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EVs and EDs: Rural electric coops to benefit from late adoption of electric vehicles

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Key Points:

- Electric vehicle (EV) adoption rates in urban and suburban areas far outpace those of rural areas, and that trend is expected to persist. Rural electric cooperatives in aggregate are unlikely to realize growth in electricity demand from EVs over the next five to ten years.
- Electric cooperatives that serve the edge of a suburban community or a resort town could see EV adoption rates similar to urban areas. However, penetration of EVs in strictly rural communities should remain below 1 percent through 2025.
- Adoption of EVs in rural America will remain muted until the price of EVs that can provide a minimum range of 200 miles on a single charge are competitive with traditional internal combustion engine.
- By 2020, most new battery EV models are expected to have a range of 200-300 mile per charge and prices will fall as technology improves.
- Longer range batteries will place less reliance on public charging infrastructure, thereby reducing the costs borne by rural electric cooperatives to provide this infrastructure when or if the need arises.
- Until EVs account for at least 3 percent of new car sales in rural communities, electric distribution cooperatives can take a measured approach to promoting EVs and deploying charging infrastructure.

Introduction

The early market for plug-in electric vehicles (referred to as EVs in this report and include battery, plug-in hybrid, and extended range EVs) has been characterized by modest but steadily increasing sales, high vehicle reliability and customer satisfaction, and a rapid evolution of both vehicle and charging technologies.[1] According to the Electric Power Research Institute (EPRI), more than 30 EV models are available from 15 automobile manufacturers, including five of the six largest U.S. automotive manufacturers. Another 32 EV models are scheduled to be launched by the end of 2021.

Despite growing momentum across the EV industry, adoption in rural America is expected to lag that of more urban and suburban communities. Limited growth in EV passenger cars coupled with increasing energy efficiency, and

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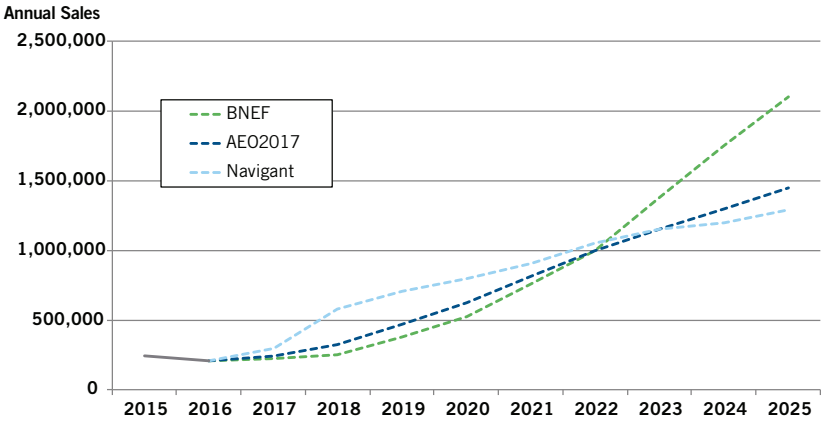
the proliferation of rooftop solar in select rural communities will likely offset the majority of growth in energy demand from EV adoption over the next decade, possibly longer.

Future improvements to battery technology will extend the range of EVs and put downward pressure on prices. Most new battery EV models in 2020 are expected to have a range of 200-300 mile per charge. Longer range batteries will place less reliance on public charging infrastructure, thereby reducing the costs borne by rural electric cooperatives to provide this infrastructure when or if the need arises.

