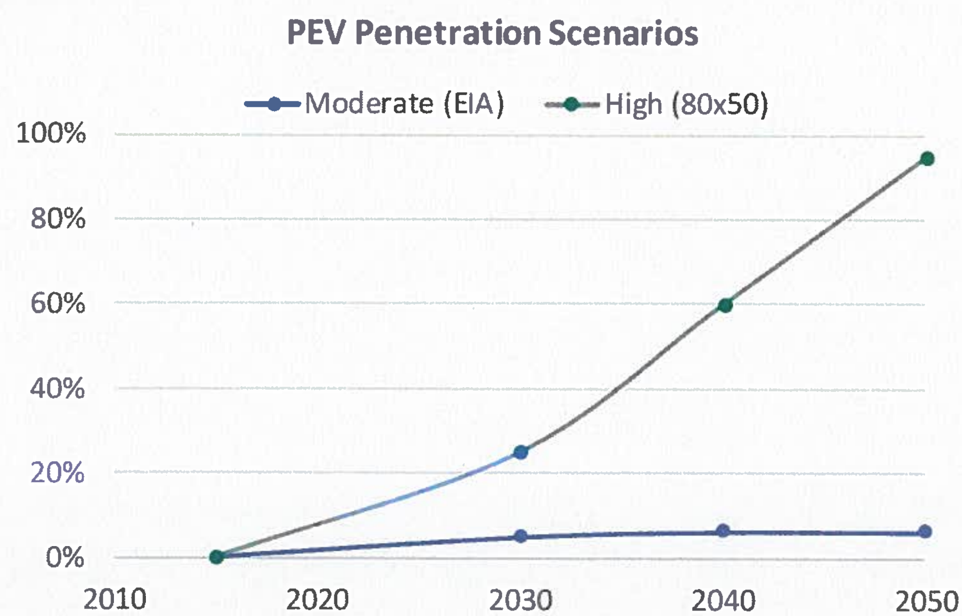
[2] Net of emissions from electricity generation

Study Results

This section summarizes the results of this study, including: the projected number of PEVs; electricity use and load from PEV charging; projected gasoline savings and GHG reductions compared to continued use of gasoline vehicles; financial benefits to utility customers from increased electricity sales; and projected financial benefits to Ohio drivers compared to owning gasoline vehicles. All costs and financial benefits are presented as net present value (NPV), using a 3 percent discount rate.

Two different PEV penetration levels between 2030 and 2050 are utilized to estimate costs and benefits.[3] The "Moderate PEV" scenario is based on current projections of annual PEV sales from the Energy Information Administration (EIA). The "High PEV" scenario is based on the level of PEV penetration that would be required to get onto a trajectory to reduce light-duty GHG emissions in the state by 70 - 80 percent from current levels by 2050. The moderate PEV (EIA) scenario is essentially a "business as usual" scenario that continues current trends. However, the significantly higher levels of PEV penetration in the high 80x50 scenario are unlikely to be achieved without additional aggressive policy action at the state and local level, to incentivize individuals to purchase PEVs, and to support the necessary roll-out of PEV charging infrastructure. See Figure 3 for a comparison of the two scenarios through 2050.

Figure 3 Comparison of PEV Penetration Scenarios



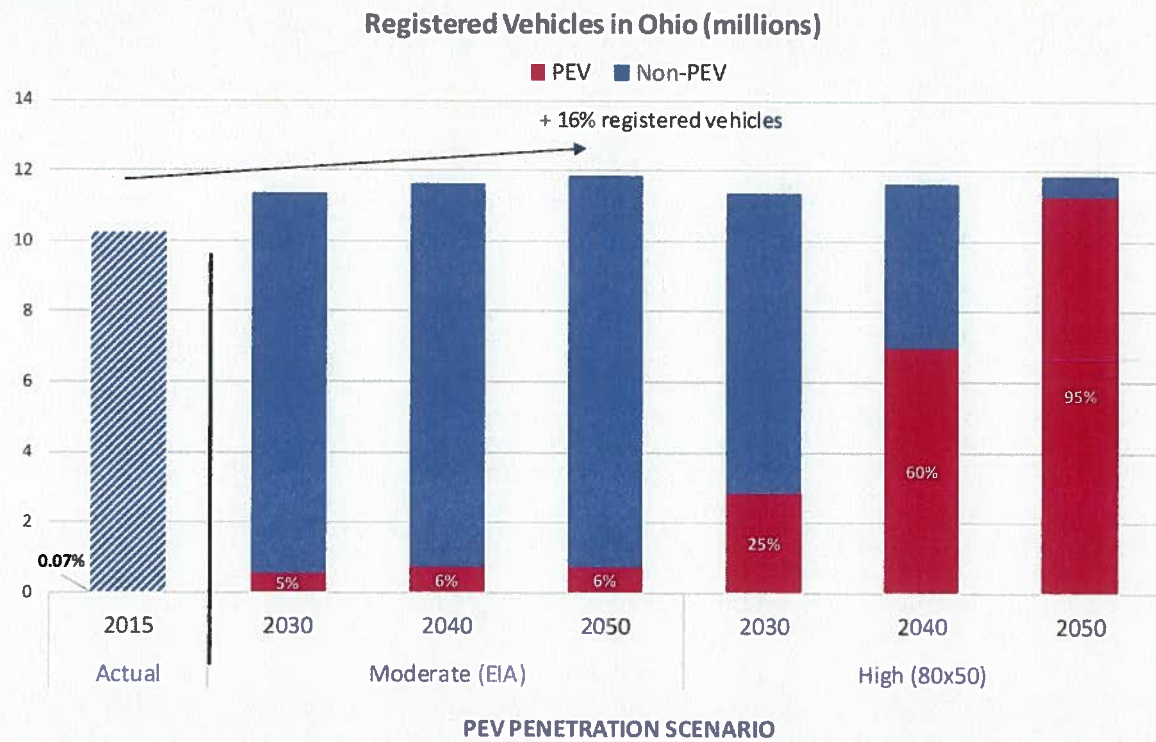
[3] PEVs include battery-electric vehicles (BEV) and plug-in hybrid vehicles (PHEV). This study focused on passenger vehicles and trucks; there are opportunities for electrification of non-road equipment and heavy-duty trucks and buses, but evaluation of these applications was beyond the scope of this study.

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

Vehicles and Miles Traveled

The projected number of PEVs and conventional gasoline vehicles in the Ohio light duty fleet[4] under each PEV penetration scenario is shown in Figure 4, and the projected annual miles driven by these vehicles is shown in Figure 5. Under the Moderate PEV (EIA) scenario, the number of PEVs registered in Ohio would increase from approximately 7,600 today to 558,400 in 2030, 720,400 in 2040, and 736,000 in 2050. Under the High PEV (80x50) scenario there would be 2.8 million PEVs in Ohio by 2030, rising to 7.0 million in 2040, and 11.2 million in 2050. This equates to 25 percent of in-use light duty vehicles in Ohio in 2030, rising to 60 percent in 2040 and 95 percent in 2050. [5]

