Going from Pump to Plug

Adding Up the Savings from Electric Vehicles

HIGHLIGHTS

Electric vehicles (EVs) are significantly cheaper than gasoline-powered vehicles to fuel and operate, according to a Union of Concerned Scientists analysis. Even with today's relatively low gasoline prices, every electricity provider surveyed in the 50 largest US cities offers a rate plan that would save the average EV owner on fuel costs, with median annual savings exceeding $770. Moreover, EVs are increasingly affordable to purchase, especially after applying federal and state incentives, and they cost less to maintain. Yet even as EVs grow in popularity, policies are essential for improving the charging infrastructure, broadening access to favorable electricity rates, and ensuring that EVs are affordable to more car buyers.

Electric vehicles (EVs) benefit both the environment and drivers. For the environment, they reduce petroleum use, global warming emissions, and tailpipe pollution. Global warming emissions from EVs depend in part on the source used for electricity generation, which varies across the United States. According to a 2017 Union of Concerned Scientists (UCS) analysis, driving the average EV in the United States produces the same emissions as a gasoline car getting 73 miles per gallon (mpg), considering total emissions from gasoline and electricity production and distribution (Reichmuth 2017). This environmental benefit will only increase as the nation's electricity generation continues to move away from carbon-intensive sources like coal to cleaner sources like wind and solar power.

EVs benefit drivers beyond reducing each person's carbon pollution footprint. *Going from Pump to Plug* looks at a second critical advantage of EVs: the cost to owners. While the cost of electricity varies across service providers and rate plans, using electricity to power a vehicle is almost always cheaper than using gasoline. Electricity prices are also less volatile than gasoline prices, and they are less sensitive to supply disruptions and international market movements because generation is distributed among many facilities and fuel types.

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EVs are significantly cheaper to refuel than gasoline-powered cars, but stronger policies are needed to effectively transition from pump to plug.

Union of Concerned Scientists

> ***At least one rate plan in each location studied would make driving an EV cheaper than driving the average new gasoline vehicle.***

In addition, EVs lessen or eliminate some vehicle maintenance costs. Because battery EVs (BEVs) have no gasoline engine, they do not need oil changes, spark plugs, or timing belts. Also, EVs offer performance advantages over gasoline vehicles, and they bring the convenience of refueling at home.

With savings on transportation through lower fuel and maintenance costs, US consumers can put more money in their pockets by switching to EVs. However, the costs to manufacture an EV are typically higher than those of a comparable gasoline vehicle, largely due to the cost of battery packs. That said, battery costs are declining rapidly, which should reduce the price gap between a gasoline-powered car and an EV. Presently, government incentives and manufacturer discounts lower EV prices for car buyers, and EV leases are available at competitive rates. All this makes the fuel and maintenance savings of EVs accessible to many car buyers (Reichmuth and Goldman 2017).

EV Charging at Home: Almost Always Cheaper Than Gasoline

The cost to fuel an EV depends on the cost of the electricity used. About 80 percent of EV charging happens at home, making the cost of residential electricity the primary factor in the cost to recharge an EV in most cases (ARB 2017a; INL 2015).

The cost of residential electricity varies from provider to provider; even a single service provider might offer several rate plans. UCS examined the rates in the 50 largest cities in the United States, plus seven other US cities. Our analysis looked at EV-charging costs on both the default rate plan and the lowest-cost, time-of-use or EV-specific rate plan available. To express electricity costs as equivalent gasoline prices, we used the average EV efficiency and the average efficiency for new 2016 gasoline vehicles (Reichmuth 2017; EPA 2016). Electric rates included taxes and fees collected on a usage

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Charging an EV at home is almost always cheaper than filling the tank of a gasoline-powered car.

basis. UCS did not include fixed charges, such as monthly meter charges. Increased electricity usage from recharging an EV would not change these.

Although electric rates vary significantly across the nation, UCS found that at least one rate plan in each location studied would make driving an EV cheaper than driving the average new gasoline vehicle (Figure 1, p. 4–5). On standard rate plans, electricity costs for recharging an EV range from $.05 per kilowatt hour (kWh) to $0.41 per kWh (NREL 2017). This translates into a cost for refueling an EV ranging from a low of $0.43 per gallon equivalent to a high of $3.34 per gallon equivalent, with a median of $0.90 per gallon equivalent. Only two of the 60 electricity providers studied had EV recharging costs higher than the current cost of gasoline.

Recharging on a time-of-use (TOU) or EV-specific rate plan can greatly reduce the cost to recharge an EV. TOU plans offer lower-cost charging during off-peak hours, usually during the late evening or early morning. Most cars are parked at home overnight, making TOU plans a good fit for most EV drivers. The off-peak TOU rates vary from $0.03 to $0.21 per kWh, resulting in equivalent costs ranging from $0.25 per gallon in Minneapolis to $1.78 per gallon in parts of Los Angeles (NREL 2017).

Recharging an EV on a TOU rate can yield significant savings on fuel costs. Using TOU pricing, our analysis found that all electricity providers examined have EV fuel costs at least $1 per gallon equivalent lower than the current cost of gasoline. All but one service provider offer electricity on a TOU plan at a cost lower than the cheapest gasoline price over the prior ten years.

Although TOU rates can mean significant savings on off-peak power use, the tradeoff is that power is more expensive during peak periods. If a household cannot shift some of its electricity use from peak to off-peak times, then a TOU rate plan may not be the best choice. Some electricity providers offer the option of installing a second electricity meter dedicated to EV charging: owners can charge their vehicles on a separate rate plan from the rest of the household. This allows using a lower, off-peak TOU rate for the power to recharge the EV, while a flat rate for the rest of the house avoids high peak charges. However, TOU rates still could be inconvenient to some drivers, such as those whose work schedules outside normal business hours prevent them from charging at home during the night. For those drivers, the standard rate plan may be more appropriate.