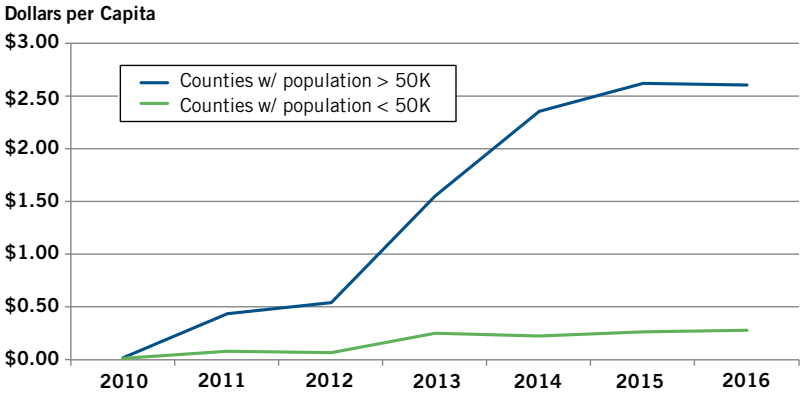
Exhibit 1: EV Sales Forecast Through 2025



Notes: Includes battery and plug-in EVs, dashed lines represent forecasts.

Sources: Edison Electric Institute, Energy Information Adminstration, Rocky Mountain Institute

Exhibit 2: EV Rebates Per Capita in CA Metro and Non-Metro Counties



Sources: CoBank, California Air Resources Board Clean Vehicle Rebate Project, Census Bureau

EV adoption to remain centered in urban and suburban communities

Roughly 700,000 EVs are currently being driven on U.S. roads, and EVs accounted for 3 percent of monthly car sales in September 2017.[2] Industry analysts expect there to be 3 million EVs on the road in the next five years, with annual sales potentially reaching 2 million by 2025. (*See Exhibit 1.*)

However, the majority of EVs on the road through 2025 will remain in cities and suburban communities. Electric cooperatives that serve the edge of a suburban community or a resort town could see EV adoption rates similar to urban areas. However, penetration of EVs in strictly rural communities should remain below 1 percent through 2025. Longer commutes in rural areas are the largest headwind to higher rates of adoption. Based on data from the National Household Travel Survey (NHTS) data, urban drivers average 23 vehicle miles traveled (VMT) per day, compared to 34 VMT for rural drivers.[3] Furthermore, roughly one-third of states report slightly lower median household income in rural communities compared to their urban counterparts.

The disparity of EV adoption in rural versus urban areas is evident in California. Aggressive state emission reduction policies aimed at promoting EVs, and generous state rebates offered for the purchase of zero emissions vehicles make California the leading EV market in the country, which accounts for half of the 700,000 EVs on the road today.[4] Based on data from the California Air Resources Board Clean Vehicle Rebate Project, EV rebates have surged to over $2.50 per capita in counties with a population greater than 50,000, compared to $0.30 per capita in non-metro counties that are below 50,000.[5] (*See Exhibit 2.*)

Adoption of EVs in rural America will remain muted until the price of EVs that can provide a minimum range of 200 miles on a single charge are competitive with traditional internal combustion engine (ICE) vehicles.

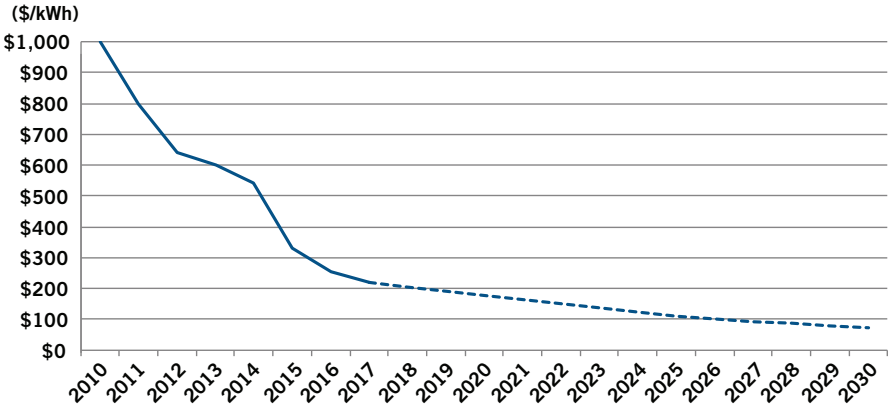
Most EVs will be more expensive than similar model ICE vehicles in 2025

