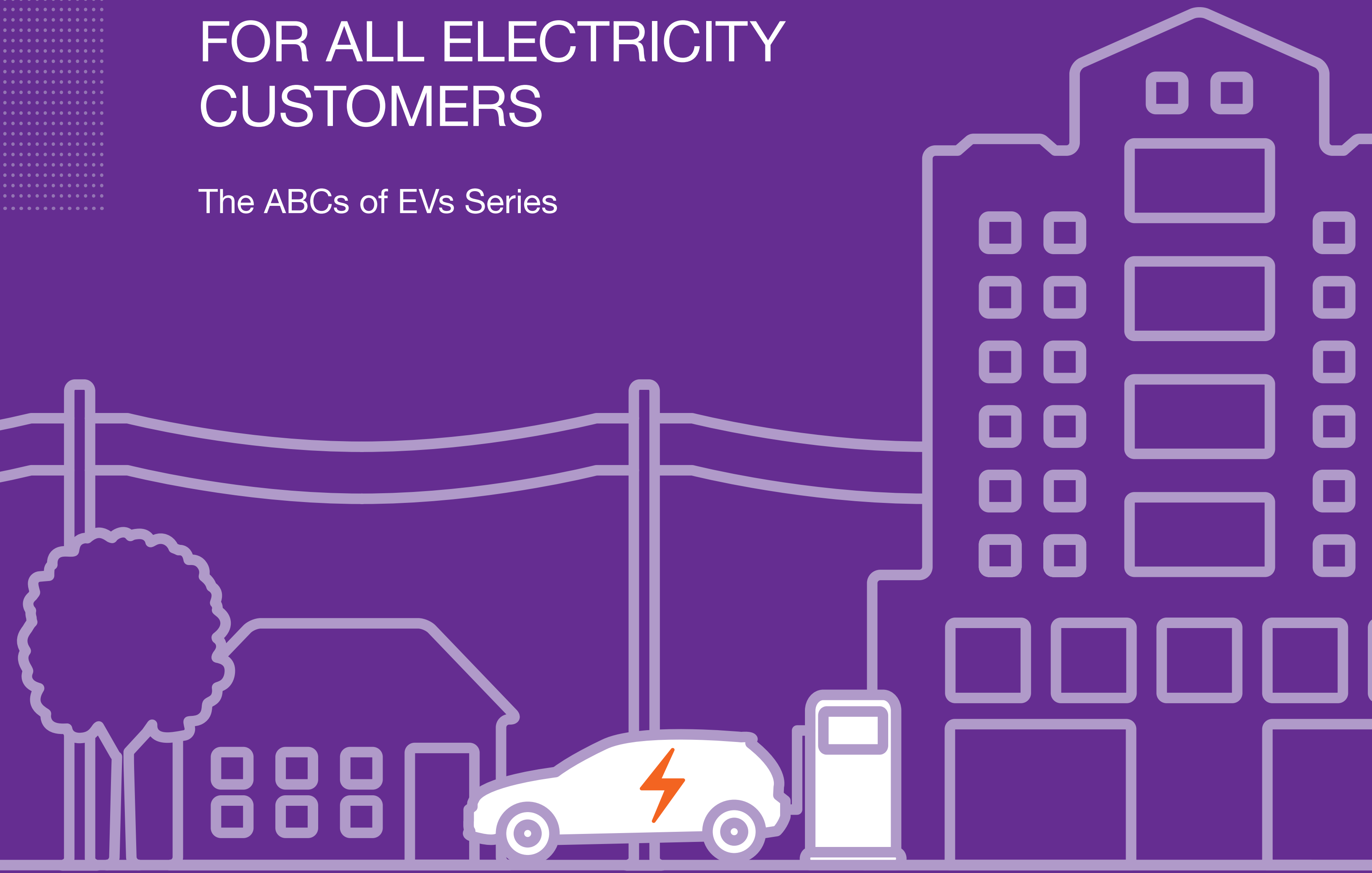
CHARGING AHEAD

DERIVING VALUE FROM ELECTRIC VEHICLES FOR ALL ELECTRICITY CUSTOMERS

The ABCs of EVs Series



The Citizens Utility Board (CUB) was created by the Illinois General Assembly in 1983 to be an independent, nonprofit organization representing the interests of residential and small commercial utility customers in regulatory matters before the Illinois Commerce Commission, the General Assembly and in the courts. Since opening its doors in 1984, CUB has helped save consumers more than $20 billion by challenging rate hikes and securing rate reductions and refunds, and it has been a leading voice in developing the state's clean energy policy. CUB was instrumental in negotiating restructuring of the Illinois electricity industry in 1997 and a series of subsequent statutes and proceedings that have made Illinois a leader in grid modernization, energy efficiency, and renewable resource deployment.

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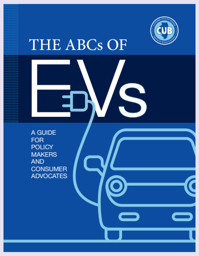
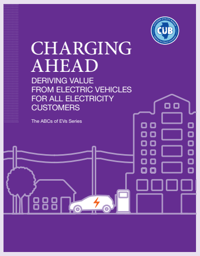
The ABCs of EVs series from the Citizens Utility Board of Illinois



Volume 1



Volume 2

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Purpose

Transportation electrification presents unique opportunities and challenges for utility customers.

According to the U.S. Department of Energy's National Renewable Energy Laboratory (NREL), electrified cars, trucks and buses could increase overall U.S. electricity usage by 38 percent by 2050, or up to 80 terawatt hours per year.[1] Failure to manage this sharp rise in demand could require a costly expansion of the electric system's delivery and generation capacity. However, the Rocky Mountain Institute found that the increased power usage needed for transportation electrification could be largely accommodated without additional power plants or grid expansion.[2]

In this paper, we use Illinois as an example to examine how electrification of a substantial share of passenger vehicles could provide tangible benefits for all electricity customers. We project the effects of state policies designed to optimize charging patterns of passenger electric vehicles (EVs), quantifying potential cost savings that will accrue not just to EV drivers, but to all utility customers, if effective charge-management strategies are put into action.[3]

We find that well-managed, or optimized, EV charging can put downward pressure on the statewide costs of energy, capacity, and delivery of electricity. Additional savings will flow to consumers when the electricity cost savings of commercial and industrial customers are reflected in lower costs of goods and services they provide. But these benefits to all electricity customers will not occur if policy makers fail to act. Given the burgeoning EV market, this report recommends that policy makers set state transportation electrification objectives, align utility and customer goals, and immediately implement initial EV charge-optimization measures.

WHAT IS OPTIMIZED CHARGING?

EVs are unique electric appliances because they store electricity for future use. Their batteries can take in energy when the vehicles are plugged in and not on the road—which is most of the time. So EVs have flexible charging needs, which open up opportunities to save money and make the electric system more efficient. "Optimized Charging" means consistently charging an EV in a manner that reduces the EV owner's electricity costs while also improving the system load shape, enhancing reliability of the grid, and maximizing utilization of clean energy.

For the customer, optimized charging is a set-it-and-forget-it experience—the only information to input is what time the vehicle will need to be fully charged. Charging is automatically throttled up and down according to system conditions and fluctuating time-based prices, to produce the lowest cost for the customer and the greatest benefit for the grid.

For example, a recent CUB analysis found that a northern Illinois EV owner taking advantage of ComEd's Hourly Pricing program and charging only overnight would save more than 50 percent on supply costs, compared with flat energy rates. Optimized charging cuts those costs further by responding to hourly fluctuations. And by using the available capacity at times of lowest demand, a vast number of EVs are charged without the cost of adding new generators or upgrading the transmission and distribution system, thus benefiting all electricity customers.

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1 Mai, T.; Jadun, P.; Logan, J.; McMillan, C.; Muratori, M.; Steinberg, D.; Vimmerstedt, L.; Jones, R.; Haley, B.; Nelson, B. Electrification Futures Study: Scenarios of Electric Technology Adoption and Power Consumption for the United States; NREL/TP-6A20-71500; National Renewable Energy Laboratory: Golden, CO, USA, 2008. Available online: https://www.nrel.gov/docs/fy18osti/71500.pdf (accessed on 17 October 2018).

2 Fitzgerald, G.; Nelder, C. From Gas to Grid: Building Charging Infrastructure to Power Electric Vehicle Demand. Rocky Mountain Institute. Available online: https://www.rmi.org/insight/from_gas_to_grid/ (accessed on 17 October 2018).

3 EV refers to any vehicle that plugs in to a source of electricity and can store electric energy to power the vehicle for some distance. These include Battery Electric Vehicles (BEV) which run on electricity only, and Plug-in hybrid vehicles (PHEV), which have sufficient range for most daily urban travel plus an auxiliary internal combustion engine to extend travel range. PHEVs are not zero-emission vehicles, but they are part of the transition to electrified transportation. EVs do not include gas-powered hybrid vehicles that do not plug in (e.g., Toyota Prius).

Executive Summary

Electric vehicles will soon be a major presence in the U.S. auto market. EV sales grew an average of 65% per year from 2011 through 2018.[4] In 2018, EV sales shot up 81%, to 361,000 units.[5] Bloomberg New Energy Finance (BNEF) and Morgan Stanley both project that most cars sold in the U.S. will be EVs by 2040.[6] NREL forecasts that by 2050 up to 79% of all light-duty vehicle miles traveled will be electric-powered.[7]

A wide range of variables will affect the pace of EV adoption over time, including the relative costs of gasoline and electricity, the cost to purchase an EV versus an internal combustion engine (ICE) vehicle, innovations in battery technology, federal and state climate policies, public charging availability, auto manufacturer strategies, and evolving consumer preferences. However, the fact that the life-cycle costs of EV ownership and operation are in some cases already comparable to similar ICE vehicles indicates mass market adoption could follow the path of other innovations that rapidly displaced earlier technologies, such as color television, DVDs and smartphones.[8]

The debate surrounding transportation electrification is beginning to focus on the details of how to maximize the value of EVs, even for those who don't drive them, and how to minimize any system costs associated with EV charging. However, some utility EV programs have assumed that EVs will automatically be charged when it is best for the grid and have not included the means to ensure this outcome. And key policy decisions have often been put off under the misconception that no urgency exists in this early stage of EV market development.

In *The ABCs of EVs: A Guide for Policy Makers and Consumer Advocates*, the Citizens Utility Board (CUB) outlined a set of principles to advance public interest goals.[9] A growing number of stakeholders representing interests that often diverge on utility policy have coalesced around similar principles.[10] The importance of well-managed charging is now acknowledged by a broad cross section of utility leaders, auto manufacturers, environmental groups, consumer advocates, and industry trade associations.[11]

4 https://insideevs.com/monthly-plug-in-sales-scorecard/.

5 *Ibid*.

6 Bloomberg New Energy Finance, *Electric Vehicle Outlook 2018)*, https://about.bnef.com/electric-vehicle-outlook/; Fred Lambert, *Electric Vehicle Sales to Surpass Gas-Powered Cars by 2040*, Says New Report, Electrek (May 5, 2017), https://electrek.co/2017/05/05/electric-vehicle-sales-vs-gas-2040/ (quoting the Morgan Stanley report).

7 https://www.nrel.gov/docs/fy18osti/71500.pdf.