Figure 4 Projected Ohio Light Duty Fleet

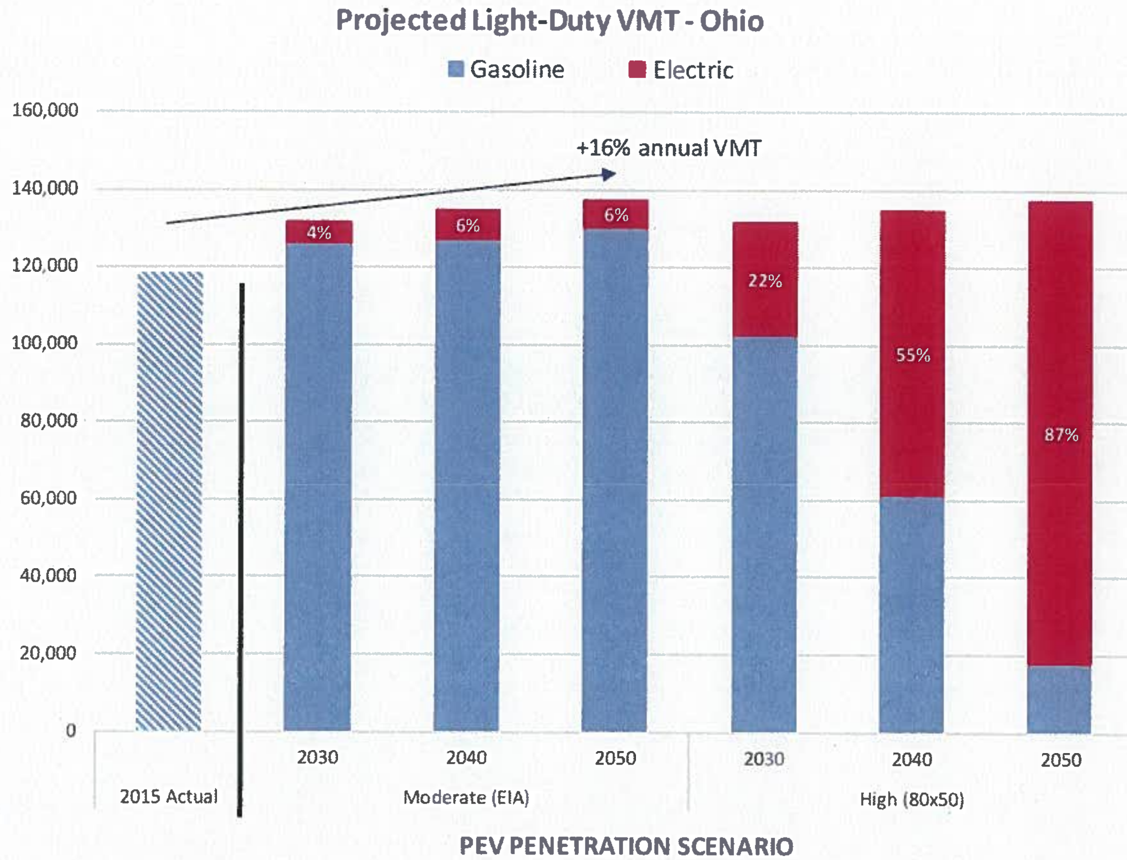


This analysis estimates that under the High PEV (80x50) scenario Ohio will reduce light-duty fleet gasoline consumption in 2050 by 49 percent compared to a baseline with no PEVs, due to 87 percent of fleet miles being driven by PEVs on electricity (Figure 5). However, to achieve this level of electric miles, 95 percent of light-duty vehicles will be PEVs, including PHEVs (Figure 4).

[4] This analysis only includes cars and light trucks. It does not include medium- or heavy-duty trucks and buses.

[5] Note that under both PEV penetration scenarios the percentage of total VMT driven by PEVs on electricity each year is lower than the percentage of PEVs in the fleet. This is because PHEVs are assumed to have a "utility factor" less than one – i.e., due to range restrictions a PHEV cannot convert 100 percent of the miles driven annually by a baseline gasoline vehicle into miles powered by grid electricity. In this analysis PHEVs are assumed to have an average utility factor of 85 percent.

Figure 5 Projected Ohio Light Duty Fleet Vehicle Miles Traveled (million miles)



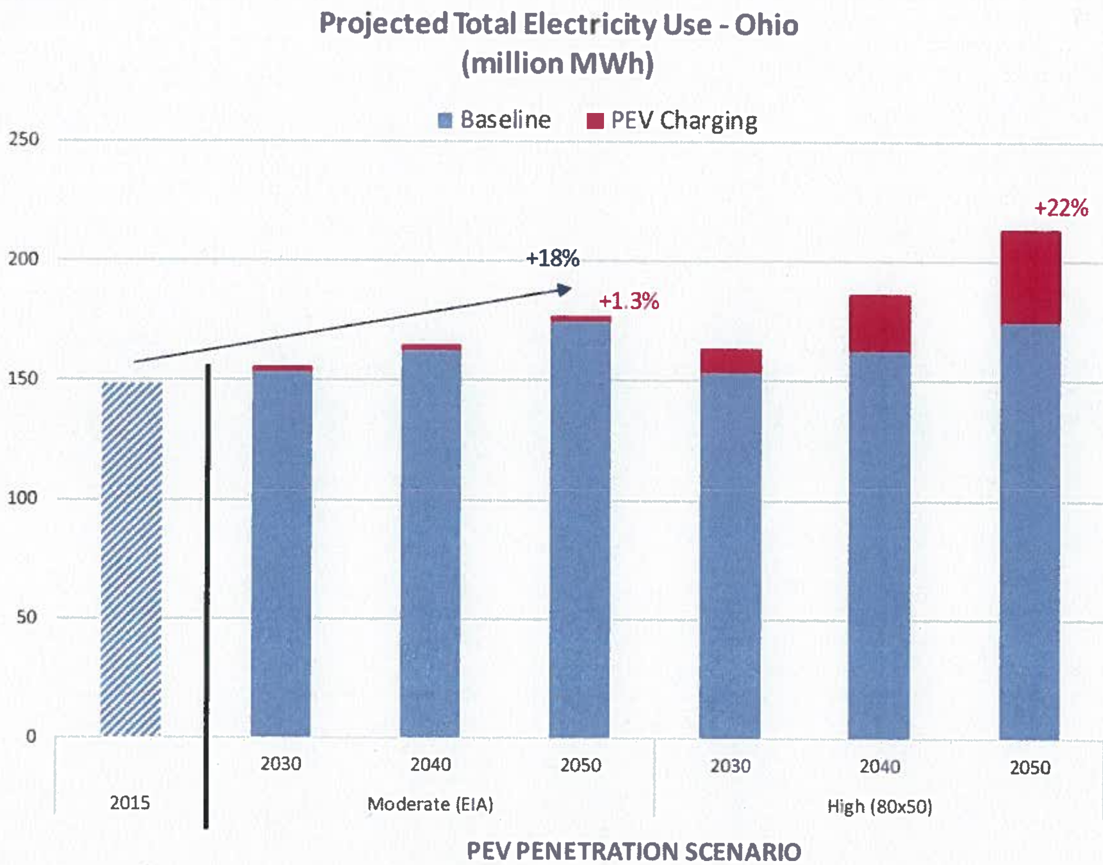
PEV Charging Electricity Use

The estimated total PEV charging electricity used in Ohio 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 Ohio is currently 149 million MWh per year. Annual electricity use is projected to increase to 154 million MWh in 2030 and continue to grow after that, reaching 175 million MWh in 2050 (18 percent greater than 2015 levels).

Under the Moderate PEV penetration scenario, electricity used for PEV charging is projected to be 1.976 million MWh in 2030 – an increase of about 1.3 percent over baseline electricity use. By 2050, electricity for PEV charging is projected to grow to 2.3 million MWh – an increase of 1.3 percent over baseline electricity use. Under the High PEV (80x50) scenario electricity used for PEV charging is projected to be 9.7 million MWh in 2030, growing to 38.8 million MWh and adding 22 percent to baseline electricity use in 2050.

Figure 6 Estimated Total Electricity Use in Ohio



PEV Charging Load

This analysis evaluated the effect of PEV charging on the Ohio electric grid under two different charging scenarios. Under both scenarios 77 percent of all PEVs are assumed to charge exclusively at home and 23 percent are assumed to charge at locations other than at home (i.e. at work or at other "public" chargers). Under the baseline charging scenario all Ohio drivers who charge at home are assumed to plug-in their vehicles and start charging as soon as they arrive at home each day, while under the managed charging scenario a significant portion of PEV owners are assumed to participate in a utility managed charging program to minimize PEV charging load in the late afternoon and early evening when other electricity demand is high.[6]

See Figure 7 (baseline) and Figure 8 (managed) for a comparison of PEV charging load under the baseline and managed charging scenarios, using the 2040 High (80x50) PEV penetration scenario as an example. In each of these figures the 2016 Ohio 95th percentile load (MW)[7] by time of day is plotted in orange, and the projected incremental load due to PEV charging is plotted in grey.

[6] Utilities have many policy options to incentivize managed PEV charging. This analysis does not compare the efficacy of different options. For this analysis, managed charging is modeled as 85% of PEV owners that arrive home between noon and 11 pm delaying the start of charging until between Midnight and 2 am. This is only one of many managed charging program options that are available to utilities.

[7] For each hour of the day actual load in 2016 was higher than the value shown on only 5 percent of days (18 days).

Figure 7 2040 Projected Ohio PEV Charging Load, Baseline Charging (High PEV [80x50] scenario)