For most customers, the default is a flat or tiered rate plan. However, in some locations the default rate will be moving to a TOU plan. Under a California Public Utilities Commission ruling, the default rate plan for many electric customers will be a TOU plan, starting in 2019 (CPUC 2017).

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BOX 1.

Residential Electricity Rate Plans

Many electricity customers can choose among rate plans. The availability of a time-of-use rate, with lower-cost electricity at night, can be an important factor in EV charging.

Flat Rate Plans: Flat rate plans are simplest: the cost to charge does not change based on the time of day. Users pay the same for power in low-demand times, like late nights, as during high-demand times, despite potentially large differences in the cost to the electric provider to deliver power. These plans are often more expensive for EV charging.

Tiered Flat Rate Plans: Tiered flat rate plans have a cost to charge that is constant at all times of the day but changes when a household exceeds set usage amounts during a month. Most electric providers using a tiered-rate structure have two to four tiers and charge more for power in higher-usage tiers. Charging an EV at home on a tiered flat rate plan would increase the likelihood that users would be in a higher rate tier.

Critical Peak Pricing Plans: Users pay less for electricity during most times in exchange for high prices during a small number of peak events, such as late afternoon on a hot summer day. Because peak events do not occur in overnight hours, the plans can reduce the cost to recharge an EV.

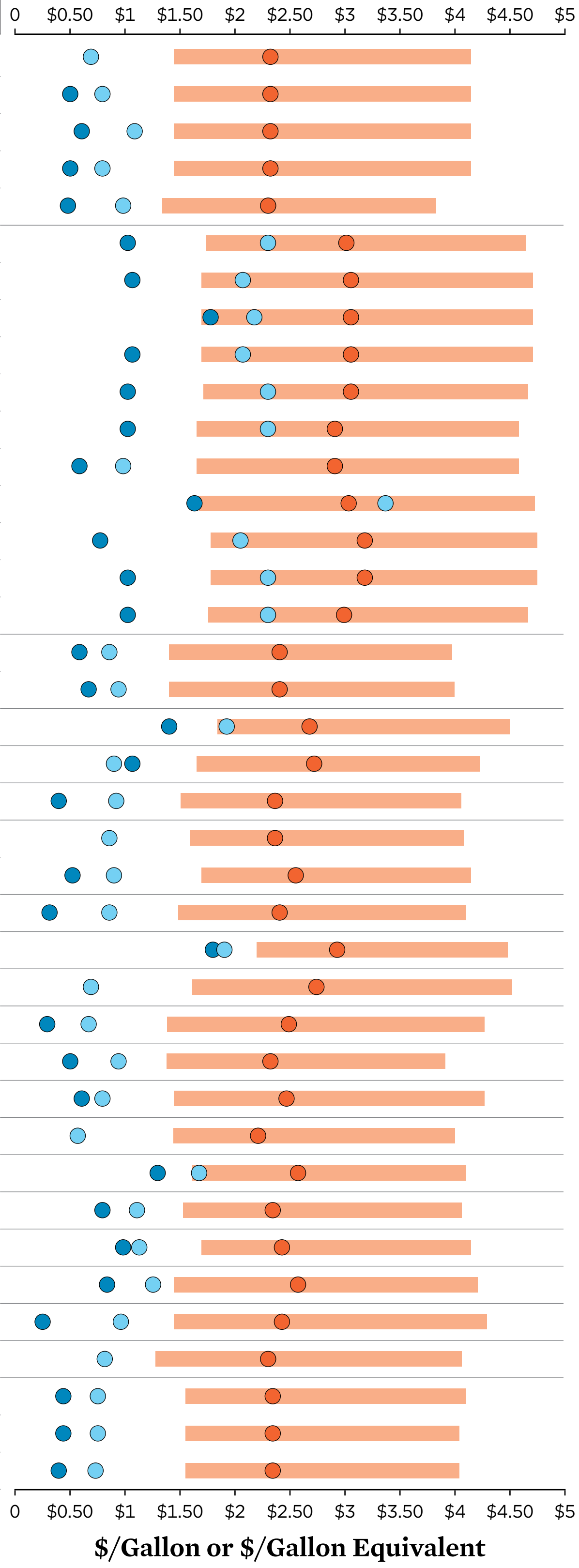
Time-of-Use Plans: Time-of use (TOU) plans offer lower prices for electricity during times when demand is low because electricity providers can draw on less costly generation sources. These off-peak hours are usually late at night and early in the morning, although the exact times depend on the provider's generation sources and consumer demand.

TOU plans are often the lowest-cost electricity for charging an EV. However, this type of plan also increases the cost of electricity during peak hours, so households that need to use large appliances or air conditioning during the day would need to consider their ability to reduce use during these peak hours. Some service providers allow the installation of a separate meter for the electric vehicle: the owner can charge the EV on a TOU rate while using a flat rate for the rest of household electricity use.