8 Analysts including BNEF (https://about.bnef.com/electric-vehicle-outlook/ and https://data.bloomberglp.com/bnef/sites/14/2017/06/BNEF_2017_04_12_EV-Price-Parity-Report.pdf) and JP Morgan (https://www.jpmorgan.com/global/research/electric-vehicles) forecast that declining battery costs will bring EV "sticker prices" to parity with ICE vehicles in 2024. Meanwhile, fuel savings of seven cents per mile would amount to $10,500 over a typical 150,000 mile vehicle lifetime, making lower-cost EVs already cost competitive. Plug-In America estimates typical fuel savings of $860/year at very low gasoline rates (https://pluginamerica.org/how-much-does-it-cost-charge-electric-car/).

9 Martin R. Cohen et al., Citizens Utility Board., *The ABCs of EVs: A Guide for Policy Makers and Consumer Advocates* (2017), https://citizensutilityboard.org/wp-content/uploads/2017/04/2017_The-ABCs-of-EVs-Report.pdf.

10 See, for example, the Transportation Electrification Accord (TEA) at TheEvAccord.com, in particular principle #7: "The build out of EVSE must optimize charging patterns to improve system load shape, reduce local load pockets, facilitate the integration of renewable energy resources, and maximize grid value." Signatories to the Accord include: GM, Lyft, Honda, NRDC, the Edison Electric Institute, Consumer Reports, and the Southern Company. Also see the resolution passed by the National Association of State Utility Consumer Advocates (NASUCA) at its 2018 Annual Meeting: http://nasuca.org/nwp/wp-content/uploads/2017/08/2018-02-Protection-for-Ratepayers-as-EV-Adpotion-Rates-Increase-Final-6-24-18.pdf.

11 See https://www.theevaccord.com/.

Building on *The ABCs of EVs*, and focusing on the projected electricity usage of passenger EVs in Illinois, this follow-up report seeks to advance the discussion by quantifying the cost effects of unmanaged versus optimized charging.[12] After analyzing the effects on electricity loads of different EV market penetration scenarios, we calculate the associated incremental delivery service revenue, and we recommend specific state policies to optimize EV charging patterns to benefit not only EV drivers, but also the distribution system and all those connected to it.

> Optimizing charging patterns could produce up to $2.6 billion in cumulative consumer benefits through 2030.

FORECASTING THE BENEFITS OF OPTIMIZED EV CHARGING

Given the uncertain EV growth trajectory, we have modeled three adoption scenarios for this report. Starting from approximately 15,000 EVs today, the slow-growth case estimates that 131,000 EVs would be on Illinois roads by 2030. Under the “Market Expansion” scenario, EV adoption accelerates to 690,000 vehicles by 2030, driven largely by market forces and EV-supportive state policies. The “Decarbonization Path” posits aggressive public policy to decarbonize the transportation sector, resulting in 2.2 million EVs in Illinois by 2030—25% of all light-duty vehicles on the road.

This report includes:

- Potential EV growth scenarios in Illinois from 2019 to 2030.
- Associated charging load growth projections.
- Projections of consumer electricity costs under EV growth scenarios, with and without optimized charging, including:
  ~ Wholesale market energy price effects.
  ~ Capacity market effects.
  ~ Utility delivery service (distribution) rate effects.
- Recommendations of initial policies to optimize EV charging and support EV growth.

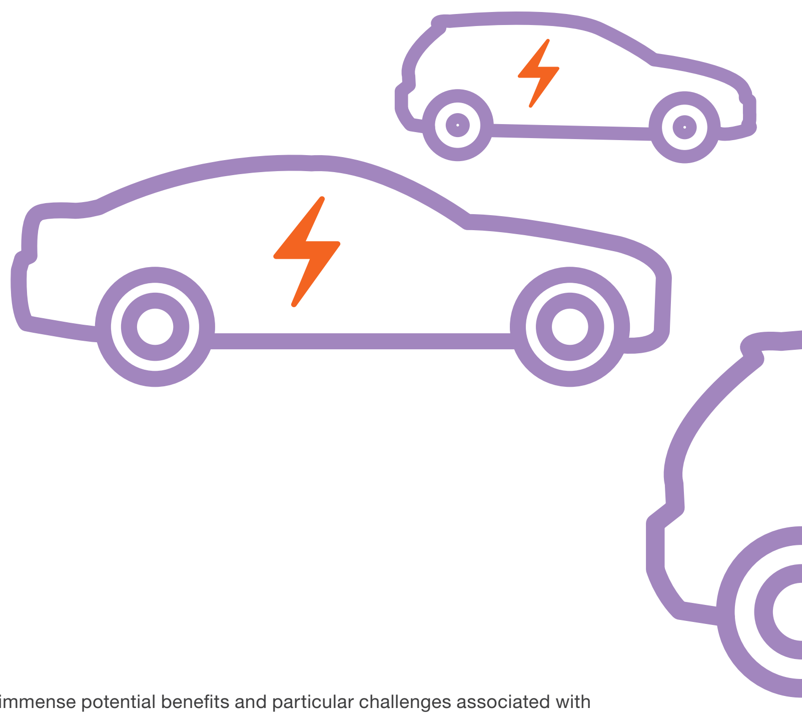
CHIEF FINDINGS

1. Optimizing charging patterns could produce up to $2.6 billion in cumulative consumer benefits through 2030.[13]

These savings accrue from three factors:

- Lower wholesale market energy prices resulting from optimized charging, as compared to unmanaged charging, total as much as $2 billion for the period, according to an analysis performed by Gabel Associates and commissioned by CUB.
- Capacity cost reductions projected by CUB total as much as $124 million.
- An increase in delivery service revenue to ComEd and Ameren Illinois of up to $193 million per year from charging by EV drivers would reduce the volumetric components of residential distribution rates by up to 12%.

Utilizing existing infrastructure for EV charging would put downward pressure on electricity costs for energy, capacity, and delivery service. Conversely, deep EV penetration without effective charge-management could lead to costly delivery system upgrades. These potential additional costs are not quantified in this analysis but could add substantially to the system benefits of optimized charging.



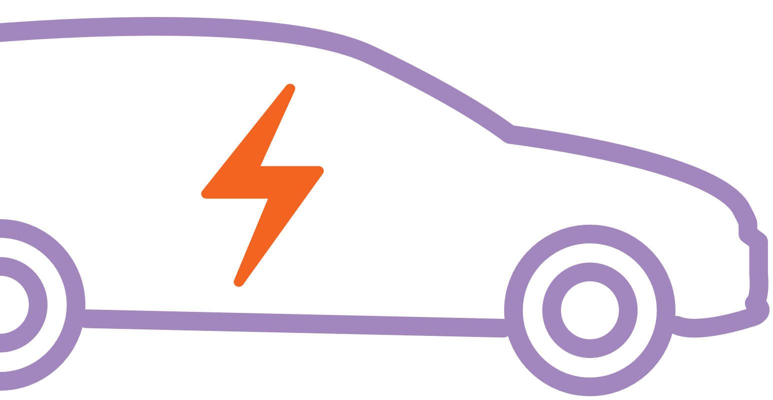
12 This report focuses on passenger vehicles—cars and light-duty trucks. The immense potential benefits and particular challenges associated with electrification of heavy-duty trucks, buses, and industrial mobility equipment (such as forklifts) and even airplanes are subjects for a future CUB report.

13 Average estimated assuming residential class usage of 31% of total, and including only energy market and capacity effects, as total distribution costs per household would not be affected.

2. Consumer savings are contingent on complementary action by state policy makers.
The interregnum between today's small but rapidly growing EV market—which has not yet had significant impact on electricity system dynamics—and robust EV adoption provides state policy makers an opportunity to design and implement strategies to support EV growth and ensure that deeper penetration levels mean greater benefits to all electricity customers.

Regulatory priority should be given to measures that can be quickly implemented by utilities and achieve the "biggest bang for the buck," including:

- **Time-Variant EV-Only Charging Rates.** Time-variant EV rates should be designed to provide powerful and easily understood incentives for charging at times of ample system capacity. A CUB study found that EV drivers would have saved 52% on the energy component of charging costs during 2016 and 2017 had they charged their car at optimal times under ComEd's Hourly Pricing program instead of at the default flat rate.[14] As detailed later, current 2019 market prices would deliver typical variable energy cost savings of 41% for overnight charging.
- **Default Opt-out for EV Owners.** Because well-designed charging rates would save money for both EV drivers and all other customers, we recommend that they be provided by the utility on an opt-out basis when an EV is acquired. However, an additional utility meter is not necessary to measure charging usage. The EV portion of household usage can be determined through the vehicle charger, or through a module that communicates with the smart meter, or by analyzing usage with disaggregation software.



Innovative measures intended to increase EV adoption and ensure their benefits reach all communities, including low-income areas, should be at the core of a comprehensive state EV strategy. In this report we focus primarily on methods to optimize charging and quantification of their projected benefits, as well as recommendations for initial EV policies and suggestions for a decisional framework to guide EV policy development.

Additional state policies and initiatives to support EV growth and optimize charging patterns include:

- Managed-charging pilot program to respond to changing system conditions.
- Evaluation of barriers to public charging and potential of public charge station pilots.
- Development of online tools to enable automatic customer charging response.
- Consumer education and communication.
- Initiatives to bring EV benefits to low and moderate-income areas.
- Performance-based incentives to align with policy objectives.

3. Regulatory clarity is needed.
State public utility regulators generally have authority to undertake measures to support EV growth that would enhance system efficiency and reliability. But the law may not be clear on the role of regulators in taking environmental consequences into account. For example, Illinois regulators are charged with reducing the environmental impact of power generation, yet the primary emissions reductions from EVs occur in the transportation sector, which is not under the jurisdiction of the Illinois Commerce Commission. Adding a legislative directive to include generally reduced pollution and carbon dioxide emissions as objectives of public utility regulation could open up additional avenues for EV-supportive policy. The Illinois General Assembly also could enact specific EV measures directly. Given the many benefits of transportation electrification, state funding through appropriation or capital programs should be a legislative priority.

14 Zethmayr, J.; Kolata, D. Charge for Less: An Analysis of Hourly Electricity Pricing for Electric Vehicles. World Electr. Veh. J. 2019, 10, 6.

The Growth of Electric Vehicles Fuels a Synergy of Public Benefits

The potential benefits of transportation electrification flow in many directions: to the environment, the EV owner/driver, the local economy, and to the electric system and all its users, if charging occurs when optimal for the grid.

BENEFITS TO THE ELECTRICITY SYSTEM

Because the utility's transmission and distribution system must be sized to accommodate peak demand, high volumes of EV charging at times of slack demand can be accommodated with little or no increase in utility delivery costs. By soaking up excess power and wire capacity in off-peak periods and spreading the cost of the grid over a higher volume of sales, EV loads can make the system more efficient and put downward pressure on electricity rates. The flexibility of EV charging also can be an asset to the electricity system as a grid-management resource used to balance loads. Eventually, EVs could be aggregated for ancillary grid services, including frequency regulation, spinning reserves, and voltage support. Using bi-directional electricity flows, the storage capacity of plugged-in EVs could offer enhanced grid support through vehicle-to-grid (V2G) applications.

The fortuitous confluence of system, environmental and consumer value from transportation electrification is why EVs appear to be the future of the automobile industry. But because EVs today have higher upfront costs than ICE vehicles and public charge facilities remain scarce, market forces need supportive public policy for their enormous potential benefits to be realized.