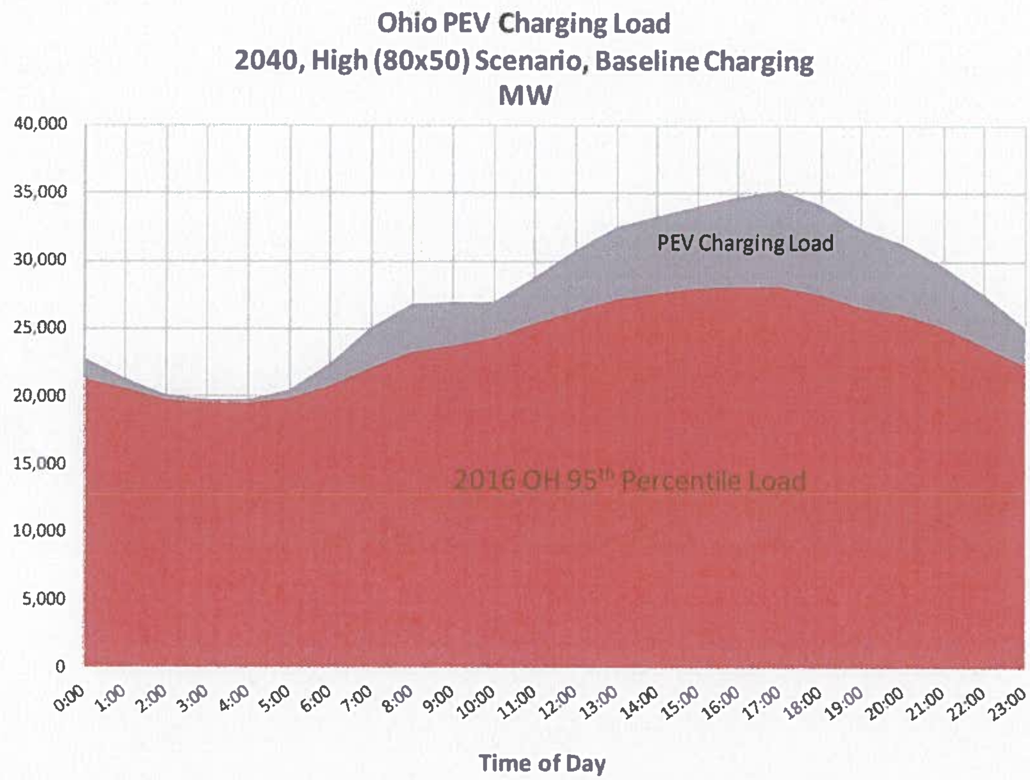
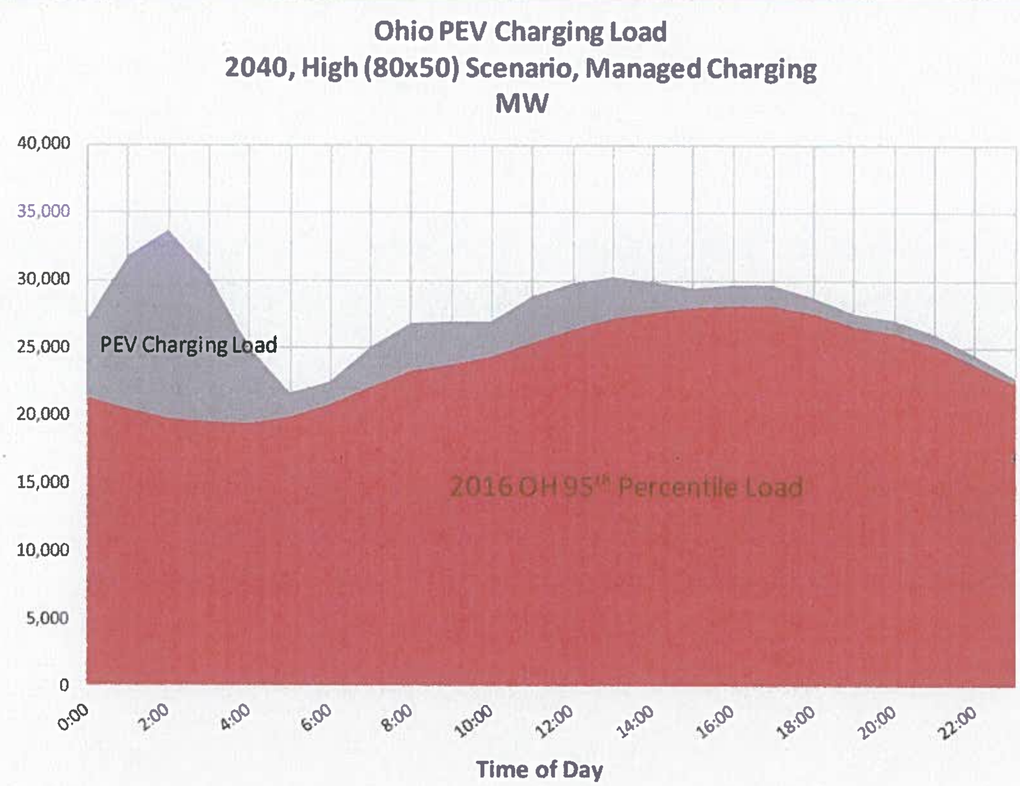


Figure 8 2040 Projected Ohio PEV Charging Load, Managed Charging (High PEV [80x50] scenario)



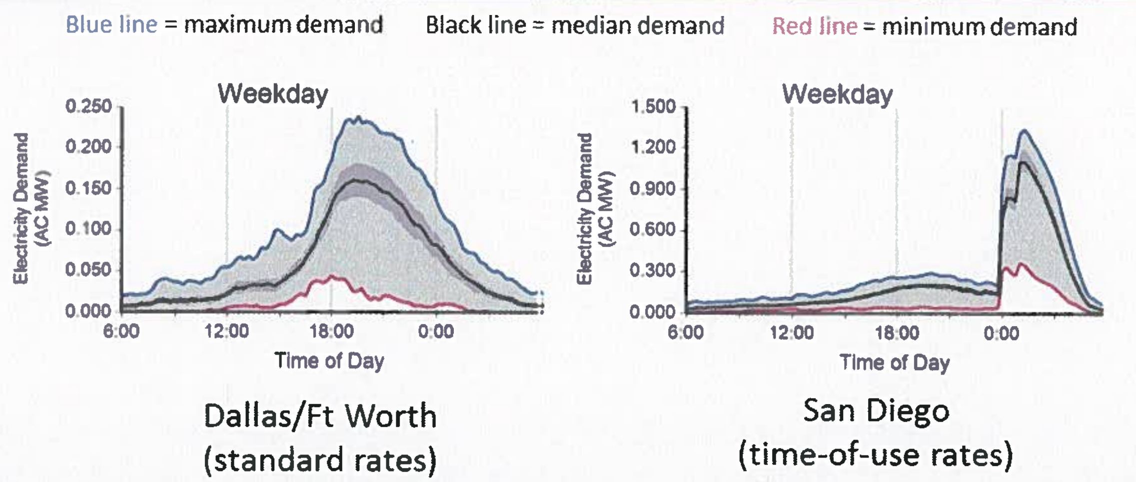
In 2016, daily electric load in Ohio was generally less than 20,000 MW from midnight to 5 AM, ramping up to about 24,000 MW at 8 or 9 AM, and continuing to climb up to peak at approximately 28,000 MW between 3 PM and 5 PM, and then falling off through the evening hours.[8]

As shown in Figure 7, baseline PEV charging is projected to add load primarily between 8 AM and 8 PM, as some people charge at work early in the day, but most charge at home in the late afternoon and early evening. Under the baseline charging scenario, the PEV charging peak coincides with the existing summer afternoon peak load period between 3 PM and 5 PM.

As shown in Figure 8, managed charging significantly reduces the incremental PEV charging load during the summer afternoon peak load period, but creates a secondary peak in the early morning hours, between midnight and 4 AM. The shape of this early morning peak can potentially be controlled based on the design of managed charging incentives.

These baseline and managed 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 managed 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. [2]

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 Ohio, 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 2016 95th percentile peak hour load. Under the Moderate PEV (EIA) penetration scenario, PEV charging would add 568 MW of load during the afternoon peak load period on a typical weekday in 2030, which would increase the 2016 baseline peak load by about 2.0 percent. By 2050, the afternoon incremental PEV charging load would increase to 681 MW, adding 2.4 percent to the 2016 baseline afternoon peak. By comparison the afternoon peak hour PEV charging load in 2030 would be only 123 MW for the managed charging scenario, increasing to 152 MW in 2050.

[8] In Figures 7 and 8, 95th Percentile Load is shown for the entire state of Ohio across the entire year.

Under the High PEV (80x50) penetration scenario, baseline PEV charging would increase the total 2016 afternoon peak electric load by about 41 percent in 2050, while managed charging would only increase it by about 9 percent.[9]

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, managed PEV charging can provide additional net benefits to all utility customers, by reducing the cost of providing electricity used to charge PEVs.

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

		Moderate PEV (EIA)			High PEV (80x50)		
		2030	**2040**	**2050**	**2030**	**2040**	**2050**
Baseline Charging	PEV Charging (MW)	568	666	681	2,630	7,097	11,474
	Increase relative to 2016 Peak	2.0%	2.4%	2.4%	9.4%	25.2%	40.8%
Managed Charging	PEV Charging (MW)	123	148	152	586	1,534	2,480
	Increase relative to 2016 Peak	0.4%	0.5%	0.5%	2.1%	5.5%	8.8%