> ***Time-of-use rates can mean significant savings on off-peak power use.***

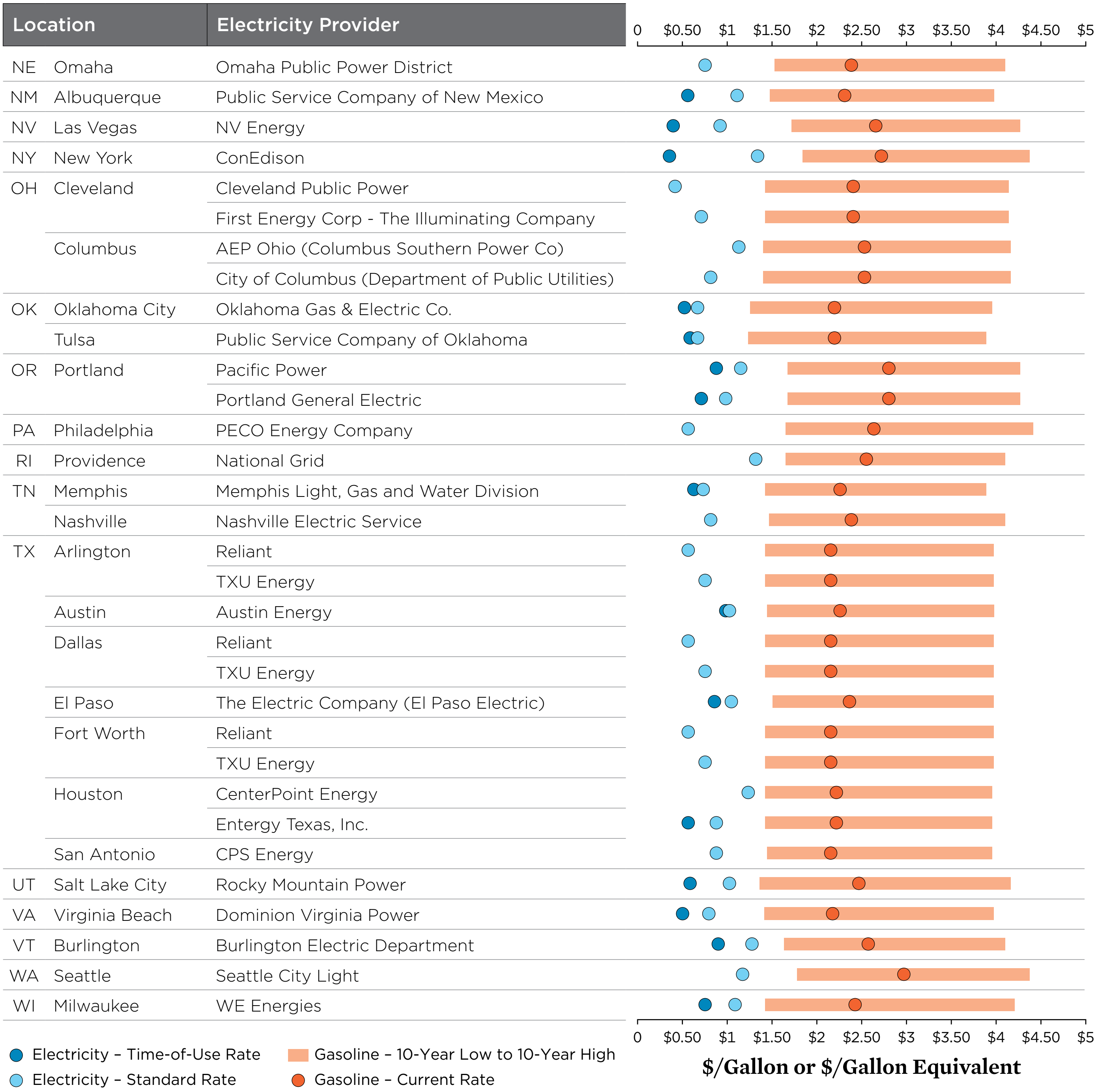
FIGURE 1. Comparing Electricity and Gasoline Refueling Costs

Location		Electricity Provider
AZ	Mesa	City of Mesa
		Salt River Project
	Phoenix	APS
		Salt River Project
	Tucson	Tucson Electric Power
CA	Fresno	Pacific Gas and Electric Company
	Long Beach	Southern California Edison
	Los Angeles	Los Angeles Department of Water and Power
		Southern California Edison
	Oakland	Pacific Gas and Electric Company
	Sacramento	Pacific Gas and Electric Company
		Sacramento Municipal Utility District
	San Diego	San Diego Gas and Electric
	San Francisco	Clean Power SF
		Pacific Gas and Electric Company
	San Jose	Pacific Gas and Electric Company
CO	Colorado Springs	Colorado Springs Utilities
	Denver	Xcel Energy
CT	Bridgeport	United Illuminating Company
DC	Washington	Pepco
DE	Wilmington	Delmarva Power
FL	Jacksonville	Jacksonville Electric Authority
	Miami	Florida Power & Light Company
GA	Atlanta	Georgia Power
HI	Honolulu	Hawaiian Electric Company
IL	Chicago	ComEd
IN	Indianapolis	Indianapolis Power & Light Company
KS	Wichita	Westar Energy
KY	Louisville	Louisville Gas and Electric
LA	New Orleans	Entergy New Orleans, Inc.
MA	Boston	Eversource
MD	Baltimore	Baltimore Gas & Electric Company
ME	Portland	Central Maine Power
MI	Detroit	DTE Energy Company
MN	Minneapolis	Xcel Energy
MO	Kansas City	Kansas City Power & Light (Missouri)
NC	Charlotte	Duke Energy
	Raleigh	Duke Energy Progress Carolinas
		Piedmont Electric Membership Corporation



● Electricity – Time-of-Use Rate
○ Electricity – Standard Rate
▬ Gasoline – 10-Year Low to 10-Year High
● Gasoline – Current Rate