The battery currently accounts for 40 - 60 percent of an EV's powertrain cost.[6] Significant adoption of EVs among the average consumer will require a major breakthrough in power density of lithium ion batteries to bring the cost of battery packs down from their current rate of $215 per kilowatt hour (kWh) to below $100 per kWh.[7] Cost curves for battery packs suggest the $100/kWh threshold could be reached by 2025. (*See Exhibit 3.*)

However, even with $100/kWh battery packs and federal subsidies, forecasts indicate that only subcompact, compact, and midsize EVs with a range of 100 miles will be priced similar to an ICE vehicle of a similar model in 2025.[8] For example, a consumer in California could have to pay a $13,100 premium over the cost of a traditional pickup truck for an EV pickup truck that has a range of 200 miles.[9] (*See Exhibit 4.*)

While electrification in the light duty market is making progress, this success does not translate readily to medium and heavy vehicles (weight classes 3-8).[10] Because of the higher, sustained power and daily energy demands, rugged operational environments, and often high lifetime miles for medium and heavy vehicles, light duty

Exhibit 3: Average Cost of Lithium-ion Battery Packs



Notes: All values are in 2016 dollars, dashed lines represent a forecast.
Sources: McKinsey & Company, Bloomberg New Energy Finance

Exhibit 4: Expected Price Premium Over Similar ICE Vehicles in 2025

Vehicle Segment	PEV Variant	Premium in 2025
Subcompact	PHEV 40	$574
	BEV 100	$0
	BEV200	$4,558
Compact	PHEV 40	$397
	BEV 100	$0
	BEV200	$4,458
Mid-size	PHEV 40	$1,700
	BEV 100	$0
	BEV200	$5,644
Full-size	PHEV 40	$2,462
	BEV 100	$118
	BEV200	$7,948
Compact SUV	PHEV 40	$1,031
	BEV 100	$120
	BEV200	$9,095
Standard SUV	PHEV 40	$2,964
	BEV 100	$1,118
	BEV200	$11,887
Pickup Truck	PHEV 40	$3,363
	BEV100	$1,816
	BEV200	$13,152

Source: Pacific Gas & Electric Company EPIC Final Report, September 2016

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technologies cannot simply be scaled up, according to Oak Ridge National Laboratory. As a result, electrification of commercial vehicles is at an early stage of development and there are few production vehicle options available.

EVs are not likely to reverse the national trend in flat electricity sales

Growth in electricity sales could be realized where there are pockets of high EV adoption. However, in aggregate rural electric cooperatives are unlikely to realize significant growth in energy demand from EVs over the next five to ten years. Energy efficiency measures should largely offset EV related electricity demand, and growth of electricity demand will be further pressured in rural communities that experience an expansion of rooftop solar photovoltaic (PV) installations in the years ahead.

Energy efficiency savings from rate-payer funded programs nationwide averaged 24.8 terawatt-hours (TWh) annually over the last five years.[11] Electric distribution cooperatives likely accounted for 2.9 TWh of annual energy efficiency savings.[12]

It would require roughly 870,000 battery powered EVs that have a range of 100 miles to offset the incremental energy efficiency savings that were realized by electric distribution cooperatives in 2016 alone. (The average battery EV drives around 10,000 miles per year, and each BEV100 consumes on average 1 kWh per 3.0 miles.) Furthermore, energy efficiency savings remain in place growing incrementally every year. The rate of EV adoption, particularly in rural areas will simply not be fast enough to offset these savings.

Growth in electricity sales from EVs will likely be further pressured in areas that experience a proliferation of rooftop PV installations. For example, Southern California Edison (SCE) expects there will be 1.05 million EVs operating within its service territory in 2027, consuming 3.5 TWh of energy (according to SCE calculations).[13] However, SCE also forecasts the cumulative installed capacity of distributed PV in its service territory to reach 5,893 megawatts (MW) in 2027. Assuming a 15 percent capacity factor, this equates to roughly 7.7 TWh of self-generated energy from distributed PV alone.