Utility Customer Benefits

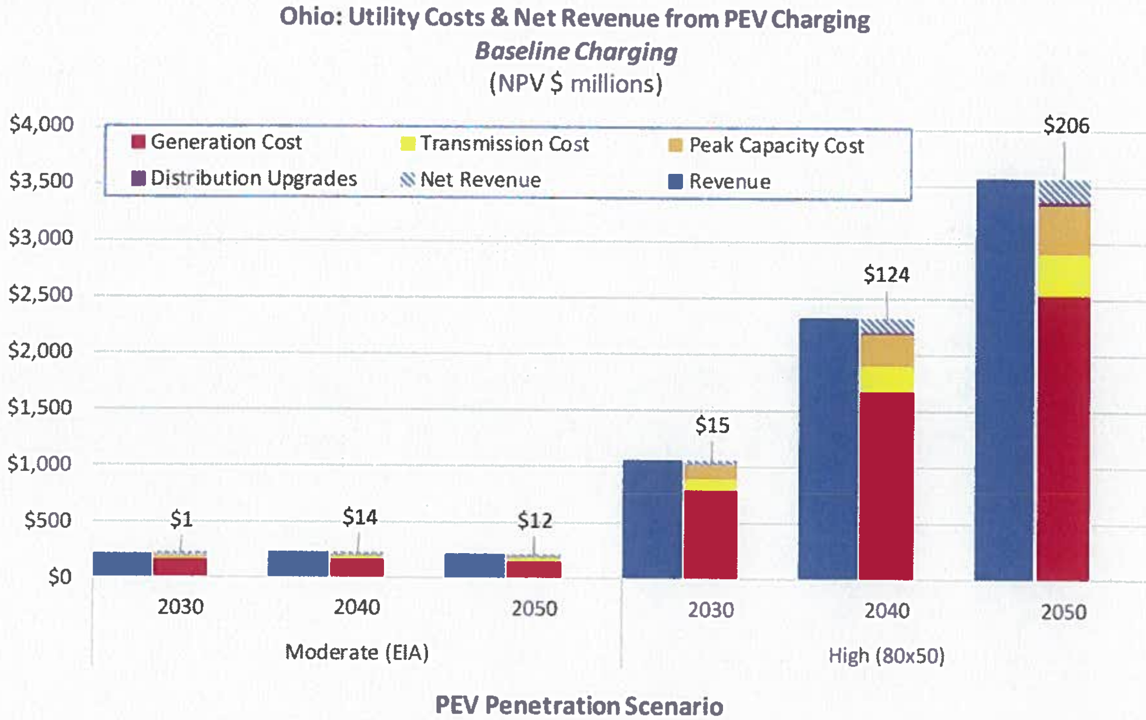
The estimated NPV of annual revenues and costs in 2030, 2040, and 2050, for Ohio's electric utilities to supply electricity to charge PEVs under each penetration scenario are shown in Figure 10, assuming the baseline PEV charging scenario.

Under the Moderate PEV penetration scenario, the NPV of annual revenue from electricity sold for PEV charging in Ohio is projected to total $213 million in 2030, and $209 million in 2050. Under the High PEV (80x50) scenario, the NPV of annual utility revenue from PEV charging is projected to total $1.0 billion in 2030, rising to $3.6 billion in 2050.

In Figure 10, projected annual utility revenue is shown in dark blue. The different elements of incremental annual 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 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 distribution infrastructure to handle the increased peak load imposed by PEV charging.

[9] 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 2016 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. The incremental costs of adding this peak capacity are accounted for in the analysis. As discussed below, even when accounting for these costs there are still net rate-payer benefits from high levels of PEV penetration. As the analysis shows, the net rate-payer benefits are higher with managed charging, because the cost of serving the incremental peak load is lower.

Figure 10 NPV of Projected Annual Utility Revenue and Costs from Baseline PEV Charging

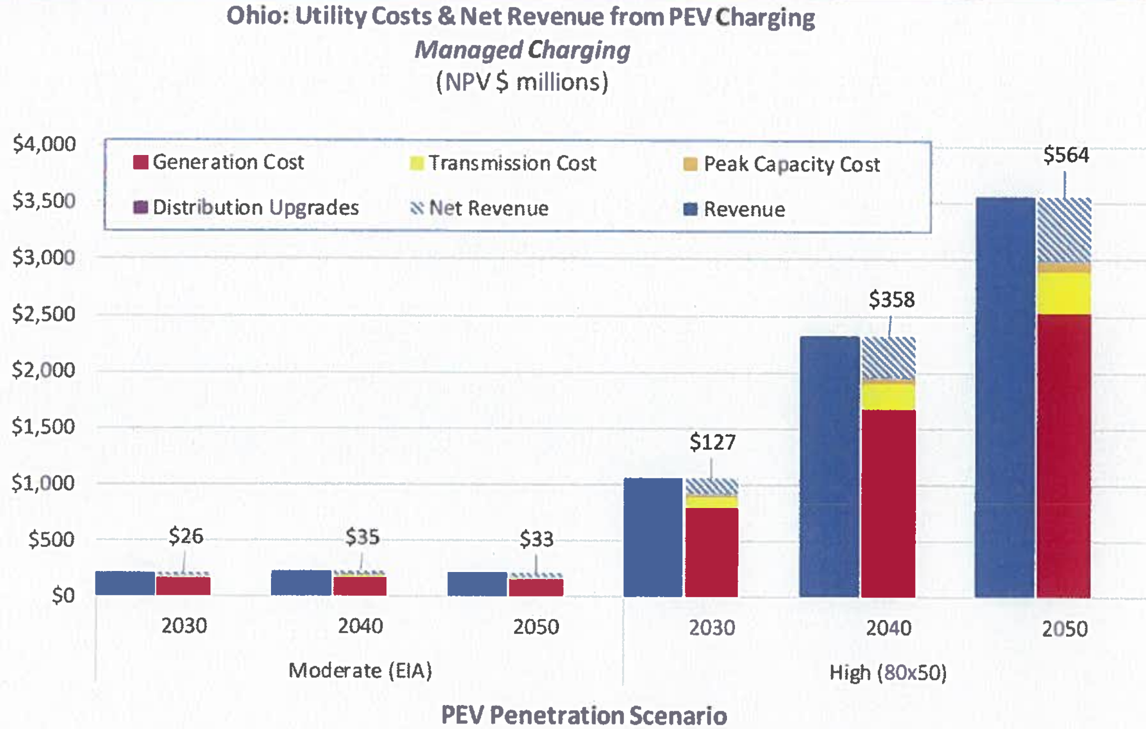


The striped light blue bars in Figure 10 represent the NPV of projected annual "net revenue" (revenue minus costs) that utilities would realize from selling additional electricity for PEV charging under each PEV penetration scenario in these years. Under the Moderate PEV penetration scenario, the NPV of net revenue in Ohio is projected to total $1 million in 2030 and $12 million in 2050. Under the High PEV (80x50) scenario, the NPV of utility net annual revenue from PEV charging is projected to total $15 million in 2030, rising to $206 million in 2050. The NPV of projected annual utility net revenue averages $3 per PEV in 2030, and $16 - $18 per PEV in 2050.

Figure 11 summarizes the NPV of projected annual utility revenue, costs, and net revenue for managed charging under each PEV penetration scenario. Compared to baseline charging (Figure 10) projected annual revenue, and projected annual generation and transmission costs are the same, but projected annual peak capacity and infrastructure costs are lower due to a smaller incremental peak load (see Table 1).

Compared to baseline charging, managed charging will increase the NPV of annual utility net revenue by $25 million in 2030 and $21 million in 2050 under the Moderate PEV penetration scenario, due to lower costs. Under the High PEV (80x50) scenario, managed charging will increase the NPV of annual utility net revenue by $113 million in 2030 and $358 million in 2050. This analysis estimates that compared to baseline charging, managed charging will increase the NPV of annual utility net revenue by $45 per PEV in 2030 and $29 - $32 per PEV in 2050.

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



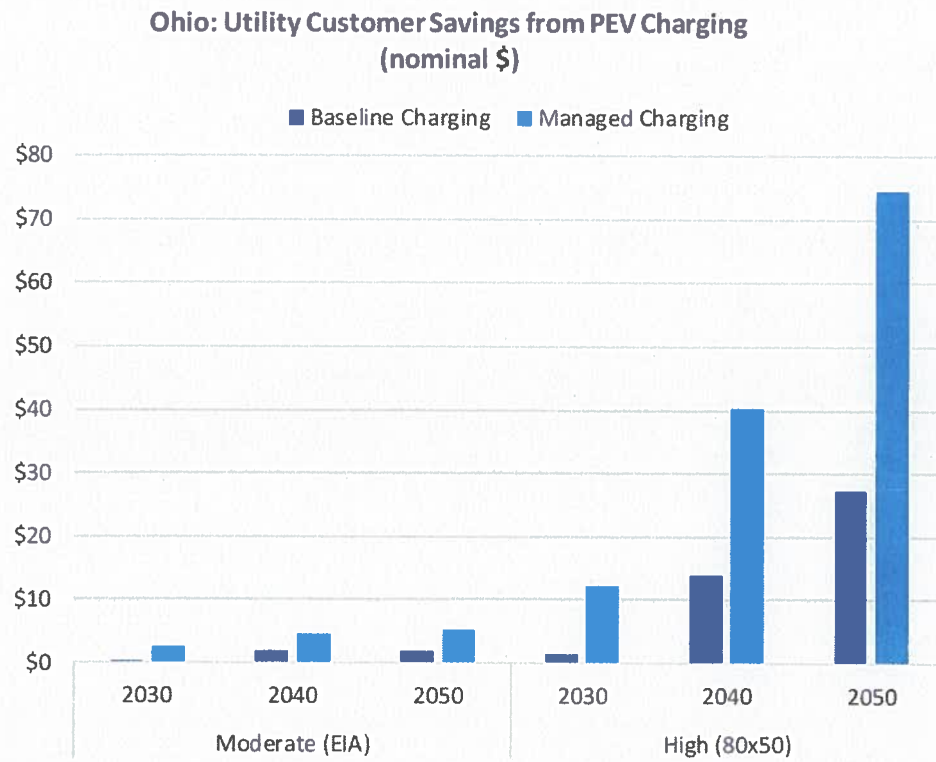
In general, a utility's costs to maintain their distribution infrastructure increase each year with inflation, and these costs are passed on to utility customers in accordance with rules established by the Public Utility Commission of Ohio (PUCO), via periodic increases in residential and commercial electric rates. However, under the PUCO rules net revenue from additional electricity sales generally offset 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 Ohio, not retained by the utility companies.