FIGURE 1. **Comparing Electricity and Gasoline Refueling Costs** CONTINUED



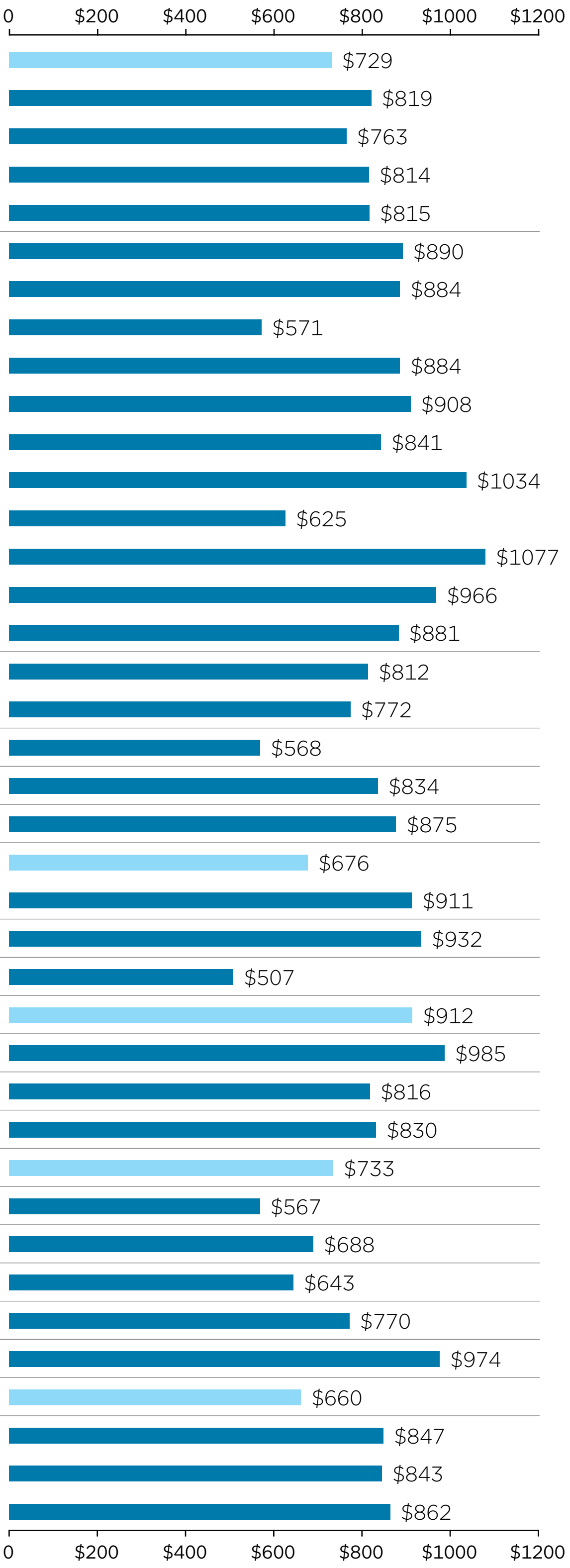
Location		Electricity Provider
NE	Omaha	Omaha Public Power District
NM	Albuquerque	Public Service Company of New Mexico
NV	Las Vegas	NV Energy
NY	New York	ConEdison
OH	Cleveland	Cleveland Public Power
		First Energy Corp - The Illuminating Company
	Columbus	AEP Ohio (Columbus Southern Power Co)
		City of Columbus (Department of Public Utilities)
OK	Oklahoma City	Oklahoma Gas & Electric Co.
	Tulsa	Public Service Company of Oklahoma
OR	Portland	Pacific Power
		Portland General Electric
PA	Philadelphia	PECO Energy Company
RI	Providence	National Grid
TN	Memphis	Memphis Light, Gas and Water Division
	Nashville	Nashville Electric Service
TX	Arlington	Reliant
		TXU Energy
	Austin	Austin Energy
	Dallas	Reliant
		TXU Energy
	El Paso	The Electric Company (El Paso Electric)
	Fort Worth	Reliant
		TXU Energy
	Houston	CenterPoint Energy
		Entergy Texas, Inc.
	San Antonio	CPS Energy
UT	Salt Lake City	Rocky Mountain Power
VA	Virginia Beach	Dominion Virginia Power
VT	Burlington	Burlington Electric Department
WA	Seattle	Seattle City Light
WI	Milwaukee	WE Energies

The cost of electricity to recharge an EV using the standard rate plan is often lower than the equivalent cost of gasoline, and using a TOU rate plan is always lower. In fact, refueling an EV is often cheaper than even the lowest gasoline price of the last 10 years.

Note: Both electricity and gasoline costs include taxes and fees. Gasoline equivalency based on average electric efficiency of 0.325 kWh per mile and average new gasoline vehicle efficiency of 25.6 mpg.

FIGURE 2. Annual Fuel Savings from Using the Average EV Instead of the Average New Gasoline Vehicle