Distribution grid upgrade costs should remain modest, even with high EV penetration rates

If a rural distribution coop happens to experience exceptionally rapid growth in EVs, the costs to upgrade the distribution grid will likely remain manageable. Similar to rooftop solar, EVs tend to cluster in certain areas of a distribution network. Studies of existing EV fleets show that 70-80 percent of charging is done at home. Therefore, multiple EVs charging during a distribution system's peak could exceed the rated capacity of installed substations and feeders, potentially posing a challenge for distribution utilities.

However, even with penetration rates that exceed 10 percent, the annual cost for distribution upgrades is likely to remain a small portion of total distribution costs. (Currently the penetration of EV passenger cars is 0.5 percent nationwide and 1.4 percent in California). Research shows that annual distribution grid upgrade costs resulting from higher EV adoption should remain slightly below 1 percent of a utility's annual distribution revenue requirement.[14] Furthermore, incentivizing customers to charge during off-peak times through time-of-use (TOU) rates could potentially reduce grid upgrade costs by over 40 percent.

The time is right for time-of-use

Utilities capture the largest benefit from EVs primarily through improvements to their load factors.[15] However, this is only possible if utilities are able to shift EV charging to off-peak times through TOU rates. Incentivizing off-peak charging provides utilities with the opportunity to increase electricity demand at a time when there is a large amount of underutilized generation capacity.

San Diego Gas and Electric conducted a thorough pricing study on the impact TOU rates (applied to demand from an entire home as opposed to demand from an EV only) have on customer's demand habits.[16] The study tracked load profiles for consumers before and after they purchased an EV, and separated customers that had a rooftop PV system installed and those that did not.

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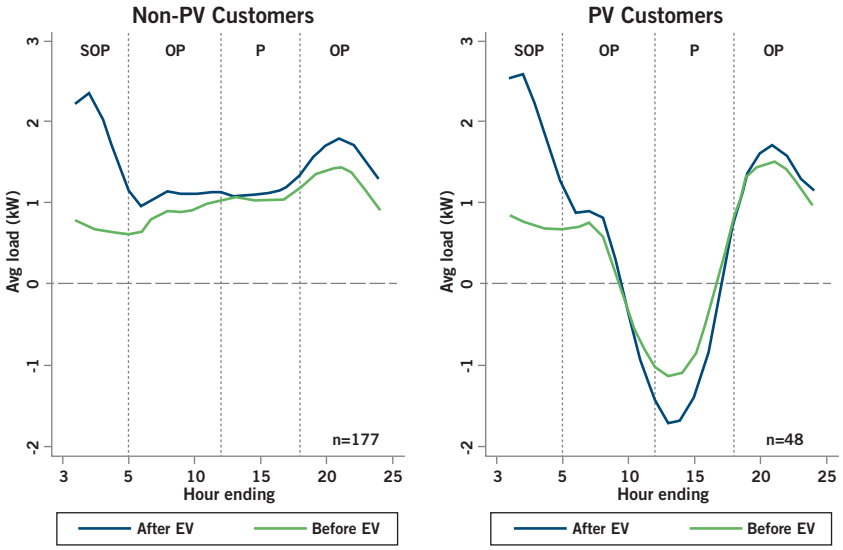
Exhibit 5: Whole House Loads for TOU Customers Before/After EV Acquisition



Source: San Diego Gas and Electric

Load profiles changed significantly after the acquisition of an EV. For non-PV customers, peak load moved from 7–9 PM to 12–2 AM and average loads increased during all hours of the day. The largest increases other than between 12 AM and 5 AM occurred during the off-peak (OP) period and there were relatively smaller increases during the on-peak period (P). This is almost certainly due to consumers shifting EV charging away from the peak period in response to the high price signals of the TOU rate. For PV customers, there was a particularly large increase during the super off-peak (SOP) period after acquiring an EV and then switching to the TOU rate. Consumption increased during both of the off-peak periods, but decreased during the on-peak period because houses with PV were sending more power back to the grid. (*See Exhibit 5.*)

Considerations for installing public charging infrastructure

Expanding charging infrastructure across an electric coop's service territory can require significant upfront capital. Furthermore, the chicken-and-egg situation that defines the relationship between charging infrastructure and EV adoption increases the uncertainty around the appropriate level and timing of investments, the right type of chargers, and the best locations for those chargers.