Under current rate structures this net revenue would in effect put downward pressure on future rates, delaying or reducing future rate increases, thereby reducing electric bills for all customers. See Figure 12 for a summary of how the projected utility net revenue from PEV charging could affect average annual residential electricity bills for all Ohio electric utility customers.[10] As shown in the figure, under the High PEV (80x50) scenario projected average electric rates in Ohio could be reduced up to 2.6 percent in 2050 due to net revenue from PEV charging, resulting in an annual savings of approximately $75 (nominal dollars) per household in Ohio.

It must be noted that how this utility net revenue from PEV charging gets distributed is dependent on rate structure. Potential changes to current rates - to specifically incentivize off-peak PEV charging - could shift some or all of this benefit to PEV owners, thus reducing their electricity costs for vehicle charging without reducing costs for non-PEV owners. In either case, rate payers who do not own a PEV will not be harmed by transportation electrification, and may benefit indirectly even if they continue to own gasoline vehicles.

[10] Based on 2016 average electricity use of 10,040 kWh per housing unit in Ohio

Figure 12 Potential Effect of PEV Charging Net Revenue on Utility Customer Bills (nominal $)



Ohio 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 as described below PEVs are projected to provide a lower total cost of ownership than conventional vehicles in Ohio by about 2035, even without government purchase subsidies.

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 $300/kWh in the last six years; many analysts and auto companies project that battery prices will continue to fall – to below $110/kWh by 2025, and below $75/kWh by 2030. [3]

Based on these battery cost projections, this analysis projects that the average annual cost of owning a PEV in Ohio will fall below the average cost of owning a gasoline vehicle by 2035, even without government purchase subsidies.[11] See Table 2 which summarizes the average projected annual cost of Ohio 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 High PEV (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.

[11] 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.

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

GASOLINE VEHICLE		Moderate (EIA)			High (80x50)		
		2030	2040	2050	2030	2040	2050
Vehicle Purchase	$/yr	$5,313	$5,918	$7,245	$4,502	$6,192	$8,394
Gasoline	$/yr	$1,202	$1,364	$1,636	$1,173	$1,464	$1,912
Maintenance	$/yr	$265	$322	$397	$263	$329	$417
TOTAL ANNUAL COST	**$/yr**	**$6,781**	**$7,604**	**$9,278**	**$5,938**	**$7,985**	**$10,723**

PEV -OH		Moderate (EIA)			High (80x50)		
Baseline Charging/Standard Rate		2030	2040	2050	2030	2040	2050
Vehicle Purchase	$/yr	$5,313	$5,918	$7,245	$5,098	$6,334	$8,601
Electricity	$/yr	$594	$667	$800	$576	$698	$890
Gasoline	$/yr	$80	$95	$113	$78	$102	$129
Personal Charger	$/yr	$81	$99	$122	$81	$99	$122
Maintenance	$/yr	$162	$197	$243	$161	$200	$251
TOTAL ANNUAL COST	**$/yr**	**$6,231**	**$6,976**	**$8,522**	**$5,995**	**$7,431**	**$9,993**
Savings per PEV	**$/yr**	**$550**	**$628**	**$755**	**-$56**	**$554**	**$730**

As shown in Table 2, under the High PEV Scenario (80x50) 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. For the Moderate PEV Scenario in 2030, the average Ohio PEV owner is projected to have annual operating savings of $550 due to reduced maintenance as well as electricity costs being lower than gasoline[12]. For both scenarios, this annual savings is projected to increase to $730 - $755 per PEV per year by 2050, as projected gasoline prices continue to increase faster than projected electricity prices.

The NPV of total annual cost savings to Ohio drivers from greater PEV ownership are projected to be $197 million in 2030 rising to $198 million in 2050 under the moderate PEV penetration scenario. Under the High PEV (80x50) scenario, the NPV of total annual cost savings to Ohio drivers from greater PEV ownership are projected to be negative in 2030 (-$103 million), but quickly increase to a positive $1.8 billion in 2040 and continue rising to $2.9 billion in 2050.

[12] Under the moderate PEV (EIA) scenario, this analysis assumes that PEV owners will pay the same net purchase price for gasoline vehicles and PEVs, despite the higher projected purchase price of comparable PEVs. There is evidence that current PEV purchasers are foregoing the purchase of more expensive vehicles to purchase higher-priced PEVs within their target budget. With only modest future PEV penetration this analysis assumes that this behavior will continue. However, for the High PEV scenario net PEV owner benefits reflect the fact that PEV purchasers will pay a higher price for their PEVs than they would have paid for a similar gasoline vehicle.

Other Benefits

Energy Security and Emissions Reductions

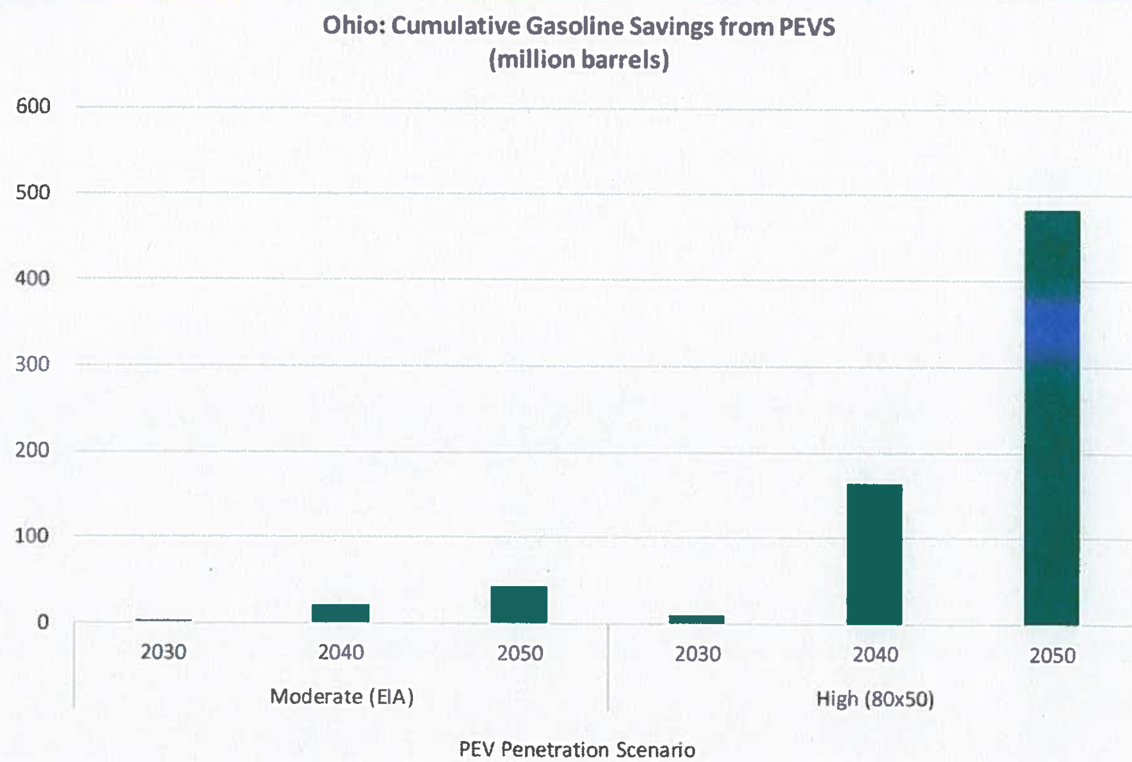
Along with the financial benefits to electric utility customers and PEV owners described above, light-duty vehicle electrification can provide additional benefits, including significant reductions in gasoline fuel use and transportation sector emissions.

The estimated cumulative fuel savings (barrels of gasoline[13]) from PEV use in Ohio under each penetration scenario are shown in Figure 13. Annual fuel savings under the Moderate PEV penetration scenario are projected to total 1.9 million barrels in 2030, with cumulative savings of more than 42 million barrels by 2050. For the High PEV (80x50) scenario, annual fuel savings in 2030 are projected to be 8.9 million barrels, and by 2050 cumulative savings will exceed 483 million barrels.