BENEFITS TO EV DRIVERS

It costs far less to operate an EV than a comparable ICE vehicle. Calculated using the national average residential retail electricity rate of 12.89 cents per kilowatt-hour (kWh), the cost to drive a typical personal EV that travels 3.57 miles per kWh comes to 3.61 cents per mile.[15 16] An ICE vehicle getting 30 MPG and paying $3 per gallon of gas costs 10 cents per mile. In other words, fueling an EV at the average electric rate is equivalent to paying $1.08 per gallon of gas.[17] However, the cost of electricity to charge an EV is less than the average cost per kWh because the average includes a fixed monthly fee for electric service that does not vary with usage. Therefore, the incremental cost of EV charging is equivalent to less than $1 per gallon, and as we demonstrate, the cost of fueling an EV can be cut further through time-variant electricity rates. For example, in Illinois, charging under time-variant rates brings today's cost down to an equivalent of about 60 cents per gallon.

EV drivers also benefit from low maintenance costs, as electric motors have few moving parts, no radiator, alternator, water pump or transmission; no oil changes, spark plugs, or tune-ups; and electric motors can last for hundreds of thousands of miles. Even the brakes on an EV last far longer because regenerative braking transfers part of the energy back into the battery instead of into the brake pads as heat and friction. Plugging in at home is more convenient than filling up at a gas station—and the lack of noise or fumes is another bonus for EV drivers. Finally, the performance of EVs is generally superior to ICE vehicles, with instant torque for quick acceleration and a vibration-free ride. EVs also are better for the economy of states like Illinois because the dollars spent on electricity circulate primarily in the local region, rather than being diverted to oil companies and foreign governments.

Today, most car buyers remain unfamiliar with EVs and are likely deterred from acquiring one by their higher upfront costs and potential concerns about

15 See 2017 U.S. EIA Electricity Annual Report: https://www.eia.gov/electricity/annual/pdf/epa.pdf.

16 EV efficiency varies between models. A Tesla Model 3 travels 3.94 miles per kWh and a Model S 3.31 miles, a Chevy Bolt travels 3.97 miles and a Nissan Leaf 3.95 miles. The most efficient EV currently sold in the U.S. is the Hyundai Ioniq at 4.46 miles per kWh. See chart at: https://cleantechnica.com/2018/06/30/what-are-the-most-efficient-electric-cars/ For this report, we assume 3.57 miles per kWh as the average EV efficiency, based on the average of the three top selling EVs. EV range drops significantly in extremely cold weather.

17 The Illinois average residential all-in electricity cost is calculated by EIA at 12.95 cents, approximately equal to the national average.

their driving range. But EV range is increasing as battery technology advances, vehicle efficiency improves and costs decline, making EVs increasingly attractive to broader segments of the car market. However, absent supportive public policy, these trends may take a long time to bring EVs to the tipping point of mass market adoption. Eventually it may be as easy and quick to "fill up the tank" with electricity as with gasoline, but fast charging is not yet widely available. Investments in charging infrastructure, public education, and market stimulation all can accelerate transportation electrification, but the costs and projected benefits of public and utility spending must be carefully evaluated. These important subjects will be addressed in future CUB reports. Here we focus primarily on charge-management as a tool to reduce EV operating costs and amplify system benefits.

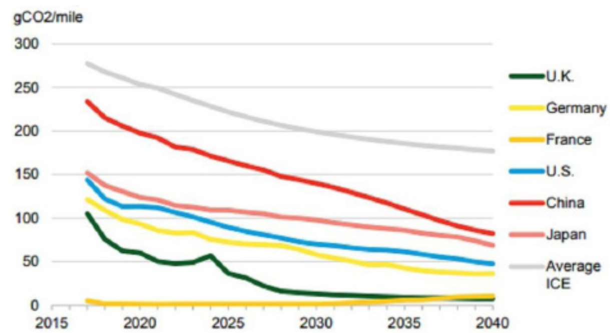
ENVIRONMENTAL BENEFITS

Transportation electrification is an essential part of any climate strategy, as emissions from ICE vehicles have surpassed power plants to become the nation's largest source of climate change pollution, responsible for 28.5% of U.S. greenhouse gas emissions.[18] Electric transportation is also better for the environment because a long list of additional tailpipe air pollutants produced by gasoline combustion are not emitted by EVs.

Addressing the carbon problem is ever more urgent, as evidenced by the effects of global warming already being felt, and the impending climate catastrophe if present trends continue, according to the latest forecast by the United State Climate Change Assessment, a quadrennial assessment by 13 federal agencies.[19] The environmental advantage of transportation electrification is growing as the proportion of fossil-fueled electricity shrinks. Electricity produced by burning coal dropped from 51.7% of U.S. generation in 2000 to 29.9% in 2017, while generation from renewable resources, primarily hydro, wind, and solar, increased from 9.4% to 17%.[20]

The Energy Information Administration (EIA) forecasts these trends to continue, with renewable generation reaching 23% of U.S. electricity generation by 2030.[21] As shown in Figure A, reduced emissions associated with EV charging is a global trend that is anticipated to continue in coming decades.

Figure A: Forecast grid-related emissions from the operation of battery electric vehicles



Source: BloombergNEF New Energy Outlook 2018. Note: The average ICE CO2 emissions are sales-weighted across all six countries.

The scale of emissions associated with EV operation depends on the mix of resources used to generate electricity, which varies by state and region. Overnight EV charging, when total electricity demand is low and wind power production is high, produces both the lowest energy costs and the highest emissions reductions. Even in coal-dominated power systems, emissions from powering a car with electricity are less than those from gasoline.[22]

The electric energy flowing to ComEd in northern Illinois, through the Regional Transmission Organization (RTO) called PJM Interconnection, is 59% carbon-free and 68% non-coal.[23] For Ameren Illinois' RTO, called MISO, generation is 30% carbon-free and 53% non-coal.[24] A study by MJ Bradley and Associates projects EV growth in Illinois could reduce net annual greenhouse gas emissions by up to 7.7 million metric tons in 2050, with a cumulative monetized social value estimated at $5.6 billion.[25]

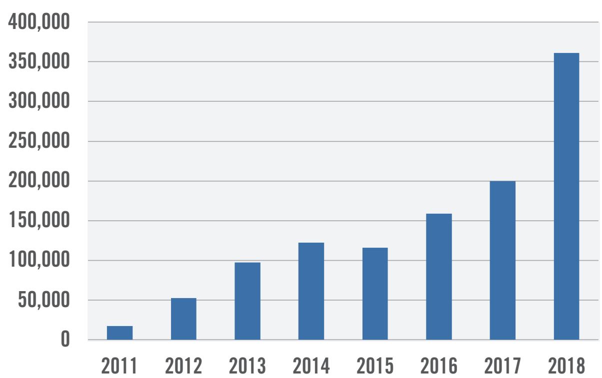
18 See EPA data: https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions. Transportation is now the largest source of carbon emissions in Illinois as well.
19 https://www.globalchange.gov/nca4.
20 See: https://www.eia.gov/tools/faqs/faq.php?id=427&t=3 and https://www.eia.gov/totalenergy/data/annual/archive/038400.pdf.
21 https://www.eia.gov/outlooks/aeo/data/browser/#/?id=8-AEO2018&region=0-0&cases=ref2018&start=2016&end=2050&f=Q&linechart=&sourcekey=0.
22 See: https://www.ucsusa.org/sites/default/files/attach/2015/11/Cleaner-Cars-from-Cradle-to-Grave-full-report.pdf.
23 https://www.comed.com/SiteCollectionDocuments/SafetyCommunity/Disclosure/Environmental_Disclosure_12_months_Ending_03312018.pdf.
24 https://q9u5x5a2.ssl.hwcdn.net/-/Media/Illinois-Site/Files/electricchoice/Sources-Of-Supply/EnvDisJan2019.pdf?la=en.
25 https://mjbradley.com/sites/default/files/IL%20PEV%20CB%20Analysis%20FINAL%2026sep17.pdf.

Forecasting EV Mass Market Adoption

Automakers are ramping up EV manufacturing capacity. By 2022, Nissan intends to sell one million new EVs and hybrids annually, and Volkswagen—the world's largest auto company—has announced plans to offer 50 electric models by 2025 and phase out ICE vehicles soon thereafter.[26] General Motors—the largest American automaker—plans to offer at least 20 new EV models by 2023.[27] Ford intends to bring 13 new EV models to market by the end of 2022.[28] The world's largest EV market is in China, where 60% of all EVs are manufactured and sales may exceed 2 million vehicles in 2019.[29]

All told, Bloomberg New Energy Finance (BNEF) anticipates 289 EV models to be marketed by the end of 2020.[30] In the second half of 2018, the highest-selling vehicle of any kind (by revenue) in the U.S. was the Tesla Model 3, with far higher unit sales than any other luxury brand, and more than half of all U.S. EV sales.[31] Total EV market penetration reached 6.6% of new passenger car sales in 2018, a one-year increase of more than 80%.[32]

Figure B: U.S. EV Sales



Inside EVs, "Monthly Plug-In EV Sales Scorecard". https://insideevs.com/monthly-plug-in-sales-scorecard/ (accessed 2/27/2019).

The pace and depth of EV penetration of the auto market will depend on many factors, including the extension of EV range, falling purchase prices, the variety of models available and promoted, the relative prices of gasoline and electricity, battery technology innovations, federal and state climate policies, market evolution, public charger availability, and evolving consumer preferences.

Because EV growth vectors are subject to significant uncertainty, we have modeled three scenarios for projecting the range of market penetration in Illinois:

- **Base Case**. The business-as-usual trajectory assumes that the EV market grows modestly over the coming decade, from 15,000 in Illinois today to 131,000 EVs on Illinois roads by 2030. It applies projections for year-over-year growth in EV sales from the U.S. Energy Information Administration's 2018 Annual Energy Outlook to annual EV sales in Illinois, linking changes in EV stock to conservative expert predictions for the national EV market.[33]
- **Market Expansion Case**. This EV adoption trajectory assumes compound annual sales growth averaging 44.8%, resulting in total EV stock of 690,000 vehicles by 2030, or almost 8% of all light-duty vehicles. This is a reasonable projection given Illinois' primarily urban and suburban population with relatively high income levels, growing focus on environmental policy and surging EV market.

26 See: https://www.eenews.net/stories/1060110789 and James Ayre, *Nissan Aiming for 1 Million EV & Series-Hybrid Sales a Year by 2022*, Clean Technica (Mar. 23, 2018), https://cleantechnica.com/2018/03/23/nissan-aiming-1-million-ev-series-hybrid-sales-year-2022/. http://infinitinews.com/en-US/infiniti/usa/channels/Sales-Reports-Infiniti-US/releases/infiniti-reports-all-time-u-s-annual-record-sales.

27 Press Release, Gen. Motors, *GM Outlines All-Electric Path to Zero Emissions* (Oct. 2, 2017), http://media.gm.com/media/us/en/gm/news.detail.html/content/Pages/news/us/en/2017/oct/1002-electric.html.

28 Michael Martinez, *Ford to Expand EV Offerings*, Automotive News (Oct. 2, 2017), http://www.autonews.com/article/20171002/OEM05/171009948/ford-to-increase-its-fully-electric-vehicle-offerings.

29 See: https://about.bnef.com/blog/bullard-dispelling-myths-chinas-ev-market/ and https://cleantechnica.com/2019/02/24/china-ev-forecast-50-ev-market-share-by-2025-part-2-consumer-demand/.

30 See: https://bnef.turtl.co/story/evo2018?teaser=true.

31 https://electrek.co/2019/01/02/tesla-record-deliveries-production-q4/.

32 EV sales totaled 2% of all light-duty U.S. vehicles sold in 2018, including pickup trucks and SUVs. See: https://insideevs.com/monthly-plug-in-sales-scorecard/ and https://www.marklines.com/en/statistics/flash_sales/salesfig_usa_2018.