Furthermore, battery technology and charging technology are constantly improving, potentially making current technology obsolete in a few years.

Batteries that have a range of 200-300 miles should be common among new EV models in 2020. As a result of longer range batteries, commuter's reliance on workplace and public charging will decline.[17] Relying on improvements to EV battery technology could save rural electric cooperatives on the future cost of providing public charging infrastructure.

In the interim, until EVs account for at least 3 percent of new car sales in rural communities, electric distribution cooperatives can take a measured approach to promoting EVs and deploying charging infrastructure. One example would be to purchase a small number of EVs and make them available to employees or members of the coop to drive around town. Coupled with the installation of a modest number of Level 2 (L2) charging stations at highly visible public locations, could serve to educate the community about EVs, and send a signal that the electric cooperative is paying attention to this technology.

The installation of direct current fast charging (DCFC) ports could make sense at businesses that are located along major highways that serve a high number of long-distance travelers. However, DCFC units have high power needs and could trigger upgrades to the distribution grid. To minimize these costs it is important to identify locations where there is available existing transformer capacity that is capable of handling the power needs of a DCFC unit. Furthermore, DCFC units can be expensive for utility customers to operate, and require the host utility to carefully consider appropriate retail rates for DCFC units.

Many factors lead to highly variable costs associated with EV charging infrastructure. Within each charging level (Level 1, Level 2, and DCFC) the unit cost depends on the mounting system, number of charge ports,

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Exhibit 6: Types of Chargers and Approximate Installation Costs

Charger Type	Voltage (V)	Capacity (KW)	Minutes to supply 80 miles of range	Unit cost range (single port)	Installation cost range (per unit)
Level 1	120	1.4-1.9	630-824	$300-$1,500	$0-$3,000
Level 2	240	3.4-20	60-350	$400-$6,500	$600-$12,700
DCFC	480	50-400	3-24	$10,000-$40,000	$4,000-$51,000

Sources: Rocky Mountain Institute, U.S. Department of Energy

communication system, and additional features.[18] According to study by the Department of Energy (DOE), installation costs have the most significant variability and are influenced by permitting, labor rates, how much electrical work is needed, and how much trenching or boring is required. (*See Exhibit 6.*)

Conclusion

The EV market and associated charging infrastructure will grow and coevolve. EV adoption rates in urban and suburban areas will continue to outpace adoption in more rural communities. Energy demand associated with slower EV adoption in rural America will struggle to offset energy efficiency savings for five to ten years. Higher load factors as a result of EV adoption will provide the largest benefit to electric coops. However this benefit can only be realized through TOU rates. Rapidly improving battery and charging technology will provide rural electric cooperatives the opportunity to save on the cost of installing this infrastructure, when or if future EV penetration rates justify a system wide charging network. ■

References

[1] Battery electric vehicles (BEVs) run completely on battery power. With the current technology, EVs can drive up to 100 miles with a single charge. Major battery manufacturers are developing a high-capacity battery that enables an EV to drive more than 200 miles with a single charge. Plug-in-hybrid vehicles (PHEV) use both an internal-combustion engine and an electric motor that relies on a battery that can be charged by external power. PHEVs have a range of about 40 miles before the battery is depleted and the system switches to the internal combustion engine. Extended range electric vehicles (EREV) run solely on the energy from their batteries until the charge gets low. Then a gasoline engine switches on - not to power the wheels, but only to recharge the battery - while the car continues to drive. Hybrid vehicles charge a small battery with internal sources only, relying mostly on a gasoline-powered engine to power the car. Hybrids are never plugged in and are not considered electric vehicles.