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]

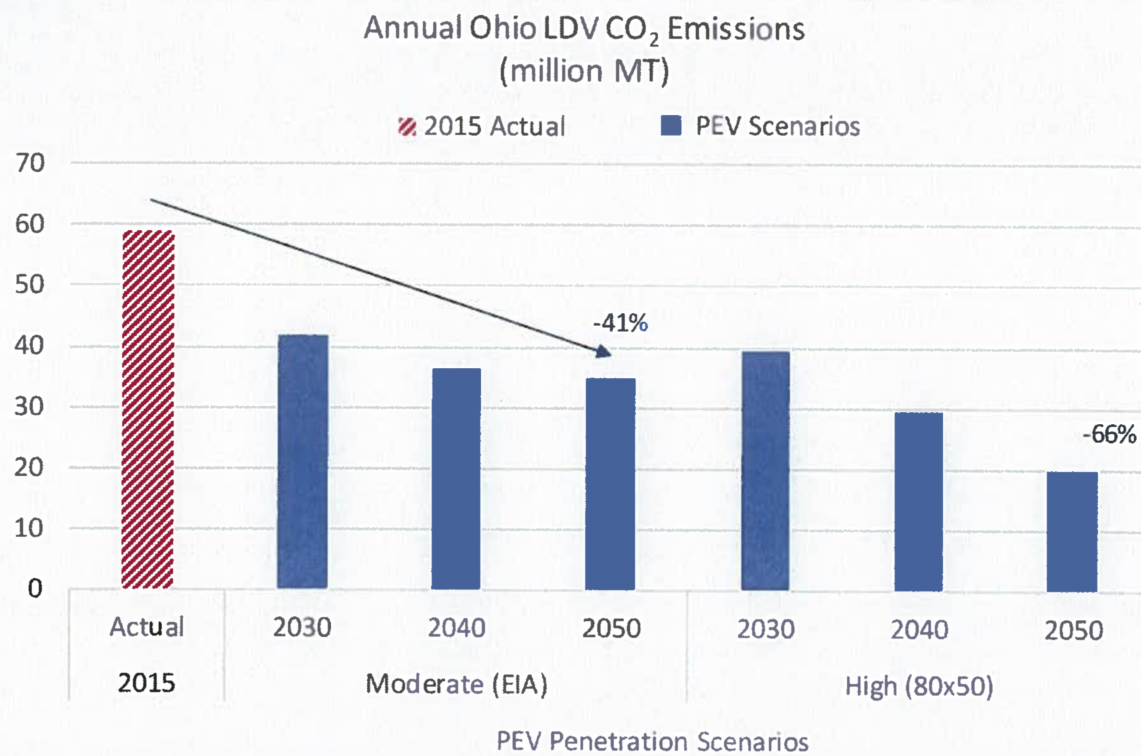
Figure 13 Cumulative Gasoline Savings from PEVs in Ohio



[13] One barrel of gasoline equals 42 US gallons

The projected annual greenhouse gas (GHG) emissions (million metric tons carbon-dioxide equivalent, CO_2-e million tons) from the Ohio light duty fleet under each PEV penetration scenario are shown in Figure 14. In this figure, projected emissions under the PEV scenarios are shown in blue. The values shown represent "wells-to-wheels" emissions, including direct tailpipe emissions and "upstream" emissions from production and transport of gasoline. Estimated emission for the PEV scenarios includes GHG emissions from generating electricity to charge PEVs, as well as GHG emissions from gasoline vehicles in the fleet. Estimated emissions from PEV charging are based on EIA projections of average carbon intensity for the Reliability First Corporation / West electricity market module region, which includes Ohio.

Figure 14 Projected GHG Emissions from the Light Duty Fleet in Ohio



As shown in Figure 14, GHG emissions from the light duty fleet in Ohio were approximately 59 million metric tons in 2015.

Compared to 2015 baseline emissions, in 2050 GHG emissions are projected to be reduced by up to 24 million tons under the Moderate PEV penetration scenario and as much as 39 million tons under the High PEV (80x50) scenario. Through 2050, cumulative net GHG emissions are projected to be reduced by nearly 445 million tons under the Moderate PEV penetration scenario and 611 million metric tons under the High PEV (80x50) scenario.

NOx Emissions

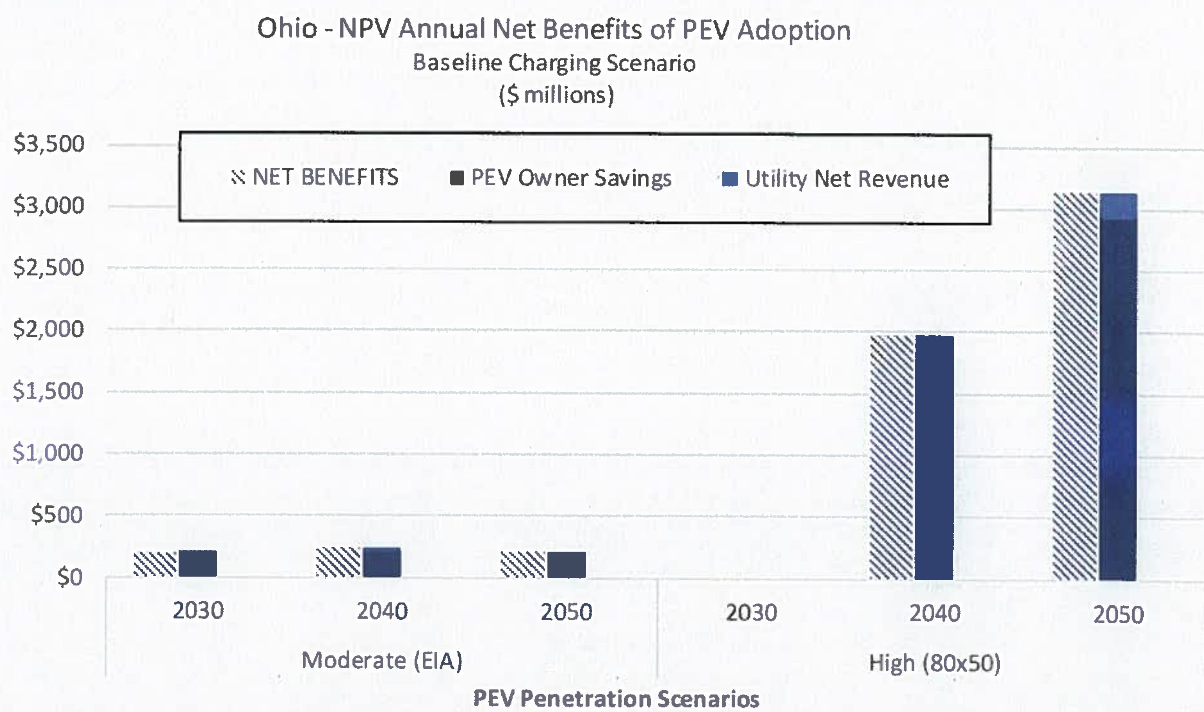
In 2015 the Electric Power Research Institute (EPRI), in conjunction with the Natural Resources Defense Council (NRDC), conducted national-level modeling to estimate GHG and air quality benefits from high levels of transportation electrification [4]. Under their electrification scenario EPRI estimated that NOx would be reduced by 11.4 tons and VOCs would be reduced by 5.5 tons, for every billion vehicle miles traveled[14].

Extrapolating from this data, under the Moderate PEV Scenario (EIA), by 2050 light-duty vehicle electrification in Ohio could reduce annual NOx emissions by 516 tons and reduce annual VOC emissions by 249 tons. Under the High PEV Scenario (80x50), total NOx reductions in 2050 could reach more than 8,000 tons per year, and total VOC reductions could reach almost 3,900 tons per year.[15]

Total Societal Benefits

The NPV of total annual estimated benefits from increased PEV use in Ohio under each PEV penetration scenario are summarized in Figures 15 and 16. These benefits include cost savings to Ohio drivers and utility customer savings from reduced electric bills. Figure 15 shows the NPV of annual projected societal benefits if Ohio drivers charge in accordance with the baseline charging scenario. Figure 16 shows the NPV of projected annual benefits with managed charging.

Figure 15 Projected NPV of Total Societal Benefits from Greater PEV use in OH – Baseline Charging



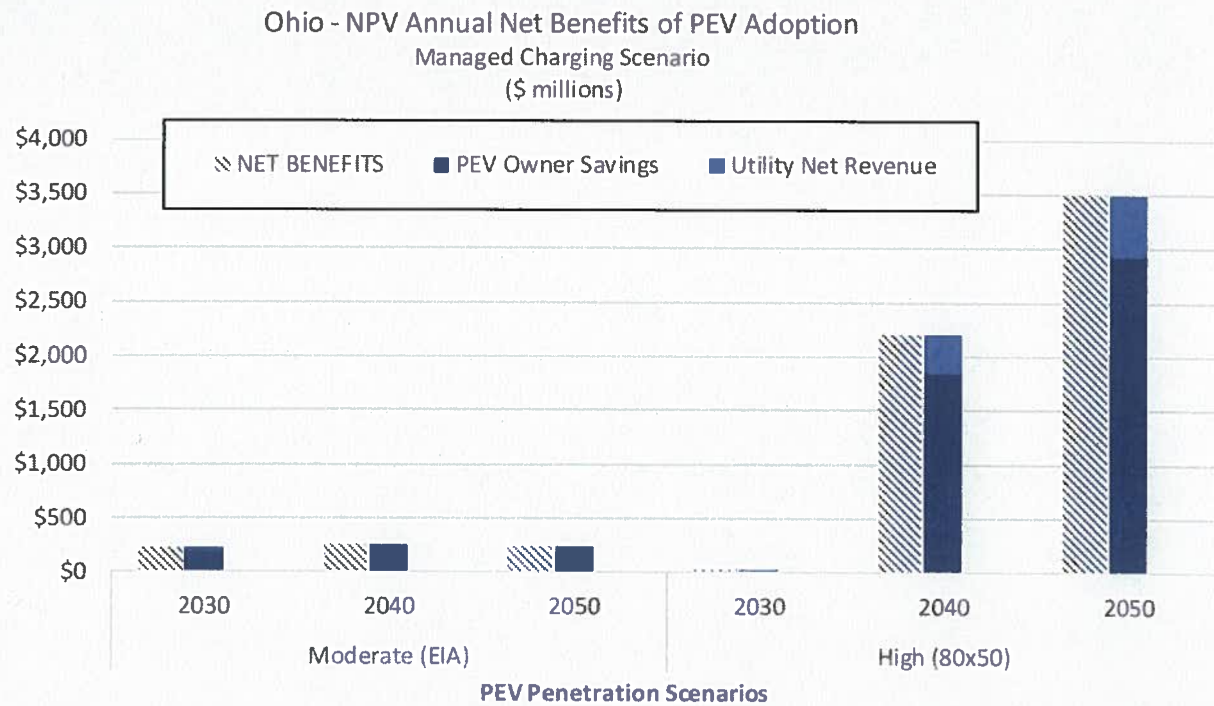
[14] For light-duty vehicles the analysis assumed that by 2030 approximately 17 percent of annual vehicle miles would be powered by grid electricity, using PEVs. Based on current and projected electric sector trends the analysis also assumed that approximately 49 percent of the incremental power required for transportation electrification in 2030 would be produced using solar and wind, with the remainder produced by combined cycle natural gas plants.