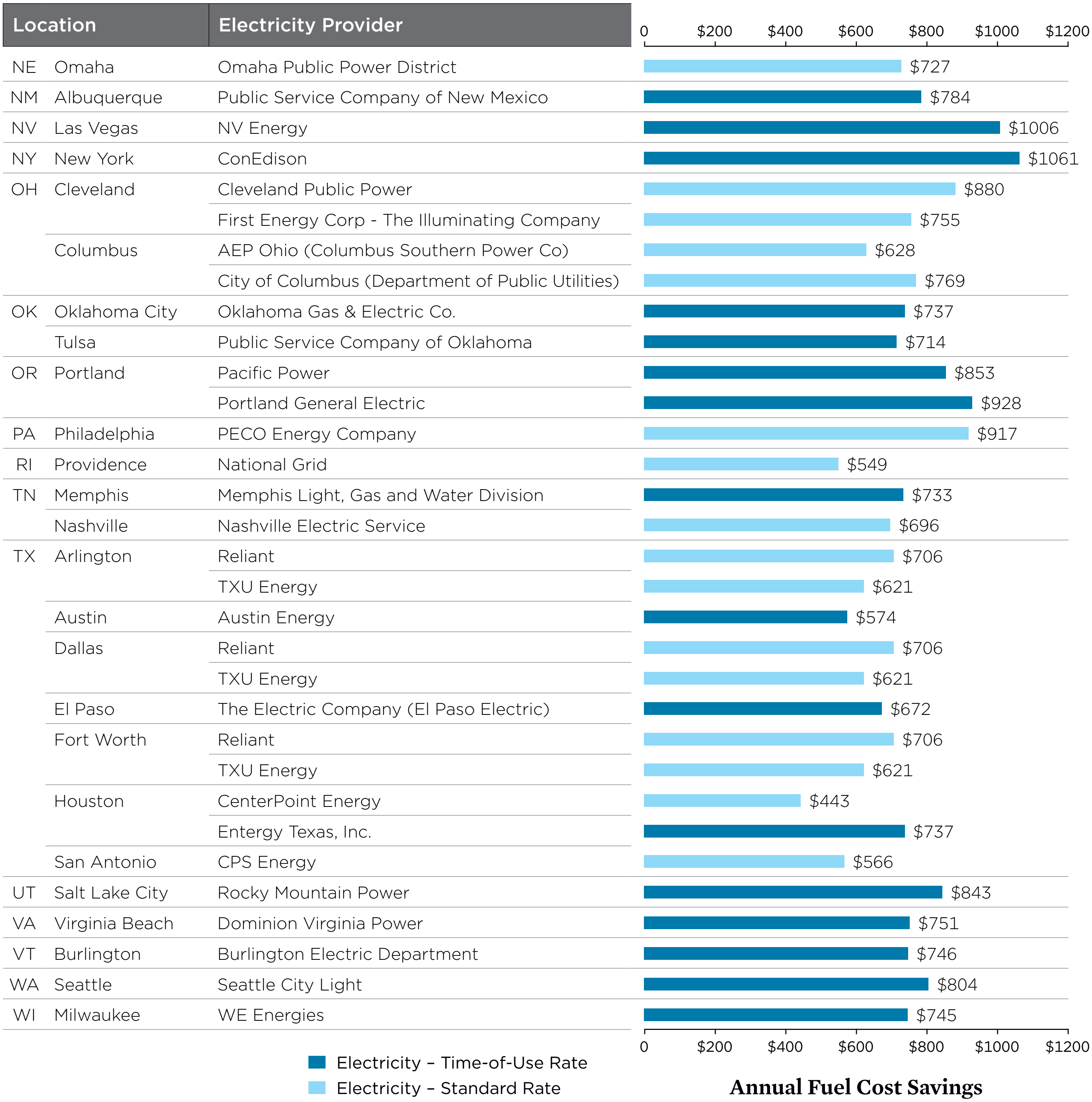
Location		Electricity Provider	
AZ	Mesa	City of Mesa	$729
		Salt River Project	$819
	Phoenix	APS	$763
		Salt River	$814
	Tucson	Tucson Electric Power	$815
CA	Fresno	Pacific Gas and Electric Company	$890
	Long Beach	Southern California Edison	$884
	Los Angeles	Los Angeles Department of Water and Power	$571
		Southern California Edison	$884
	Oakland	Pacific Gas and Electric Company	$908
	Sacramento	Pacific Gas and Electric Company	$841
		Sacramento Municipal Utility District	$1034
	San Diego	San Diego Gas and Electric	$625
	San Francisco	Clean Power SF	$1077
		Pacific Gas and Electric Company	$966
	San Jose	Pacific Gas and Electric Company	$881
CO	Colorado Springs	Colorado Springs Utilities	$812
	Denver	Xcel Energy	$772
CT	Bridgeport	United Illuminating Company	$568
DC	Washington	Pepco	$834
DE	Wilmington	Delmarva Power	$875
FL	Jacksonville	Jacksonville Electric Authority	$676
	Miami	Florida Power & Light Company	$911
GA	Atlanta	Georgia Power	$932
HI	Honolulu	Hawaiian Electric Company	$507
IL	Chicago	ComEd	$912
IN	Indianapolis	Indianapolis Power & Light Company	$985
KS	Wichita	Westar Energy	$816
KY	Louisville	Louisville Gas and Electric	$830
LA	New Orleans	Entergy New Orleans, Inc.	$733
MA	Boston	Eversource	$567
MD	Baltimore	Baltimore Gas & Electric Company	$688
ME	Portland	Central Maine Power	$643
MI	Detroit	DTE Energy Company	$770
MN	Minneapolis	Xcel Energy	$974
MO	Kansas City	Kansas City Power & Light (Missouri)	$660
NC	Charlotte	Duke Energy	$847
	Raleigh	Duke Energy Progress Carolinas	$843
		Piedmont Electric Membership Corporation	$862



Electricity – Time-of-Use Rate

Electricity – Standard Rate

FIGURE 2. Annual Fuel Savings from Using the Average EV Instead of the Average New Gasoline Vehicle CONTINUED



Location		Electricity Provider	
NE	Omaha	Omaha Public Power District	□ $727
NM	Albuquerque	Public Service Company of New Mexico	■ $784
NV	Las Vegas	NV Energy	■ $1006
NY	New York	ConEdison	■ $1061
OH	Cleveland	Cleveland Public Power	□ $880
		First Energy Corp - The Illuminating Company	□ $755
	Columbus	AEP Ohio (Columbus Southern Power Co)	□ $628
		City of Columbus (Department of Public Utilities)	□ $769
OK	Oklahoma City	Oklahoma Gas & Electric Co.	■ $737
	Tulsa	Public Service Company of Oklahoma	■ $714
OR	Portland	Pacific Power	■ $853
		Portland General Electric	■ $928
PA	Philadelphia	PECO Energy Company	□ $917
RI	Providence	National Grid	□ $549
TN	Memphis	Memphis Light, Gas and Water Division	■ $733
	Nashville	Nashville Electric Service	□ $696
TX	Arlington	Reliant	□ $706
		TXU Energy	□ $621
	Austin	Austin Energy	■ $574
	Dallas	Reliant	□ $706
		TXU Energy	□ $621
	El Paso	The Electric Company (El Paso Electric)	■ $672
	Fort Worth	Reliant	□ $706
		TXU Energy	□ $621
	Houston	CenterPoint Energy	□ $443
		Entergy Texas, Inc.	■ $737
	San Antonio	CPS Energy	□ $566
UT	Salt Lake City	Rocky Mountain Power	■ $843
VA	Virginia Beach	Dominion Virginia Power	■ $751
VT	Burlington	Burlington Electric Department	■ $746
WA	Seattle	Seattle City Light	■ $804
WI	Milwaukee	WE Energies	■ $745

■ Electricity – Time-of-Use Rate
□ Electricity – Standard Rate

Annual Fuel Cost Savings

The median EV driver could save more than $770 per year compared with the cost of driving the average new gasoline vehicle ($706 on a standard rate plan, and $818 on a time-of-use plan). Annual savings were calculated using the lowest electric rate plan available for EV charging and October 2017 gasoline prices in each city. Values in dark blue represent cities where a time-of-use rate plan is the lowest cost option and light blue shows cities where a standard (flat) rate plan is the lowest-cost or only option for residents.