33 U.S. Energy Info. Admin., *Annual Energy Outlook* 115–16 (2018), https://www.eia.gov/outlooks/aeo/pdf/AEO2018.pdf.

SHOULD EV ACQUISITION BE STATE SUPPORTED?

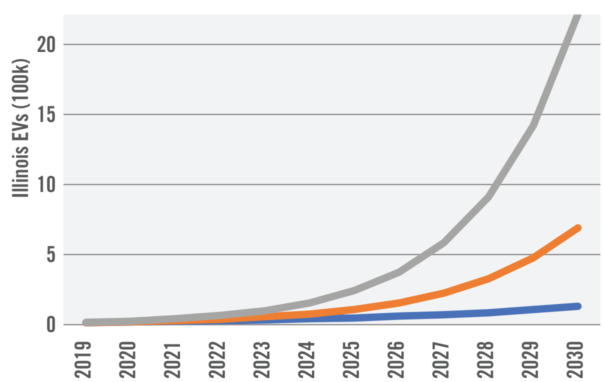
Seven states and several utilities provide financial incentives to reduce the cost of buying an EV. Market data through 2017 suggest that each $1,000 of state incentives corresponds to a 2.6% increase in EV sales. State incentives may be even more important to EV proliferation as the federal tax credit begins to phase out after a manufacturer reaches 200,000 EV unit sales. (Tesla and General Motors have already reached that milestone). The most effective way to boost EV sales is through instant incentives when the vehicle is acquired. Instead of an incentive provided many months later through a tax rebate, an immediate point-of-sale discount reduces the initial purchase price and therefore means lower monthly financing charges, a key measure of vehicle affordability. Rebates large enough to significantly affect EV penetration are expensive programs and must be carefully evaluated and authorized by statute.

- **Decarbonization Path**. If public policy targets carbon fuels for substantial reduction, fast public charging becomes widely available, and initial purchase costs of EVs reach anticipated parity with ICE vehicles, EVs may quickly displace outdated technology. Under this deep-penetration trajectory, 25% of all cars would be EVs by 2030, achieving the amount of vehicle electrification calculated by climate experts to be necessary in this timeframe to put carbon emissions on a path to acceptable levels. The number of EVs is higher than most current forecasts but not out of line with the performance of other disruptive new technologies that reached a market "tipping point."

Table 1: Total Illinois EVs

	Market Expansion		Decarbonization Path	
Year	Total EVs	EV Consumption (MWh)	Total EVs	EV Consumption (MWh)
2019	14,538	39,374	16,860	43,246
2020	19,921	53,677	26,268	67,535
2021	27,717	74,076	40,928	104,982
2022	38,745	103,368	63,768	163,567
2023	54,301	144,731	99,353	254,847
2024	76,510	204,006	154,798	397,978
2025	108,961	288,688	241,184	618,651
2026	156,893	413,997	375,778	963,893
2027	226,462	597,033	585,483	1,501,798
2028	326,630	863,394	912,216	2,345,261
2029	475,058	1,248,937	1,421,283	3,645,673
2030	690,039	1,814,988	2,214,439	5,680,162

Figure C: EV Adoption Scenarios



Inside EVs, "Monthly Plug-In EV Sales Scorecard". https://insideevs.com/monthly-plug-in-sales-scorecard/ (accessed 2/27/2019).

These EV adoption scenarios are not exact predictions of what will unfold in the automobile market, but they are used to demonstrate outcomes under different growth assumptions. As depicted in the table on this page, the difference among these adoption scenarios reflects the potential impact of forceful EV-supportive public policies as well as continuing technology innovation and market development.

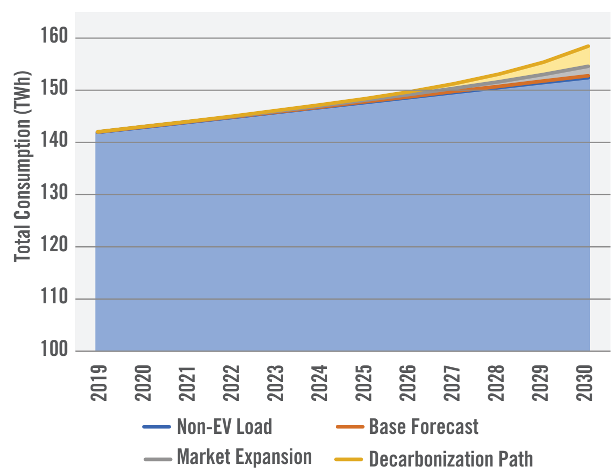
EV Growth Will Boost Electricity Consumption

Electricity suppliers, grid operators and utility customers will all be affected by the scale of additional load from EV charging. A personal EV driven an average of 30 miles per day would travel 10,950 miles annually and consume 3,066 kilowatt-hours (kWh),[34] adding 37 percent to the 8,304 kWh of annual electricity consumption of an average Illinois household (assuming all home charging).[35]

EV load can be accommodated without substantial investment in electricity system upgrades if effective charge-management strategies are employed.

Under the range of projected growth scenarios, EVs in Illinois would consume as much as 5.6 million megawatt-hours (MWh) of electricity in 2030. This new load would remain a relatively small portion of Illinois electricity consumption, projected to be about 158 million MWh in 2030. Figure D shows projected EV energy consumption in Illinois relative to total electricity consumption from 2019 through 2030. Under the Decarbonization Path scenario, EV energy consumption would not rise above 5% of overall Illinois electricity usage, although it could have significant impact on consumer costs, depending on charging patterns. As we will discuss, EV load can be accommodated without substantial investment in electricity system upgrades if effective charge-management strategies are employed.

Figure D: Illinois Load Projections - Total Consumption



34 Assuming 3.57 miles/kWh, the average rating of today's Tesla Model S, Chevy Bolt and Nissan Leaf.
35 Data from EIA and ICC.

WHO WILL BE THE SOURCES OF EV EDUCATION AND OUTREACH?

Utility customers, car shoppers, and even car dealers by and large do not yet understand the unique characteristics and value of EVs. Because of their low maintenance requirements, which challenge the service-based dealer business model, car dealers may need to revise their business strategies to thrive as EVs emerge, and both sides of an EV transaction would benefit from better information at the dealership. Communication modes could include kiosks and brochures explaining EVs and detailing the savings from time-of-use (TOU) rate plans and available EV support programs, or opportunities for utilities or state programs to connect interested customers with proactive dealers. In addition to online tools and comparison apps, utilities can proactively engage customers by expanding the range of EV information they provide, as ComEd has begun to do on its website. Customer-trusted third parties could be enlisted to help bring accurate and digestible information to diverse communities.

EV Load Will Reduce Distribution Rates for All Residential Customers

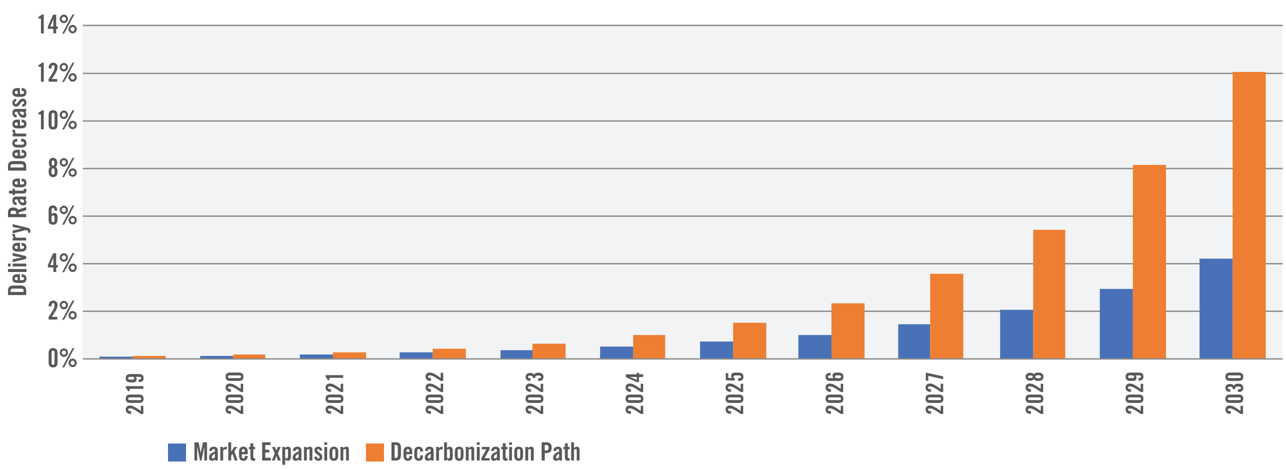
Illinois has a "restructured" electricity market, in which utility companies do not own power plants and all electricity supply is sourced from competitive wholesale and retail power markets. Utilities distribute that power to customers and recover their costs through regulated rates for delivery service. Under current rate design for ComEd, which serves 70% of the state's electricity customers, residential customers pay an average of 3.34 cents per kWh in volumetric delivery charges, in addition to fixed monthly charges.[36] For Ameren Illinois, these volumetric delivery service charges average 3.51 cents per kWh.

At current rates, a typical EV driver in Illinois would pay $105 per year in per-kWh utility charges (in addition to monthly fixed fees and the market-based costs of electric energy and capacity). Electricity consumption by EVs in Illinois would total approximately 5.85 million MWh through 2030 under the Market Expansion scenario, resulting in $198 million in additional utility delivery service revenue (at current rates). Under the Decarbonization Path, consumption through 2030 would total 15.8 million MWh, with utility revenue amounting to $536 million, as detailed in Table 5 (see page 16).

This new revenue would put downward pressure on rates paid by all residential customers, provided that EV charging can be accommodated using the surplus capacity of the distribution system that exists most hours of the day. As depicted in Figure E, under the Market Expansion scenario, revenue from EV charging would lower the volumetric component of residential distribution rates (from what they would be otherwise) by an average of 4.2% in 2030. Under the Decarbonization Path scenario, the potential volumetric rate suppression rises to 12%.[37]

As we will discuss next, market energy prices paid by all customers can also benefit from optimized charging, with statewide customer savings potentially far larger than those projected for delivery services.

Figure E: Distribution Benefits from Optimized EV Charging



36 Rates of residential customers in Illinois vary among four subclasses, depending on type of dwelling unit and whether or not electricity provides the primary heat source.

37 Calculations based on per-kWh volumetric distribution charges projected to total approximately $1.41 billion in 2030 for combined ComEd and Ameren Illinois residential customers.

Optimized EV Charging Patterns Are Projected to Generate Large Energy Cost Savings for Consumers

The effect of EV charging load on distribution systems is distinct from its effects on power generation dynamics and wholesale market prices. As a result, in order to capture both distribution and market price impacts for this study, CUB commissioned an analysis by Gabel Associates, an expert in the dynamics of power markets, to project the long-term effects of EV charging scenarios on wholesale energy prices.

Gabel conducted comprehensive energy market simulations for the period 2019-2030 using the AURORA Energy Market Model to estimate price effects of optimized versus unmanaged home charging patterns.[38] AURORA simulates operation of the physical grid and resulting wholesale market real-time prices under specified load and cost inputs, employing a transmission-constrained dispatch logic to simulate economic dispatch of existing and projected generators under real market conditions. Gabel's Illinois analysis used the following simplified charging patterns:

- Unmanaged Charging assumes all EV charging occurs between 6 PM and 9 PM, when drivers plug them in after returning from work and other activities.