[15] Across the entire state, estimated annual light-duty vehicle miles traveled (VMT) totals 1.37 trillion miles in 2050. Of these miles approximately, 6 percent are powered by grid electricity under the EIA penetration scenario, and 87 percent are powered by grid electricity under the 80x50 penetration scenario

As shown in Figure 15, the NPV of annual benefits is projected to be a minimum of $209 million per year in 2050 under the Moderate PEV penetration scenario and $3.1 billion per year in 2050 under the High PEV (80x50) scenario. Approximately 93 percent of these annual benefits will accrue to Ohio drivers as a cash savings in vehicle operating costs and 7 percent will accrue to electric utility customers as a reduction in annual electricity bills.

As shown in Figure 16, the NPV of annual benefits in 2050 will increase by $21.1 million under the Moderate PEV (EIA) penetration scenario, and $358 million under the High PEV (80x50) scenario with managed charging. Of these increased benefits, all will accrue to electric utility customers as an additional reduction in their electricity bills.

Figure 16 Projected NPV of Total Societal Benefits from Greater PEV use in OH – Managed Charging



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).[16] This report can be found at:

http://mjbradley.com/sites/default/files/NE_PEV_CB_Analysis_Methodology.pdf

This study evaluated the costs and benefits of two distinct levels of PEV penetration in Ohio between 2030 and 2050, based on the range of publicly available PEV adoption estimates from various analysts.

Moderate PEV Scenario –EIA: Based on EIA's current projections for new PEV sales between 2015 and 2050, as contained in the 2017 Annual Energy Outlook (AEO). Under this scenario approximately 4.9 percent of in-use light duty vehicles in Ohio will be PEV in 2030, rising to 6.2 percent in 2040 and remaining steady through 2050.

High PEV Scenario – 80x50: PEV penetration levels each year that would put the state on a trajectory to reduce total annual light-duty fleet GHG emissions by 70 – 80 percent from current levels in 2050. Under this scenario 25 percent of in-use vehicles will be PEV in 2030, rising to 60 percent in 2040 and 95 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 Energy Information Administration in their most recent Annual Energy Outlook (AEO 2017).

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 Ohio'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) a managed 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.[17] However, if given a "nudge" - in the form of a properly designed and marketed financial

[16] 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 2017. Finally, for projections of future PEV costs this analysis used updated July 2017 battery cost projections from Bloomberg New Energy Finance.

[17] 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.

incentive - many Ohio drivers will choose to delay the start of charging until later times, thus reducing the effect of PEV charging on evening peak electricity demand (scenario 2). [5]

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 the Moderate PEV Scenario, it was assumed that PEV vehicle costs are the same as baseline gasoline vehicles, with the reasoning that consumers have a set budget and will purchase what they can afford, regardless of technology type. For the High PEV Scenario, the same logic could not be applied, as it is assumed that nearly all vehicle purchases will be PEV. 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 Ohio drivers.

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_2-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 an electricity scenario that is consistent with the latest Energy Information Administration (EIA) projections for future SERC Reliability Corporation / Virginia -Carolina.

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.

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[5] Idaho National Laboratory, *2013 EV Project Electric Vehicle Charging Infrastructure Summary Report*, January 2013 through December 2013

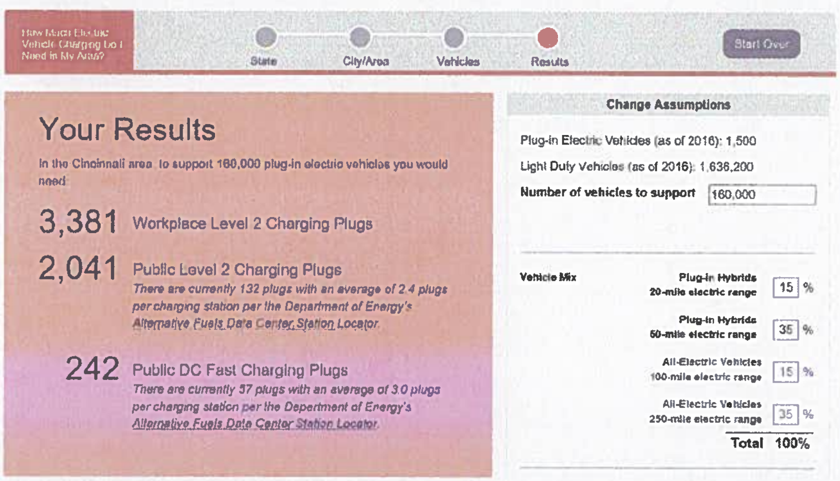
Acknowledgements

Lead Authors: Dana Lowell, Brian Jones, and David Seamonds

This study was conducted by M.J. Bradley & Associates for Duke Energy. It is one of six state-level analyses that will be conducted of plug-in electric vehicle costs and benefits in the different U.S. states in which Duke operates. These studies are intended to provide input to state policy discussions about actions required to promote further adoption of electric vehicles, as well as to inform internal Duke planning efforts.

Attachment LWR-2. Duke Energy Ohio EV Forecast and Station Quantity Calculations

PEV Forecasts	Current number of PEV's in Ohio - end of 2018	12,711	EPRI/Duke report using BMV data
	Current number of PEV's in Duke Energy Ohio - end of 2018	2,942	EPRI/Duke report using BMV data
	Percentage of PEV's in Duke Energy Ohio	23%	
	MJB - 2030 Ohio PEV Forecast - 5% market share	560,000	MJB Ohio Report
	MJB - 2030 Duke Energy Ohio PEV Forecast - 5% market share	129,614	23% of state forecast
	MJB - 2030 Ohio PEV Forecast - 25% market share	2,800,000	MJB Ohio Report
	MJB - 2030 Duke Enregy Ohio PEV Forecast - 25% market share	648,069	23% of state forecast
	EEI - 2030 US PEV Forecast (7% of all Light Duty Vehicles will be PEV)	18,700,000	EEI EV Forecast November 2018
	EEI - Ratio of total Light Duty Vehicles (Ohio to US)	4%	US Total 260M, Ohio has 10.5M
	EEI - 2030 Ohio PEV Forecast	755,192	4% of 18.7M
	EEI - 2030 Duke Energy Ohio PEV Forecast	174,792	23% of state forecast
Current Charging Stations	# DCFC ports in Cincy Metro Area (Excluding 30 Tesla)	14	US DOE AFDC
	# public L2 ports in Cincy Metro	132	US DOE AFDC
Charging Stations Needed	DCFC Qty needed to support 160,000 by 2030	242	EVI Pro Lite
	Public L2 Qty needed to support 160,000 by 2030	5422	See image below
Duke Energy Ohio Pilot Plan	Company's role in achieving 2030 goal	25%	Strategic company decision
	DCFC responsibility - Pilot proposal	57	Proposing 25 DCFC locations (50 units)
	Public L2 responsibility - Pilot proposal	1323	Proposing 1200 L2 stations