This could help EV drivers: customers will default to a plan that is cheaper for most EV drivers. Those who do not have EVs can still save money if they can shift their electric use to lower-cost time periods.

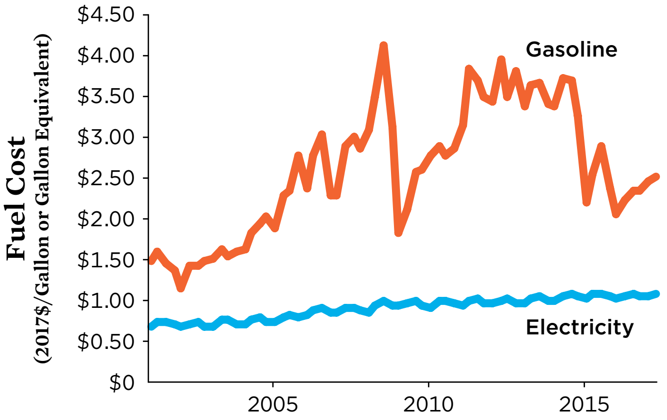
Off-peak charging benefits electricity providers by lessening peak demand, but off-peak periods may not align with the availability of low-emission sources of electricity like wind and solar power. In areas with higher amounts of intermittent renewable generation, it may be important to coordinate electric rates for EV charging with the availability of renewables. This would reduce the cost of charging and minimize emissions from EV recharging (O'Connor and Jacobs 2017).

By comparing the cost of refueling the average new gasoline vehicle with the cost of recharging an EV on the cheapest electric rate plan available, UCS estimated the average annual fuel cost savings for switching from gasoline to electricity (Figure 2, p. 6–7). For every city in the study, the annual savings exceed $440 per year, and the median savings are more than $770 per year. In four cities, at least one electricity provider offers a rate plan that would lead to more than $1,000 in annual fuel savings. Most providers with the highest savings offer a TOU rate.

Electricity Prices: Less Volatility

While the price of electricity varies among electricity providers, the average is much less volatile than that of gasoline (Figure 3). US electricity prices often rise in the summer, but year-to-year variations are low (EIA 2017a). In comparison, regional and national gasoline prices vary greatly and unpredictably, whether in response to refinery accidents, natural disasters, global politics, military actions, or other events.

FIGURE 3. Price Volatility, Electricity vs. Gasoline



Average US residential electricity prices are much more stable than gasoline prices.

Note: Prices are in constant dollars, referenced to September 2017.

SOURCE: EIA 2017A, EIA 2017B, AND BLS 2017.

> ***While electricity prices can vary, the average is much less volatile than that of gasoline.***

Over the past 15 years, the average residential electricity rate in the United States has remained nearly constant except for minor and predictable seasonal variations. In constant dollars, the price of electricity as vehicle fuel has ranged from $0.88 to $1.17 per gallon gasoline equivalent over the last 15 years. Gasoline prices have swung from below $2.00 per gallon to more than $4.50 a gallon (EIA 2017b; BLS 2017).

While EV drivers benefit from lower and more predictable fuel costs, gasoline-powered vehicles expose car buyers to potentially large increases. For example, hurricanes in 2017 caused gas spikes of more than 30 cents per gallon in one week, and a 2015 refinery fire in California led to price jumps in the state of 25 cents in one week (Anair 2017; Flaccus 2015).

Cost of Charging at Public Charging Stations

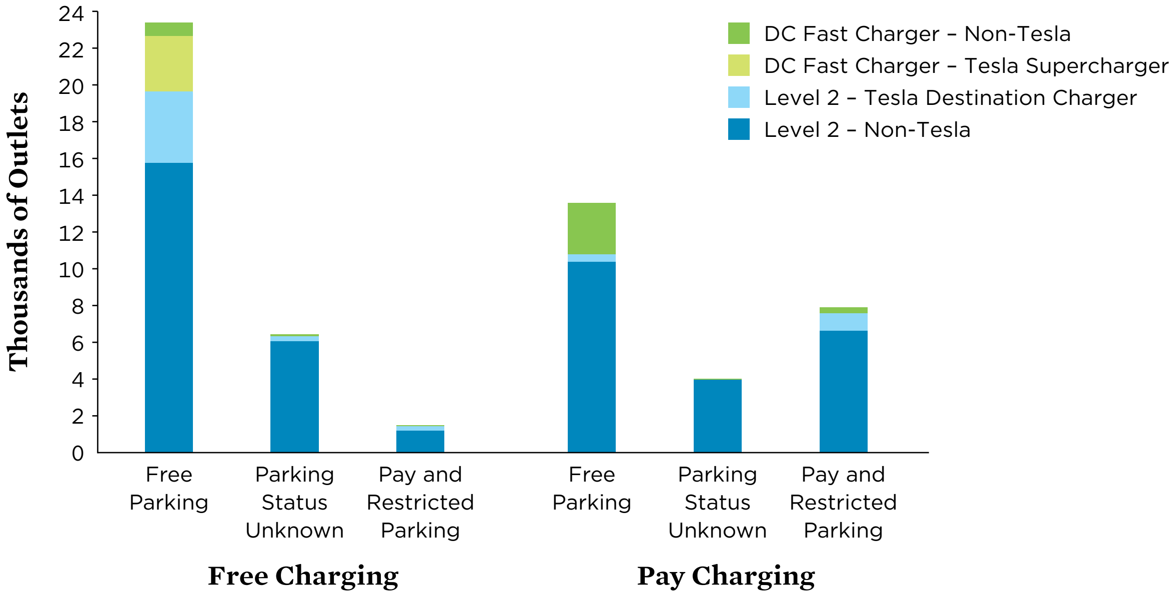
About 80 percent or more of all EV charging takes place at home (ARB 2017a; INL 2015). However, some charging uses facilities away from home—workplace charging, free public charging, or paid public charging (often via a charging network provider).