- Optimized Charging assumes all EV charging occurs between 12 AM and 6 AM.

While home EV charging would not precisely follow these patterns, they were modeled to show the effects of these reasonably anticipated charging patterns on market prices. Under the unmanaged charging pattern, EV load occurs during three primarily on-peak hours, resulting in slightly higher wholesale energy prices than without the EV load. The optimized charging pattern spreads the same load over six off-peak hours, which results in slightly lower wholesale energy prices.

Why does optimized charging reduce market energy prices, whereas unmanaged charging increases them? These price effects occur because higher demand during peak periods results in operation of additional generators with higher operating costs to serve the additional load. Higher demand in off-peak periods of ample capacity results in greater utilization of generators that have already been dispatched or are almost always operating, such as wind turbines and nuclear plants. Increased production from a generator will produce a lower average total cost per megawatt-hour (MWh) because its fixed costs can be spread over more output.

Under any EV adoption scenario, all electricity customers see lower power costs when EVs charge in periods of low electricity demand.

If significant charging were to occur during system peak hours such as weekday mid-afternoons, the result would be higher market prices than under these modeled charging patterns. Importantly, under any EV adoption scenario, all electricity customers see lower power costs when EVs charge in periods of low electricity demand.

While the initial effect of EV charging on power prices is small, as EV penetration rises, the effect becomes significant. As shown in Table 2, under the Market Expansion Scenario, in 2030 optimized charging causes average market prices to fall by 19.6 cents per MWh, whereas unmanaged charging results in an increase of 11.0 cents per MWh, a net difference of 30.6 cents. Larger charging loads under the

38 The AURORA model was developed by EPIS, Inc. to simulate the hourly commitment, dispatch and operation of all generators.

Figure F: Energy Costs Under Market Expansion Scenario

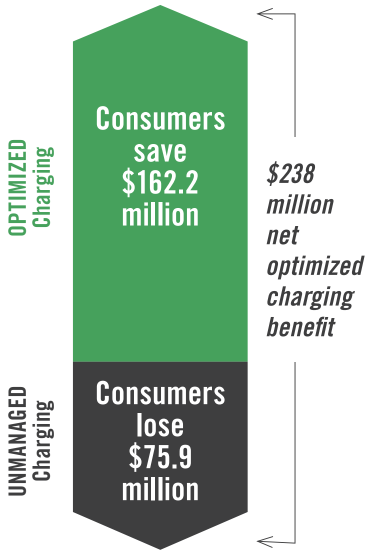


Table 2: Market Price Effects and Net Consumer Costs: Market Expansion Scenario

Year	Base Price Forecast	Unmanaged Charging	Optimized Charging	Unmanaged Charging Costs	Optimized Charging Costs
2019	31.854	0.012	-0.018	1,763,140	(2,494,746)
2020	32.526	0.006	-0.021	893,682	(3,059,106)
2021	33.534	0.014	-0.011	1,995,177	(1,652,191)
2022	34.297	0.009	-0.050	1,307,116	(7,248,099)
2023	42.620	0.026	-0.039	3,821,216	(5,734,656)
2024	44.275	0.042	-0.083	6,231,987	(12,130,391)
2025	47.054	0.033	-0.065	4,879,898	(9,608,306)
2026	49.707	0.056	-0.087	8,372,313	(12,956,442)
2027	52.097	0.048	-0.158	7,150,286	(23,791,121)
2028	53.737	0.076	-0.160	11,465,675	(24,169,189)
2029	56.324	0.073	-0.191	11,097,317	(29,213,659)
2030	58.960	0.110	-0.196	16,967,717	(30,150,360)
			Total	**75,945,524**	**(162,208,265)**

Figure G: Energy Costs Under Decarbonization Path Scenario

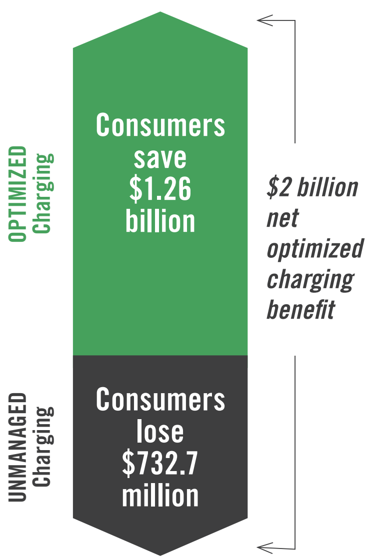


Table 3: Market Price Effects and Net Consumer Costs: Decarbonization Path Scenario

Year	Base Price Forecast	Unmanaged Charging	Optimized Charging	Unmanaged Charging Costs	Optimized Charging Costs
2019	31.854	0.077	-0.076	10,914,570	(10,845,356)
2020	32.526	0.111	-0.241	15,965,092	(34,636,512)
2021	33.534	0.140	-0.246	20,365,251	(35,663,104)
2022	34.297	0.200	-0.391	29,405,215	(57,305,510)
2023	42.620	0.371	-0.584	54,983,001	(86,490,798)
2024	44.275	0.450	-0.824	67,349,244	(123,430,803)
2025	47.054	0.413	-0.808	62,488,110	(122,312,461)
2026	49.707	0.453	-0.925	69,284,796	(141,449,642)
2027	52.097	0.522	-0.956	80,631,036	(147,563,651)
2028	53.737	0.620	-0.996	96,692,619	(155,360,203)
2029	56.324	0.630	-1.081	99,393,357	(170,412,637)
2030	58.960	0.786	-1.097	125,225,210	(174,754,838)
			Total	**732,697,501**	**(1,260,225,517)**

Decarbonization Path amplify these effects to market price suppression of $1.097 per MWh under optimized charging versus 78.6 cents per MWh in higher prices from unmanaged charging, a net difference of almost $1.88 per MWh (Table 3). The impact on Illinois electricity costs of this differential is sizable because the price effects apply to all energy sold in the relevant market and the effects are felt by every residential, commercial and industrial customer in the state.

When applied to projected Illinois electricity consumption through 2030, the cumulative effect of unmanaged charging amounts to $76 million in higher energy costs, compared to $162 million in potential savings from optimized charging, a $238 million difference under the Market Expansion scenario.[39] In the Decarbonization Path scenario, the cumulative cost of higher prices from unmanaged charging totals $733 million, while the cumulative savings from optimized charging amount to $1.26 billion, for a nearly $2 billion dollar projected net cost differential between these charging patterns. Market energy prices fluctuate based on variables including fuel prices, technology development, changes in demand, plant construction and retirement, carbon emission policies and other regulatory and market factors; however, the relative cost differential between EV charging scenarios would persist under any price forecast.

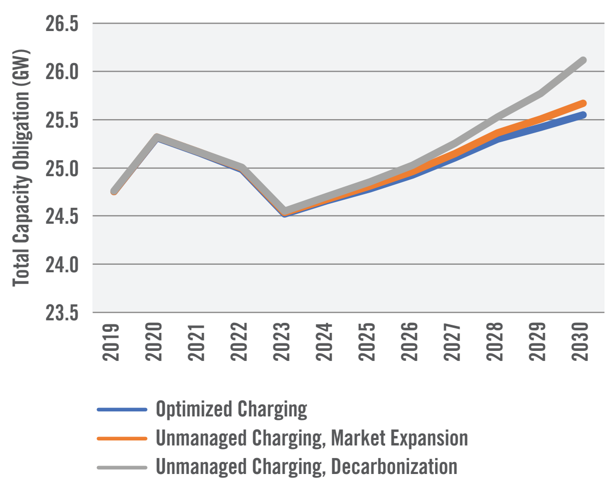
EV LOADS WILL AFFECT CAPACITY COSTS

All public utilities and other power suppliers (known as load-serving entities or LSEs) are required to purchase generating capacity commitments sufficient to meet the combined peak load of their customers plus a reserve margin. In PJM, generators bid in annual auctions held three years in advance of capacity commitments and LSEs all must buy their proportional share of capacity at the auction clearing price. Capacity prices have risen substantially in recent years and have become a large revenue source for power plant owners, now amounting to more than 20% of the average total cost of electricity supply.

The capacity market will be affected by EV load growth. Depending on when EVs charge, higher demand would mean higher capacity charges. Off-peak EV charging would not increase capacity requirements, while unmanaged charging would lead to a need for more contracted capacity, potentially higher auction prices, and increased costs to consumers. To estimate the potential impact of EV charging on capacity costs paid by Illinois consumers, we project capacity obligations for ComEd and Ameren Illinois through 2030, and then simulate the additional capacity obligations that would result from unmanaged charging of additional EVs under the adoption scenarios.

As a member of PJM, ComEd procures capacity through that RTO's auction process, known as the Reliability Pricing Model (RPM). An LSE's capacity obligation is based on its coincident peak, calculated as the LSE's average load during the five PJM system peak hours, which typically occur during summer weekday afternoons. For this analysis, we simulate the month and hour of five summer peaks for each year according to the frequency that recent PJM peaks have occurred during those times, and we calculate the average of the projected EV charging load during those hours under each growth scenario. The result is added to PJM's base projection for ComEd's capacity obligation.[40] Figure H compares the annual capacity obligations resulting from unmanaged versus optimized charging under the Market Expansion and Decarbonization Path adoption scenarios.

Figure H: Projected ComEd Capacity Obligations



Without optimized charging, this additional charging load increases the capacity obligation and the charges that must be recovered on customers' supply bills. The cost of the additional capacity is projected based on a cost of $190 per megawatt-day, the price paid by ComEd customers in the most recent PJM auction.

Ameren Illinois belongs to MISO and procures capacity through that RTO's annual auction. MISO calculates a Planning Reserve Margin Requirement (PRMR) for each zone of the RTO based on the zonal

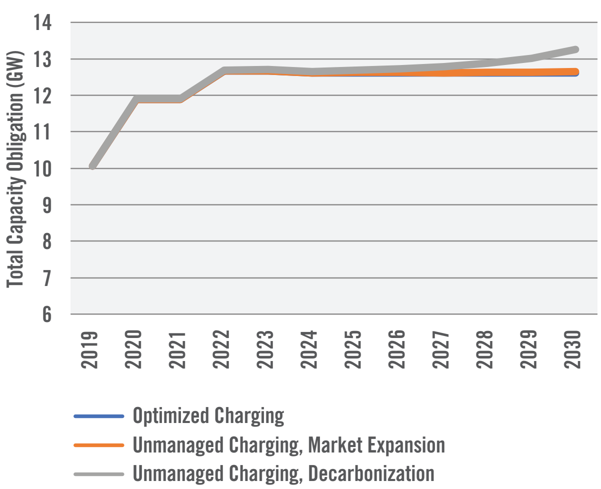
39 The study extrapolated Illinois-specific effects after modeling generation dispatch and costs in the Eastern Interconnect, using a composite approach for PJM and MISO.

40 PJM Interconnection, "PJM Load Forecast Report: 2019", Table B-1, pg. 45. https://pjm.com/-/media/library/reports-notices/load-forecast/2019-load-forecast-report.ashx?la=en (accessed 1/12/2019).