[2] Argonne National Laboratory, Light Duty Electric Vehicles Monthly Sales Update. Available here.

[3] U.S. Department of Transportation. Summary of Travel Trends: 2009 National Household Travel Survey. June 2011. Available here.

[4] The California Clean Vehicle Rebate Project (CVRP) offers rebates for the purchase or lease of qualified vehicles. The rebates include a subsidy of $2,500 for light-duty BEVs and $1,500 for light-duty PHEVs that are approved or certified by the California Air Resources Board (ARB).

[5] Data on EV rebates is from the Center for Sustainable Energy (2017). California Air Resources Board Clean Vehicle Rebate Project, Rebate Statistics. Data last updated 10/2/2017 Retrieved 10/15/2017 from https://cleanvehiclerebate.org/eng/rebate-statistics. County population is from the Census Bureau.

[6] The powertrain consists of the battery pack, battery management system, cooling system, electric motor, inverter, converter, gear box, control unit, on-board charger, high voltage cables, pumps, battery heater and other ancillaries.

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[7] The composition of an EV battery might vary slightly depending on the types of electric vehicles, but generally EV batteries are composed of cells, modules and a pack. Simply put, cells, modules and packs are units of gathered batteries. A cluster of cells make up a module and a cluster of modules make up a pack. Ultimately packs are installed in electric vehicles.

[8] The federal government is providing tax credits as part of the American Recovery and Reinvestment act to buyers of plug-in hybrid and electric cars subject to meeting certain eligibility criteria. The amount of credit varies from $2,500 to $7,500 depending on the size of the battery in the car. On the low end of the spectrum, cars with 4 kWh battery packs will qualify for a $2,500 tax credit. The credit maxes out at $7,500 for cars with a 16 kWh battery pack. The incentive begins phasing out after an automaker sells 200,000 vehicles that are eligible for the credit.

[9] Metcalfe, M. Pacific Gas and Electric Company. Electric Program Investment Charge (EPIC), Direct Current (DC) Fast Charging Mapping. September 31, 2016. Available here.

[10] Birky, A, et al. Oak Ridge National Laboratory. Transportation Electrification Beyond Light Duty: Technology and Market Assessment. September 2017.

[11] Berg, W. et al. American Council for an Energy-Efficient Economy (ACEE). The 2017 State Energy Efficiency Scorecard. September 2017. Available here.

[12] Total EE savings across all utilities in 2016 was 25.4 TWh, or 0.789% reduction in retail sales. Applying this percentage to electric distribution coop's share of U.S. retail sales in 2016 results in 2.924 TWh of EE savings.

[13] Public Utilities Commission of the State of California Energy Division. Advice 3670-E. Subject: Adjustments to photovoltaic and electric vehicle forecasts to be used in Southern California Edison Company's 2017-2018 Distribution Planning. October 6, 2017. Available here.

[14] Energy Environmental Economics (E3). California Transportation Electrification Assessment Phase 2: Grid Impacts. October 23,2014. Available here.

[15] Salisbury, M., Toor, W. Southwest Energy Efficiency Project (SWEEP). How Leading Utilities are Embracing Electric Vehicles. February 2016. Available here.

[16] Dr. Cook, J., et al. Nexant. Final Evaluation for San Diego Gas & Electric's Plug-in Electric Vehicle TOU Pricing and Technology Study. February 20, 2014. Available here.

[17] Wood, E., et al. National Renewable Energy Laboratory (NREL). Regional Charging Infrastructure for Plug-In Electric Vehicles: A Case Study of Massachusetts. January 2017. Available here.

[18] Smith, M., Castellano, J. Prepared for the U.S. Department of Energy. Costs Associated With Non-Residential Electric Vehicle Supply Equipment. November 2015. Available here.

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