The cost of charging outside the home varies considerably. Many workplace chargers are free, as are some public chargers. Public chargers that are not free have a number of cost structures. Some are free to use but are located in paid parking facilities. Others base costs on the length of time charging or the amount of energy used, or they simply have a flat fee per session. Some charging network companies offer subscription plans that include unlimited charging or result in a discounted rate. And some automakers include free access to public charging networks, either through a third-party network or, in the case of Tesla, through infrastructure built and owned by the EV manufacturer. Many of the slower, Level 2 chargers in the United States are available for free (Figure 4). Except for the Tesla chargers, most of the high-power, DC fast chargers (DCFC) require payment (Box 2, p. 10) (Recargo 2017).

Clean Energy Resource Team/Creative Commons (Flickr)

The cost for charging an EV away from home can vary: some chargers are free but others require a subscription fee.

FIGURE 4. Public EV Charging Outlets in the United States, by Type



Many Level 2 stations are free or free with paid parking. Most DC fast charge stations, except for Tesla Superchargers, require payment for charging, parking, or both. Some stations, such as Tesla destination chargers, are installed at businesses (such as hotels and restaurants) and are free to patrons of the businesses but require payment otherwise.

SOURCE: UCS ANALYSIS OF RECARGO INC. 2017.

BOX 2.

Types of Charging

Level 1—Home Charging: Level 1 charging cords are standard equipment on a new EV. Level 1 charging only requires a grounded (three-prong) 120V outlet and can add about 40 miles of range in an eight-hour overnight charge. Overnight Level 1 charging is suitable for low- and medium-range plug-in hybrids and for battery electric vehicles with low daily driving usage.

Level 2—Home and Public Charging: Level 2 charging typically requires a charging unit on a 240V circuit, like the circuit used to power a common electric clothes dryer. The charging rate depends on the vehicle's acceptance rate and the maximum current available. With a typical 30 amp circuit, about 180 miles can be added overnight during an eight-hour charge. Level 2 chargers are the most common public chargers. Public Level 2 chargers have a standard EV connection plug that fits all current vehicles, except for Teslas, which require an adapter.

DC Fast Charging (DCFC)—Public Charging: DC fast charging is the fastest currently available recharging method. It can typically add 50 to 90 miles in 30 minutes, depending on the station's power capacity and the make of EV. Tesla's Superchargers are even faster, adding up to 170 miles of range in a half hour. DC fast chargers are most useful for longer trips, cars in use most of the day (like taxis), and drivers who have limited access to home recharging.

DC fast chargers use three different plug types and are not interchangeable. Japanese automakers typically use the CHAdeMO standard; most European and American makers use the CCS system. Tesla's Supercharging stations use a proprietary connector specific to their vehicles.

Public Charging: Minimal Impact on Overall Cost Savings

Because the costs of charging at public stations and workplaces vary highly, it is not possible to calculate exact costs for recharging outside the home. However, we can estimate the costs to use an EV with some of the charging occurring at public facilities. Using San Francisco as an example, if 20 percent of EV charging happens at Level 2 public chargers, average fuel costs could increase from $0.78 per gallon equivalent to $1.05 per gallon (Table 1). If 20 percent of the charging occurs at faster, but typically more expensive, DC fast chargers, then the cost would increase to the equivalent of $1.36 per gallon, still well below San Francisco's average gasoline price in September 2017 of $3.30 per gallon.

Most fee-based, DC fast charging is priced at a premium and serves as a way to enable occasional longer trips. However, some fast charging is being deployed in urban locations in order to serve the needs of those without easy access to home recharging. For example, Tesla has announced plans to install DC fast charging units in urban parking structures (Lambert 2017).

In California, most DC fast chargers have effective charging costs of less than $4 per gallon equivalent (Figure 5), although some are priced above $5 per gallon. For EV drivers who rely on DCFC for most or all of their needs, the pricing needs to be competitive with that of other options like gasoline-powered vehicles. Some EV charging providers offer plans with monthly fees that allow for lower-cost DC fast charging.

> [*EV charging providers offer plans that allow for lower-cost DC fast charging.*]

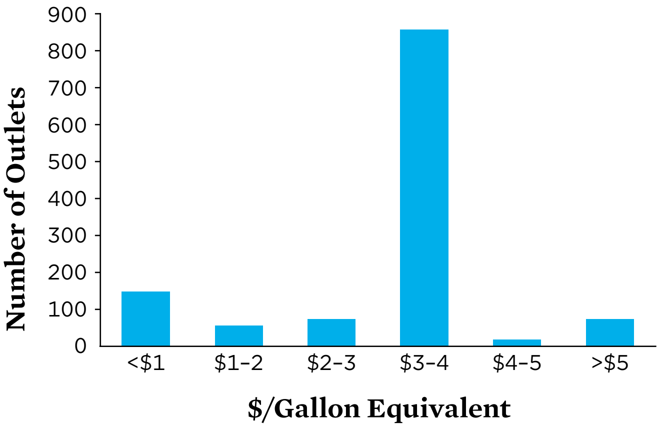
TABLE 1. Illustrative Costs to Charge in San Francisco, Based on Mix of Charging Types

Home Charging	Free Level 2 Charging	Paid Level 2 Charging	Paid DC Fast Charging (DCFC)	Average Fuel Cost
100%	0%	0%	0%	$0.78/gallon equivalent
80%	20%	0%	0%	$0.62/ gallon equivalent
80%	0%	20%	0%	$1.05/ gallon equivalent
80%	0%	0%	20%	$1.35/ gallon equivalent

The majority of EV owners will use a mix of charging types to fuel their vehicle. A combination of home and free charging represents the biggest savings.