Table 4: Increased Capacity Costs from Unmanaged EV Charging

	PJM		MISO		Total/Avg	
	Market Expansion	Decarbonization	Market Expansion	Decarbonization	Market Expansion	Decarbonization
Total Capacity Increase (Residential)	$13.5 million	$50.2 million	$185,840	$2.6 million	$13.7 million	$52.8 million
Avg Annual Increase	$2.2 million	$4.2 million	$30,377	$219,064	$2.2 million	$4.4 million
Total Capacity Increase (All Customers)	$31.7 million	$117.4 million	$435,166	$6.2 million	$32.1 million	$123.6 million
Avg Annual Increase	$2.6 million	$9.8 million	$36,263	$512,963	$2.7 million	$10.3 million

Figure I: Projected Ameren Capacity Obligations



non-coincident peak and a zonal coincidence factor. To project the impact of unmanaged charging for Ameren customers, we simulate the timing of the zonal non-coincident peak, by month and hour, for each year of the analysis, and add the projected unmanaged EV charging load for both adoption scenarios to MISO's current projections.[41] Figure I compares the resulting PRMR obligations for unmanaged charging in the Market Expansion and Decarbonization Path scenarios to the baseline projection for optimized charging.

By raising capacity obligations, unmanaged EV charging load increases the capacity charges for all customers. Table 4 compares the projected capacity costs for optimized versus unmanaged charging scenarios. In the Market Expansion scenario, Illinois customers pay an additional $32.1 million for capacity. In the Decarbonization Path scenario, customers pay an additional $123.6 million. Higher capacity costs would result from unmanaged charging regardless of the capacity market price levels. While these are not large dollar amounts compared to the energy and distribution effects, capacity is another area of potential EV benefit.

41 Midwest Independent System Operator, "Planning Year 2019-2020 Loss of Load Expectation Study Report". https://cdn.misoenergy.org/2019%20LOLE%20Study%20Report285051.pdf, accessed 1/16/19.

Summing Up the Value of Optimized Charging

As summarized below in Table 5, the combined projected value to Illinois electricity customers of optimized EV charging patterns is up to $2.6 billion. Of course, there are additional public benefits from EVs that are difficult to quantify precisely but are substantial nonetheless. These include the net local economic value, job creation, public health benefits of cleaner air, and the broad economic and social value of reduced carbon emissions. The amount of reduction in pollution and emissions depends on the efficiency of the vehicle, the fuel mix in the region and the marginal local generator at the time of charging. The monetary value of reduced greenhouse gas emissions is a function of the social cost of climate change, which is difficult to estimate and increases over time as the emissions produce greater incremental damage.

Figure J: Total Cost Benefits of Optimized Charging

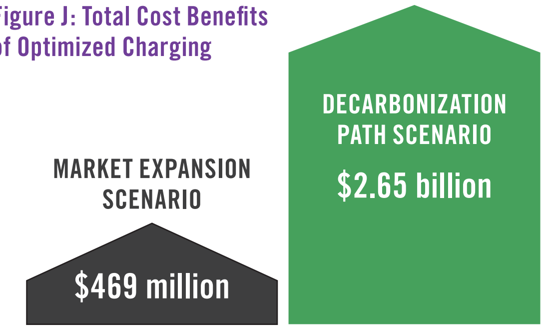


Table 5 summarizes the projected quantifiable benefits in Illinois of optimized charging versus unmanaged charging through 2030, including only the electricity distribution system net contributions and the energy and capacity market cost benefits.

Under the Market Expansion scenario, net benefits from optimized charging total $469 million and average $39 million annually over the 12-year modeled period. Under the Decarbonization Path, net annual benefits total $2.65 billion and average $221 million. While these amounts are not large until EV penetration becomes substantial in the later years, the modeling shows that there will always be savings for all customers, provided that effective charge-management strategies are in place.

Table 5: Total Net Benefits with Optimized Charging ($ million)

	Added Distribution Revenue		Capacity Costs Net Benefit		Energy Market Price Benefit		Total Benefits	
Year	Market Expansion	Decarbonization Path	Market Expansion	Decarbonization Path	Market Expansion	Decarbonization Path	Market Expansion	Decarbonization Path
2019	$1.3	$1.5	$0.06	$0.07	$4.3	$21.8	$5.7	$23.30
2020	$1.8	$2.3	$0.07	$0.13	$4.0	$50.6	$5.9	$53.02
2021	$2.5	$3.6	$0.09	$0.19	$3.7	$56.0	$6.3	$59.78
2022	$3.5	$5.6	$0.13	$0.29	$8.6	$86.7	$12.2	$92.55
2023	$4.9	$8.7	$1.1	$2.3	$9.6	$141.5	$15.6	$152.42
2024	$6.9	$13.5	$1.5	$3.5	$18.4	$190.8	$26.8	$207.78
2025	$9.8	$21	$2.0	$5.3	$14.5	$184.8	$26.3	$211.09
2026	$14.1	$32.7	$2.7	$8.1	$21.3	$210.7	$38.1	$251.49
2027	$20.3	$51	$3.7	$12.2	$30.9	$228.2	$54.9	$291.36
2028	$29.3	$79.6	$4.9	$18.5	$35.6	$252.1	$69.8	$350.09
2029	$42.4	$123.7	$6.6	$27.9	$40.3	$269.8	$89.3	$421.41
2030	$61.6	$192.7	$9.3	$45.2	$47.1	$300.0	$118.0	$537.88
Total	**$198**	**$536**	**$32**	**$124**	**$238**	**$1,993**	**$469**	**$2,652**

The Time Has Come for Charge-management Rates

The combined potential effect of EV loads on the distribution system and the electric energy and capacity markets shows that the first order of business is for state policy makers to develop efficient charge-management policies designed to:

- Utilize existing utility delivery assets for EV charging loads.
- Reduce peak electricity market prices.
- Put downward pressure on electricity delivery rates.
- Minimize charging costs to EV drivers and support market growth.
- Improve air quality and decarbonize transportation.

Each state must adopt load-management policies appropriate to its unique circumstances and system dynamics. States with deep penetrations of variable-output generation resources may experience a more complex interaction between supply and demand. For example, California's millions of distributed solar photovoltaic panels produce peak supply during the sunniest time of day and cease output at night. On occasion, 50% of the afternoon demand has been met with solar power, meaning less demand at those times for grid-sourced energy from large power plants (and therefore lower wholesale energy market prices). These independent supply and demand cycles interact to form what is referred to as the California "duck curve," in which market prices tend to dip midday and spike in the evening, a pattern that can make daytime workplace EV charging a cost-effective strategy for using the existing assets on the grid. Similarly, states with significant wind power at night can incentivize overnight charging to leverage this lower-cost, night-peaking resource.

Most EV charging in all states—80% or more—occurs at home.[42] Until low-cost public charging becomes widely available, the proportion of charging occurring at home is likely to grow as typical EV battery capacity increases. Tools for managing home charging loads start with time-variant rate designs and extend to targeted load control programs. The measures described below would reward beneficial load-shifting, provide utilities with new load-management tools to support reliability, and better align customer bills with the costs to serve them.

WILL SUFFICIENT HIGH-SPEED PUBLIC CHARGING BE DEVELOPED?

High voltage "level 3" chargers (Direct Current Fast Chargers [DCFC]) are too costly for home installation but essential for public charging, especially along highway corridors and urban centers. Affordable and widely available public charging is necessary to address "range anxiety" and to enable drivers to have an EV without a dedicated parking spot (with an electrical connection). Fast charging availability is critical to mass EV adoption, but because of its sporadic yet high-intensity loads, a business model to pay for DCFC through usage charges has not emerged. Barriers include conventional rate design with high demand charges as well as the high upfront costs of infrastructure. DCFC presents a challenge to load management because EVs need to charge during peak driving periods. Ways to shift DCFC load away from peak periods, such as combining DCFC with energy storage, may become cost-effective. Volkswagen's "Electrify America" (a company created as part of the settlement of their diesel cheating scandal) is planning $2 billion in charge station investment.

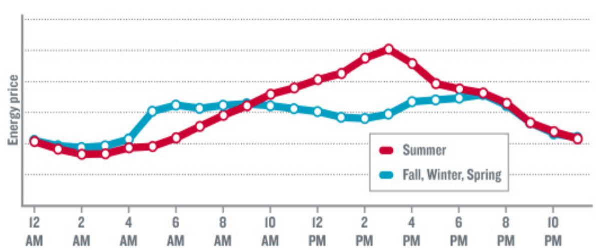
States including New York, Massachusetts, California, Minnesota, and Missouri are pursuing different models of utility involvement in developing and funding high-speed charge stations.

42 See: https://www.energy.gov/eere/electricvehicles/vehicle-charging; also: The EV Project, Idaho Nat'l Lab., *What Were the Driving and Charging Behaviors of High Mileage Accumulators?* 2 (June 2015), https://avt.inl.gov/sites/default/files/pdf/EVProj/WhatWereDrivingAndChargingBehaviorOfHighMileageAccumulators.pdf.

HOURLY PRICING

While the cost of producing electricity and therefore its price in wholesale markets fluctuates significantly over the course of a day, most Illinois households pay the same price for each kilowatt-hour of electricity, regardless of when they use it. But Illinois is the only state in the country that offers most electric customers an alternative rate option: market-based "hourly pricing," also sometimes referred to as "real-time pricing."[43] ComEd and Ameren—the state's two largest utilities—are required by law to offer residential customers the option to have their energy purchased by the utility in the wholesale power market (PJM for ComEd and MISO for Ameren) and to pay electricity rates based on these fluctuating market prices.[44]

Figure K: Hourly Pricing



Source: *Live Prices*, Commonwealth Edison, https://hourlypricing.comed.com/wp-content/uploads/2017/05/2017-HP-program-guide-pricechart-web-01.png. (last updated June 29, 2018).

Figure K shows the typical pattern of real-time price fluctuations in ComEd's service territory. It does not show the occasional price spikes that may send hourly prices soaring for brief periods, usually during summer heat waves. Because of air-conditioning demand, the summer has a more pronounced average peak in the late afternoon. An analysis by CUB found that hourly prices for 81% of the hours in 2016 and 2017 were lower than the flat-rate energy price for utility supply.[45] Year-round the lowest market prices (and best time for an hourly pricing customer to charge an EV) is almost always at night.

Hourly energy prices from 10 PM through 6AM averaged 2.13 cents per kWh in 2018 for ComEd customers and 2.37 cents per kWh for Ameren Illinois. These compare to the flat rates that are in place until June 2019 for utility supply: 7.219 cents per kWh for ComEd and 5.026 cents per kWh for Ameren Illinois.[46] Customers paid additional per-kWh charges for transmission, capacity, energy efficiency programs, renewable energy certificates, zero-emission credits, and procurement costs averaging 0.6537 cents. All residential customers pay the same rates for the volumetric component of delivery services, which for ComEd presently average 3.34 cents per kWh and for Ameren Illinois 3.51 cents per kWh.

Adding up the incremental costs of EV home charging, a ComEd customer using 3,066 kWh to drive an EV 10,950 miles would pay approximate annual costs of $200 if charging under hourly pricing at night compared with $337 under flat rates (plus taxes), a savings of 41%. Similarly, an Ameren Illinois customer would pay $200 for overnight charging under that utility's real-time pricing program, compared with $276 under prevailing flat rates (plus taxes), a savings of 27%. In either case electricity would cost far less than gasoline, which would amount to $1,095 for the same driving distance, assuming a 30 mile per gallon (mpg) vehicle using $3 per gallon gasoline.[47]

Most residential customers would have saved money in recent years if all of their household usage was priced at hourly rates—and EV drivers would have saved the most. A study conducted by CUB and Environmental Defense Fund found that roughly 97% of ComEd residential customers would have paid less for electricity in 2016 under hourly pricing, without changing their usage pattern or consumption

43 Default flat rates for residential and small commercial utility supply are set through long term power contracts procured in a wholesale bidding process run by the Illinois Power Agency, a state bureau.