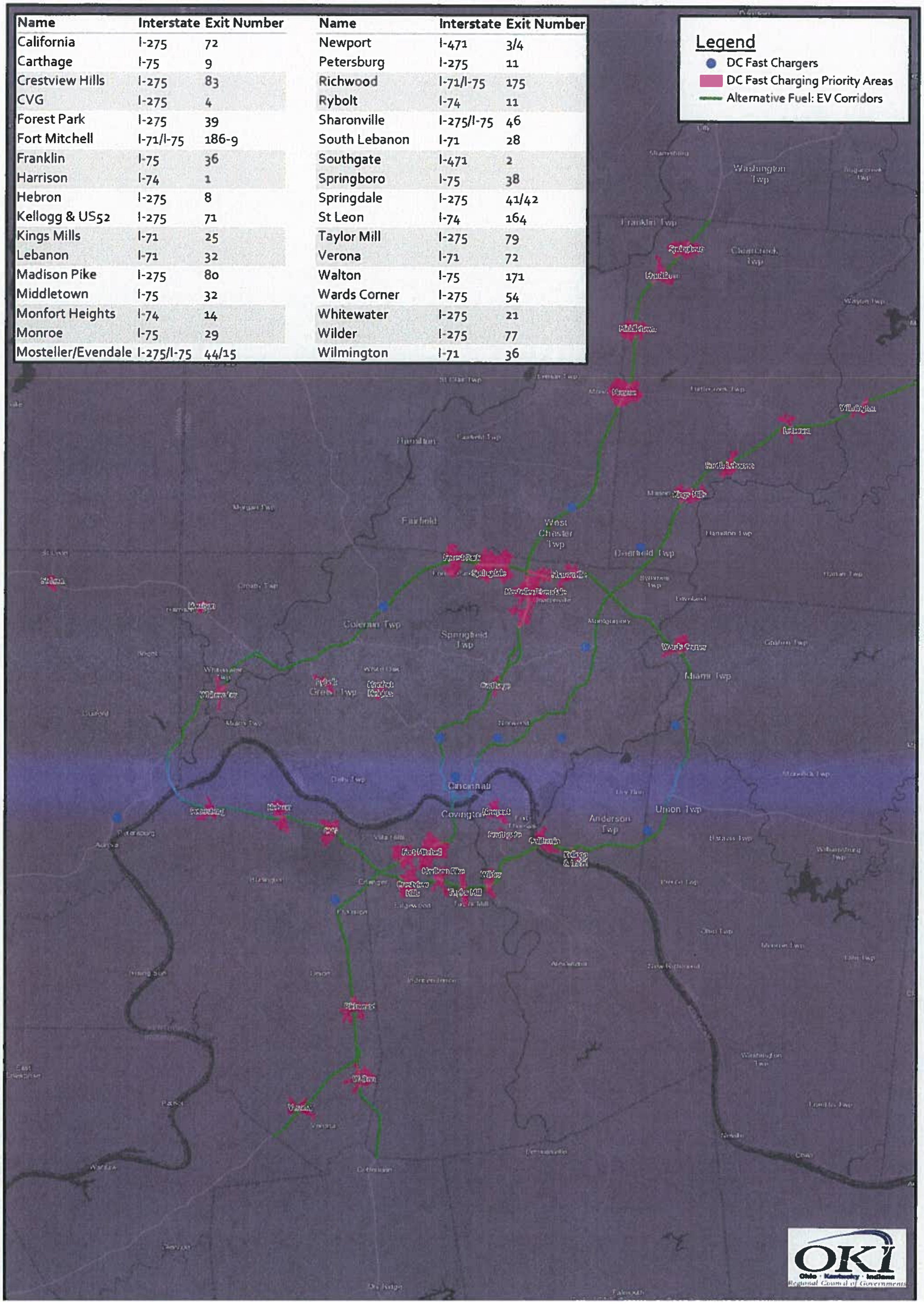


Reporting Metrics and Learning Objectives	DCFC	Transit Bus	School Bus	Residential L2	Non-Res L2
Data on the effects of charging multiple types of electric vehicles	Y	Y	Y	Y	Y
Network utilization rates and geographic patterns of utilization	Y	Y	Y	Y	Y
Net revenue in excess of cost of service – net revenue benefits to ratepayers	Y	Y	Y	Y	Y
Electricity consumption, charging behaviors, timing of consumption for EV charging	Y	Y	Y	Y	Y
System impacts	Y	Y	Y	Y	Y
Customer experience information	Y	Y	Y	Y	Y
User demographics who live within DEO service territory, Statewide, and/or out of state	Y				
Transit and School bus reliability statistics		Y	Y		
Customer operational savings associated EV Transit and School Bus deployment.		Y	Y		
Amount of electricity used to fuel a EV Transit and School Bus		Y	Y		
Transit and School bus procurement and infrastructure costs		Y	Y		
Storage value of school bus battery available for dispatch to the grid			Y		
Resilience value of school bus battery available for backup generation during storm events or other outages			Y		
Charging station reliability data	Y	Y	Y		
Proportion of PHEV vs. BEV operated by Duke Energy Ohio customers				Y	Y
Number of rebates and make-ready incentives issued	Y			Y	Y
Comparison of Non-Res, Res, and DCFC charging	Y			Y	Y
Cost of Make-Ready hardware and installations.	Y	Y	Y		Y
Change in percentage of state EV sales and percentage of EV registrations in Duke Energy Ohio's service territory				Y	Y

DC Fast Charging Priority Areas

OKI Region

Name	Interstate	Exit Number	Name	Interstate	Exit Number
California	I-275	72	Newport	I-471	3/4
Carthage	I-75	9	Petersburg	I-275	11
Crestview Hills	I-275	83	Richwood	I-71/I-75	175
CVG	I-275	4	Rybolt	I-74	11
Forest Park	I-275	39	Sharonville	I-275/I-75	46
Fort Mitchell	I-71/I-75	186-9	South Lebanon	I-71	28
Franklin	I-75	36	Southgate	I-471	2
Harrison	I-74	1	Springboro	I-75	38
Hebron	I-275	8	Springdale	I-275	41/42
Kellogg & US52	I-275	71	St Leon	I-74	164
Kings Mills	I-71	25	Taylor Mill	I-275	79
Lebanon	I-71	32	Verona	I-71	72
Madison Pike	I-275	80	Walton	I-75	171
Middletown	I-75	32	Wards Corner	I-275	54
Monfort Heights	I-74	14	Whitewater	I-275	21
Monroe	I-75	29	Wilder	I-275	77
Mosteller/Evendale	I-275/I-75	44/15	Wilmington	I-71	36



Attachment LWR-5. Example E-School and E-Transit Bus Savings.

Calculations		School		Transit	
Useful Life (yrs)			20		12
Annual Mileage			14,400		50,000
Operating Cost Savings					
Vehicle Efficiency (kWh/Mi)			1.4		1.5
Annual Energy Consumption (kWh)			20,160		75,000
Battery Charging Efficiency Loss	10%				
Total Annual Energy Consumption			22,176		82,500
Annual Electricity Cost ($/kWh)	$ 0.101	$	2,231	$	8,300
Diesel Fuel Economy (MPG)			7		4
Diesel Fuel Price ($/gal)			2.5		2.5
Diesel Annual Fuel Cost		$	5,143	$	31,250
Annual Fuel Cost Savings		$	2,912	$	22,951
Annual Maintenance Cost ($/Mi) - Diesel		$	1.00	$	0.77
Annual Maintenance Cost ($/Mi) - Electric		$	0.39	$	0.32
Annual Maintenance Cost Savings		$	8,784	$	22,500
Total Annual Operating Cost Savings		$	11,696	$	45,451
Total Operating Cost Savings Per Bus		$	233,919	$	545,406
Emissions Reductions		School		Transit	
Conventional Diesel Annual Nox Emissions (lb/yr)			442		486
Electric System Nox Emissions (lb/kWh)			0.0014		0.0014
Electric System Nox Emissions (grams/kWh)			0.6164		0.6164
Electric Bus Nox Emissions (lb/yr)			30.14		112
Total NOx Emissions Reductions - Lifecycle			[illegible]		[illegible]

Additional Inputs
Diesel Bus Tons of Nox Per year
0.221
Lbs to grams
453.592
Lbs of Nox per MWh
1.359

MWh to kWH
1000
$ per kWh
$ 0.101

Attachment LWR-6 Marketing, Education and Outreach Budget						
Media	Description	2020 Budget	2021 Budget	2022 Budget	2023 Budget	
Collateral & Promotional Items	Print literature, promos for events	$11,250	$9,020	$7,500	$1,025	
Events & Outreach	Community outreach to Schools, Dealerships, etc	$9,525	$7,500	$6,500	$1,000	
web development	includes video(s) specific to P&P DEO	$20,125	$23,125	$9,750	$2,125	
Email Marketing	development email campaigns to reach individual segments	$10,500	$10,520	$6,500	$3,200	
Social media marketing (Paid)	Facebook, twitter, SEM, streaming radio	$27,500	$29,500	$19,500	$7,250	
General awareness	promotion of Evs to customers not currently aware of advantages	$21,500	$19,500	$13,250	$2,000	
Paid Search (YouTube)	Drive site visits and engagement by intercepting relevant search queries	$26,125	$23,250	$13,750	$4,125	
Paid Search (Bing and Google)	Drive site visits and engagement by intercepting relevant search queries	$25,250	$26,750	$17,250	$3,200	
Out of home	Billboards, gas station TV, etc	$18,215	$22,450	$13,500	$1,750	
Photography (location)	Two 8-hour day shoots. Photos specific to DEO	$13,200	$8,300	$5,120	$1,000	
Photography (assets)	Two 8-hour day shoots. Chargers, infrastructure, etc.	$9,125	$6,200	$2,000	$0	
	TOTALS	**$192,315**	**$186,115**	**$114,620**	**$26,675**	**$519,725**