44 The statute 220 ILCS 5/16-107e requires the utilities to choose a third-party administrator of the hourly pricing programs. Both ComEd and Ameren Illinois have chosen the non-profit organization Elevate Energy as current program administrator. The "ComEd Hourly Pricing" program rate is the real-time average of each current hour's 5-minute PJM market prices, whereas participants in Ameren's "Power Smart Pricing" pay the day-ahead hourly MISO energy price.

45 Zethmayr, J.; Kolata, D. Charge for Less: An Analysis of Hourly Electricity Pricing for Electric Vehicles. World Electr. Veh. J. 2019, 10, 6.

46 ComEd hourly pricing customers are charged for capacity on a per kilowatt basis, not volumetrically.

47 Calculated as 10,950/30 = 365 gallons X $3 = $1,095.

amounts.[48] Yet after more than 10 years of hourly pricing options, only about 1% of residential customers are enrolled in the programs.[49] As we will discuss further, simply offering the option is not sufficient to ensure enrollment of customers who would benefit from it.

TIME-OF-USE PRICING

Most of the customer savings of hourly pricing can be achieved without its potential price fluctuations by developing fixed time-of-use (TOU) rates. TOU rates are set for specified periods, providing more predictable rates at known times. For example, a TOU rate design might have three pricing periods, such as on-peak weekday hours, off-peak overnight hours and weekends, and shoulder-peak hours in early morning and early evening. These periods might be modified between summer and non-summer to reflect seasonal changes in load patterns. Prices could be set annually. And to address the rare times when demand spikes to levels that threaten reliability, such as during extreme weather events, critical peak prices could also be employed (as well as direct load control of EV charging) to temporarily reduce demand.

A successful TOU rate structure must have price variance large enough to incent drivers to charge their EV during the low-price periods and to avoid charging during high-price periods. To be effective at shaping charging patterns, the rate must be easily understood by customers and designed to achieve intended outcomes. Higher price differentials would have greater impact, but regulators should consider how to recover the costs of service fairly and reflect market acquisition costs, while achieving intended outcomes. Different pricing models, such as using simple ratios of peak to off-peak prices, should be tested and evaluated.

EV-ONLY RATES

The savings from charging at off-peak under well-designed time-variant rates would make EVs affordable to a larger segment of car buyers. Based on today's costs, over a period of five years, an EV in ComEd's service territory would save an additional $685 from charging overnight at prevailing hourly prices compared with today's flat-rate energy supply — on top of more than $3,500 in savings over gasoline at $3 per gallon.[50]

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The first step toward increasing participation in time-variant rates is a utility TOU rate plan that applies only to the EV charging portion of a customer's bill. The second step is to enroll EV owners automatically in this beneficial rate.

Illinois does not have an EV-only rate plan, but other states are beginning to offer them. For example, Xcel

48 Citizens Utility Board and Environmental Defense Fund, *The Costs and Benefits of Real-Time Pricing*, 3 (2017), https://citizensutilityboard.org/wp-content/uploads/2017/11/FinalRealTimePricingWhitepaper.pdf.
49 Correspondence with Elevate Energy, the administrator for ComEd Hourly Pricing.
50 All in nominal dollars and assuming no changes in rates or gas price.

Energy in Minnesota offered a TOU rate—applicable to EV charging only. It featured electricity rates of 4.2 cents per kWh (less than half the standard flat rate) during off-peak periods and as high as 21.1 cents per kWh (about twice the standard flat rate) during on-peak summer periods. These rates provide a powerful incentive to charge an EV at off-peak times. However, because the Minnesota program initially required participants to pay for a separate meter for EV usage, very few customers chose to participate and a new program has been designed to use a smart charger instead.[51]

As the Minnesota pilot suggests, there is no need for an additional utility meter to measure EV charging or a separate bill for the customer. EV electricity usage and costs can be easily separated from other consumption on the household electric bill, which should include a chart showing when charging occurred on a graph of time-based prices. To be effective, an EV-only rate plan needs these elements:

- **No extra meter required**. Smart meters in Illinois already provide accurate interval usage data for customer billing. The EV portion of that household usage can be determined through the vehicle charger, or through a module that communicates with the smart meter, or by analyzing usage with disaggregation software. These methods should be studied for relative cost and accuracy, but in any case there is no need to incur the expense of a separate utility meter. Because the existing utility meter accurately captures billing-quality data for all usage, any small discrepancies in allocating between EV and other household usage are inconsequential.

- **Significant and comprehensible price differentials**. As with any time-variant rate design, the customer savings from charging in low-priced periods must be substantial enough to motivate efficient charging behaviors.

- **Automatic enrollment**. Customers purchasing an EV should be enrolled in EV-only rates, with an opt-out choice for those who want another plan. At a minimum, any state incentives promoting EV adoption should be tied to participation in some type of dynamic pricing. While the savings from off-peak charging would make TOU rates a "no-brainer" for knowledgeable consumers, inertia, as well as a lack of awareness about time-variant rates, and mistrust of the utility could leave many EV owners charging on more expensive flat rates—and during peak periods.

There are no "losers" from EV-only rates.

Offering time-based pricing on an opt-in basis may not attract sufficient enrollment to shape charging patterns, despite the customer savings, as demonstrated by the low participation in existing hourly pricing programs. This phenomenon is not unique to Illinois or even to electricity. Default bias steers people away from opting into alternative rates, even if choosing a new plan would reduce their monthly bills.[52] A recent California study randomly assigned electricity customers a fixed rate or a TOU rate and then asked each of them if they wanted to switch to the other rate design.[53] 98% of those assigned to TOU chose to keep the TOU rate, and 80% of the fixed-rate default group chose to stay on the fixed rate.[54] A survey of similar studies across the country found an average participation rate of 28% for those who were offered optional TOU pricing and 85% for those who were placed on TOU as a default rate.[55] By making time-based pricing the default rate for EV charging, regulators can help consumers save money, promote deeper penetration of EVs, and achieve higher system benefits. There are no "losers" from EV-only rates.

51 A revised Xcel pilot program now utilizes a Level 2 (240 volt) smart charger rather than a separate meter and charges a fixed monthly fee. See: https://www.xcelenergy.com/energy_portfolio/innovation/electric_vehicles/ev_service_pilot_pre_enrollment.

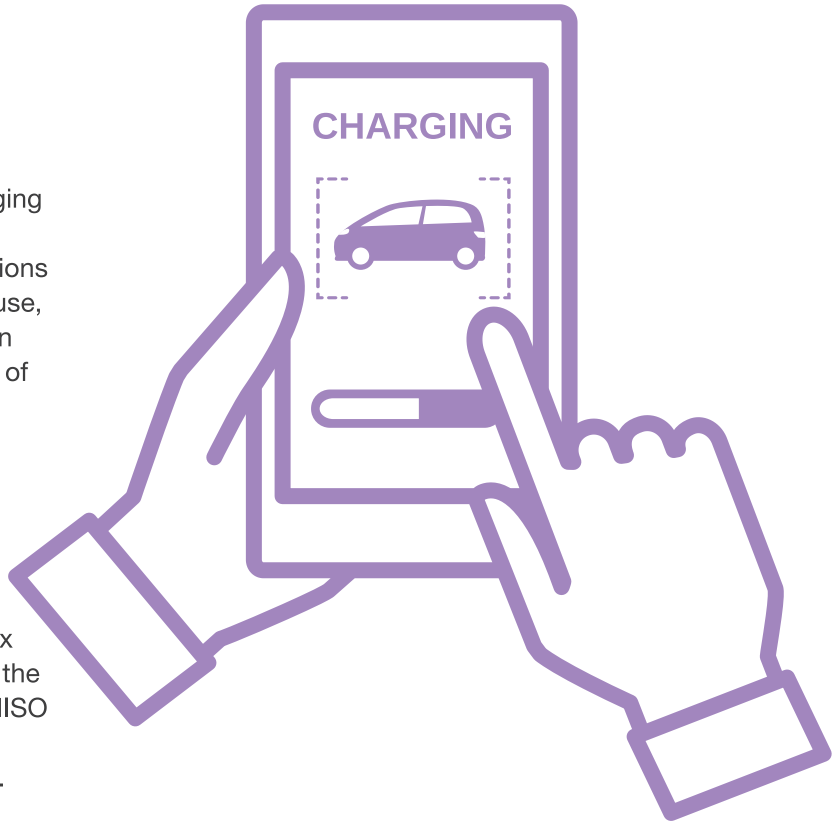
52 Ian Schneider & Cass R. Sunstein, *Behavioral Considerations for Effective Time-Varying Electric Prices*, 1 Behavioral Pub. Pol'y 219, 228–30 (2017), https://www.cambridge.org/core/services/aop-cambridge-core/content/view/79540B0B70604EFF676BE86B89F96800/S2398063X17000021a.pdf/behavioral_considerations_for_effective_timevarying_electricity_prices.pdf.

53 Peter Cappers et al., *Time-of-Use as a Default Rate for Residential Customers: Issues and Insights* (2016).

54 *Ibid*.

55 Ahmad Faruqui, Ryan Hledik & Neil Lessem, *Smart by Default* 24–32, Pub. Utils. Fortnightly (Aug. 2014), http://www.fortnightly.com/fortnightly/2014/08/smart-default.

Customers and Utilities Need New Digital Tools



Enabling customers to optimize their EV charging loads requires technical solutions to provide them real-time information on system conditions and market prices, and the ability to schedule, pause, and resume charging remotely and automatically in response to customer-specified variables. As part of their responsibility for the reliable and efficient operation of the grid, utility companies should be given the new responsibility to make these tools available and integrate them into grid operations.

Real-time and day-ahead market prices are available on the ComEd website, and current PJM generation system fuel-mix data can be accessed via the *PJM Now* app[56]. Similar MISO information is available to Ameren Illinois customers. However, while real time prices and other current information such as wind output and emissions are available to those who look for them, there is no way to start, stop, and schedule EV charging according to these variables. An applet to automatically adjust charging in response to price signals or other customer settings is essential to boost the customer, environmental and system value of flexible EV charging.

An applet to automatically adjust charging in response to price signals or other customer settings is essential to boost the customer, environmental and system value of flexible EV charging.

UTILITY-MANAGED CHARGING PROGRAMS

Time-variant pricing provides customers a financial incentive to charge during periods of low demand. Smart chargers could respond to price signals and other optimization variables chosen by the customer. However, high neighborhood EV concentrations may require additional load control strategies to avoid congestion and unnecessary infrastructure upgrades.

For example, if everybody on a block starts charging at level 2 when they get home from work at 6 PM or sets their charging to start at 9 PM (or whenever the TOU rates go down), a new neighborhood peak could result and the local transformer might need to be upgraded to reliably meet the high localized demand.

Any costs to upgrade the circuit would be recovered by the utility in the rates of all customers. Without a way to manage charging, needless extra costs might be incurred to ensure reliability in neighborhoods with high EV concentration. While this is not an immediate problem, clusters of EVs, particularly in affluent areas, are already appearing. Utilities could begin the process by analyzing circuits to identify those that might become congested by EV proliferation.

Because the utility must provide reliable service at least-cost to all customers at all times, managed EV charging programs eventually could provide a new method of responding to changing system conditions, particularly as periods of high demand caused by

56 *See PJM Now*, PJM, http://www.pjm.com/markets-and-operations/etools/pjm-now.aspx (last visited July 20, 2018).

extreme heat and cold become more frequent and severe. A simple and predictably effective way to spread out EV demand during periods of local congestion or critical system peaks is through direct, centralized and automated charging control. In addition to supporting reliability, centrally managed EV charging also could become a valuable demand response resource for dispatch by the utility to balance supply and demand, to maximize renewables utilization, and to respond to other system conditions. The flexibility and potential scale of EV charging will provide a unique opportunity for Direct Load Control (DLC) programs to optimize system efficiency and reduce costs.

To address a potential overload of a circuit with high EV load, each vehicle charger could be centrally controlled to operate intermittently overnight, or all could be throttled simultaneously so vehicles are fully charged by morning but load at any time is minimized. Similar DLC programs have been operated for many years by Illinois utilities to manage peak period air-conditioning loads on hot summer days. Under a DLC model, the utility could throttle down peak-period EV charging or suspend it during critical demand events that threaten service reliability.[57] As with other DLC programs, EV owners could volunteer to participate at different levels of interruptibility in exchange for cost-effective incentives in the form of payments, rate discounts, provision of charging equipment or other rewards. The utility's operation of charge-management programs could be subject to incentive mechanisms in a performance-based rate plan, so as to align the utility's financial interests with reducing customer costs (and perhaps with other goals such as emissions reduction).

Most EV drivers have flexibility in their home charging patterns because they rarely plug in needing a full charge and, in fact, larger batteries and longer range vehicles will expand this flexibility. Several utilities have experimented with different models for managing EV charging load. For example, a pilot program of San Diego Gas and Electric charges day-ahead prices for charging and allows customers to schedule it with an app. Southern California Edison designed a workplace charging pilot with several rate options: a high-price option with no service disruptions, a medium-price option allowing the utility to throttle level 2 charging down to level 1 during peak demand hours, and a lower-price option under which charging may also be suspended by the utility during critical demand events.

57 See: Smart Elec. Power Alliance, *Utilities and Electric Vehicles 5* (2017) https://sepapower.org/.

Summary of Policy Recommendations

Illinois, and the entire country, are on the verge of an EV boom. As the nascent EV market develops, public policy should focus on the dual goals of stimulating EV market growth and maximizing its benefits to users of the electricity system. We recommend an integrated set of initial EV policies and programs, including:

IMPLEMENT OPT-OUT TOU RATE FOR EV HOME CHARGING

Automatically enroll all EVs in EV-only time-of-use (TOU) rates. All EV owners will save money by charging in off-peak periods, and other customers will benefit from a more efficient electricity system.[58] Allow an option for the customer to choose a different tariff, such as an hourly rate or a flat rate. The EV-only TOU rates should have these features:

- No separate meter required.
- No extra monthly fees beyond the cost of service.
- EV usage listed separately on a single household bill.
- Time price differential that creates meaningful savings.

DEVELOP MANAGED-CHARGING PROGRAM PILOT

- Identify circuits based on loads, EV clusters, charging behaviors.
- Direct load control programs designed to:
  - ~ respond to local system conditions.
  - ~ manage critical peak periods.
  - ~ aggregate EV load as a Demand Response resource.
  - ~ maximize renewable energy utilization.
- Test voluntary participation rewards.
- Include performance-based incentives.

IDENTIFY BARRIERS TO PUBLIC CHARGING

- Consider alternative rate designs to encourage development of public charge stations.
- Test effects on charging behaviors, charge station deployment, and site owner response.
- Consider benefits, costs, and other ramifications of different ways of involving utilities in developing public-charging infrastructure.

DEVELOP EV ONLINE TOOLS AND APPS

- Automate charging response to price and other signals such as emissions and real-time renewable generation output.
- Provide shadow bill option to allow customer to compare current and historical monthly bills under different rate plans.
- Include cost calculators to compare EV with ICE vehicle costs, given inputs such as miles driven, purchase price, financing, gasoline cost, electricity rate plans, and other variables.

INTENSIFY OUTREACH AND EDUCATION

- Use utility communications for proactive customer engagement about EVs.
- Develop and distribute electricity rate and cost information materials for car dealers and their customers.
- Employ trusted independent third parties for targeted consumer outreach tailored to diverse communities.

DESIGN INNOVATIVE PROGRAMS TO ENSURE ALL CUSTOMER SEGMENTS BENEFIT

- Identify areas in particular need of electrification benefits such as environmental justice and economically disadvantaged communities.
- Where personal EVs are unlikely to proliferate, deploy e-buses and other initiatives such as low-cost EV car sharing in low and moderate-income urban areas.
- Develop strategies, with stakeholder input, to address challenges of EV charging availability at multi-unit buildings and for drivers without access to a garage or permanent parking space.

58 Enrollment assumes the utility is informed when a customer acquires an EV; how this would occur should be determined.

Conclusion: Public-Interest Outcomes Require Public Policy Support

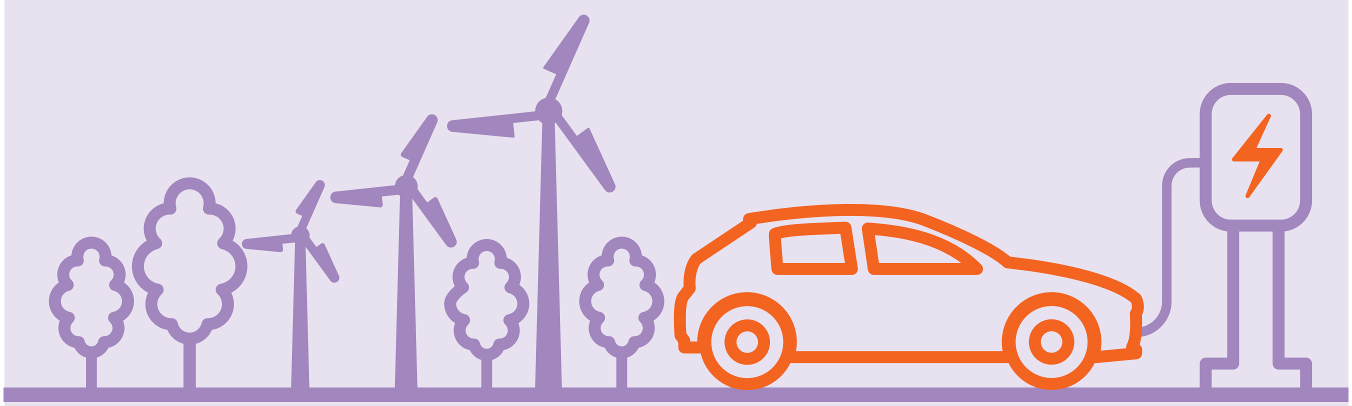
Whatever the EV growth trajectory, all electricity customers will benefit from transportation electrification, provided charging occurs at times of ample system capacity—and the larger the number of EVs on the road, the greater the benefits. The initial policies discussed above are ripe for immediate consideration to set a policy direction as the mass EV market begins to emerge. But they are the beginning, not the endpoint, for EV policies and programs.

EV benefits will be amplified and adoption accelerated by state support and utility involvement. The twin goals of stimulating EV market growth and maximizing EV's public value should be part of an integrated statewide strategy to ensure that all customers benefit, whether or not they ever drive an electric car. Policy makers must evaluate the appropriate and necessary roles of utilities and other entities in advancing beneficial electrification. The strengths of the utility—its existing infrastructure, access to capital, long-term integrated planning, program experience, customer relationships, operational expertise and accountability under the regulatory framework—should be leveraged for maximum public benefit. The regulatory framework should align utility incentives with achieving specific electrification goals. At the same time, state policies should support customer choice and private investment to stimulate effective competition for EV products and services.

A step-by-step decision-making methodology should be at the core of a strategic planning process

SHOULD RESIDENTIAL EV CHARGERS BE PUBLICLY SUPPORTED?

EVs can charge from an ordinary 110-120 volt wall outlet ("level 1") using just the power cord that comes with the car. A typical charge rate uses about the same amount of electricity as a toaster and provides about 4 miles of travel per hour of charging. You can charge up to six times faster using a 220-240 volt "level 2" charger, which costs from $200 to $600, plus installation. To boost EV adoption and system benefits from effective charge-management, several states and utilities offer rebates or discounts on "smart" communicating home chargers that can allow automatic control of charging patterns and are essential to charge-optimization strategies. Discounts on smart home chargers may be an effective way to enroll EV owners in charge-management, ensure EVs are providing system benefits, test rate designs and load programs, and collect essential data about EV charging patterns.



intended to maximize consumer and social value from transportation electrification. Not everything has to be (or can be) done at the outset, but proactive initial policies should attempt to "get ahead of the curve." A phased-in approach allows time for evaluation of these efforts and course correction as circumstances change, the trajectory of market development becomes more clear, and customer needs evolve. The risk that EV technologies and markets will not develop as anticipated means that public and customer funding of EV initiatives should be committed gradually and be responsive to inevitably changing conditions.

While the eventual net benefits of many EV-supportive initiatives may be substantial, none of them will be cost-free at the outset. Most can be tested through pilot programs, evaluated and adjusted before being rolled out at scale. Public and private stakeholders should be engaged by policy makers in a process that considers all costs and benefits in developing a least-cost transportation electrification strategic plan.

In considering which policies to pursue and how much is reasonable and prudent to invest, policy makers should attempt to:

- **Pick the low-hanging fruit**. Some policies are ripe for immediate impact, such as innovative EV rate plans for both end-users and charge providers, shadow billing to provide customers with comparisons of alternative rate plans, and consumer education initiatives.

- **Get the biggest bang for the buck**. Each strategic element of an EV plan should be analyzed and prioritized for its projected costs, benefits, and risks—mapped to those who will pay for it, those who will derive value, and those who will bear risks. The performance of all initiatives should be regularly tracked and evaluated.

- **Build on existing platforms**. Illinois utilities have fully deployed smart meters, which can be the basis for a range of EV-supportive customer-beneficial applications. Existing infrastructure and available capacity should be evaluated and exploited.

- **Leverage multiple funding sources**. Some measures, such as direct support for EV acquisition and subsidies of public charging facilities, may have relatively high up-front costs but also could have benefits that substantially exceed those costs. However, for initiatives with high public costs, funding through tax policy, direct state expenditures, bond issues and other mechanisms, as well as leveraging private investment, should be considered along with utility-based initiatives.

- **Ensure low-income consumer benefits**. Limited access to capital, and lack of a place to plug in at home are substantial barriers to EV acquisition. And of course, many consumers do not have the means or desire to own any vehicle. While all customers will benefit to the extent that EVs put downward pressure on electricity rates, particular issues facing low and moderate-income households should be addressed at the outset. The means to bring EV benefits to all neighborhoods, such as low-cost EV car sharing, public charge facilities, and electric buses and trucks should be included in comprehensive transportation electrification plans.

- **Create the right incentives**. Expenditure of public or utility funds should entail accountability by the recipients. Utility compensation for EV initiatives should be tied to performance and achievement of public goals such as improved load shape, reduced costs, and high reliability and utilization levels. Any vendors receiving utility or public funding should be subject to reasonable standards and consumer protections. Successful policy will align the interests of all participants with achieving customer benefits and social goals.

President Abraham Lincoln never had the opportunity to drive an EV, but the words of Illinois' favorite son apply to the task confronting policy makers: "Leave nothing for tomorrow which can be done today." This is a key moment — energy and transportation policy meet at a crossroads. The stakes are high. Our policy decisions will have enormous impact not only on the environment and the economy but also on the electricity prices all of us pay — whether we drive an EV or not. Policy makers have an immediate responsibility but also an unprecedented opportunity to set smart EV policy that will lay the groundwork for an affordable clean energy future.

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