Note: Home charging represents Clean Power SF's time-of-use-rates. Paid Level 2 and DC Fast Charge represent EVGO's Flex non-subscription plan.

FIGURE 5. Non-Tesla DCFC Charging Outlets in California, by Price



The cost to charge at DCFC stations in California varies greatly, but it is often less than $4 per gallon equivalent. Most EV drivers use DCFC only occasionally, so they offset the higher charging costs for DCFC with lower Level 1 and 2 charging costs at home.

Note: This analysis does not include charging providers' membership plans, which can reduce the effective cost to charge. Some EV manufacturers include free DCFC privileges for a set period after purchase.

SOURCE: UCS ANALYSIS OF RECARGO INC. 2017.

Charging Infrastructure: Spreading but More Is Needed

The availability of charging stations is an important consideration for EV owners. Level 2 chargers are most common, with more than 16,000 stations in the United States (Figure 6, p. 12) (DOE 2107). Concentrated in California and other states with higher EV sales, they are available across the country. When it comes to DC fast chargers, non-Tesla outlets are less common nationwide and concentrated in coastal states and urban areas (Figure 7, p. 13). Tesla's DCFC Supercharger network shows better coverage for nationwide long-distance travel, with fast-charging stations spaced along major travel routes (Figure 8, p. 13).

The difference between Tesla's DCFC deployment and that of other DCFC networks reflects different business models. Tesla has built a network of stations to build confidence among drivers; low utilization of charging stations is not a concern because Tesla derives little revenue from charging. (Most Tesla drivers can charge for free, although drivers of their new Model 3 EV will be charged.) In contrast, the charging networks that supply most non-Tesla DC fast chargers earn more for their investors when utilization is high. Hence, they place chargers in locations with a high density of EVs.

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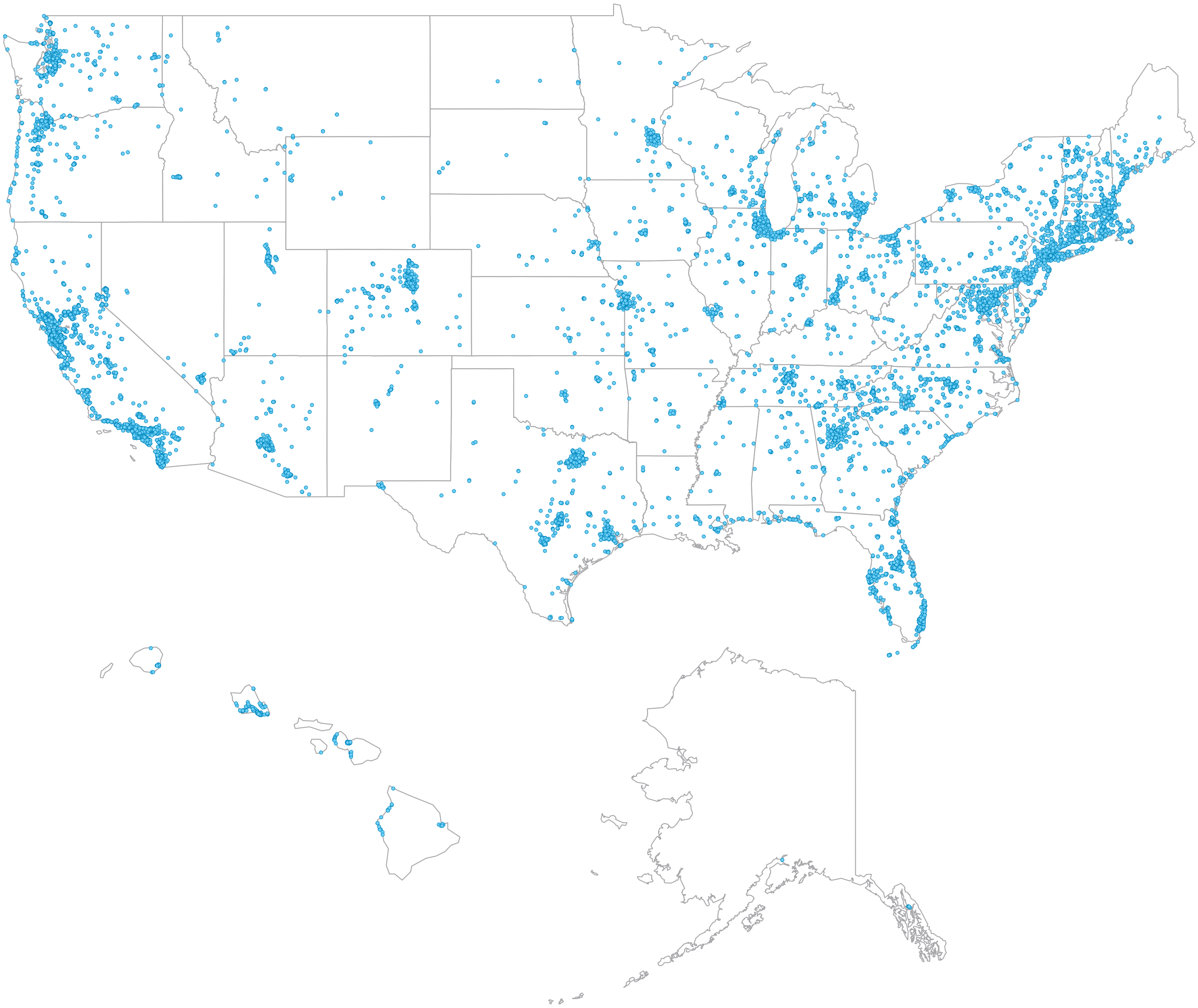
EVgo Network/Creative Commons (Flickr)

DC fast chargers allow for longer distance travel and could help provide charging for those unable to charge easily at home. The cost to use DC fast charging varies greatly, but is often less than $4/gallon equivalent.

FIGURE 6. Public Level 2 EV Chargers

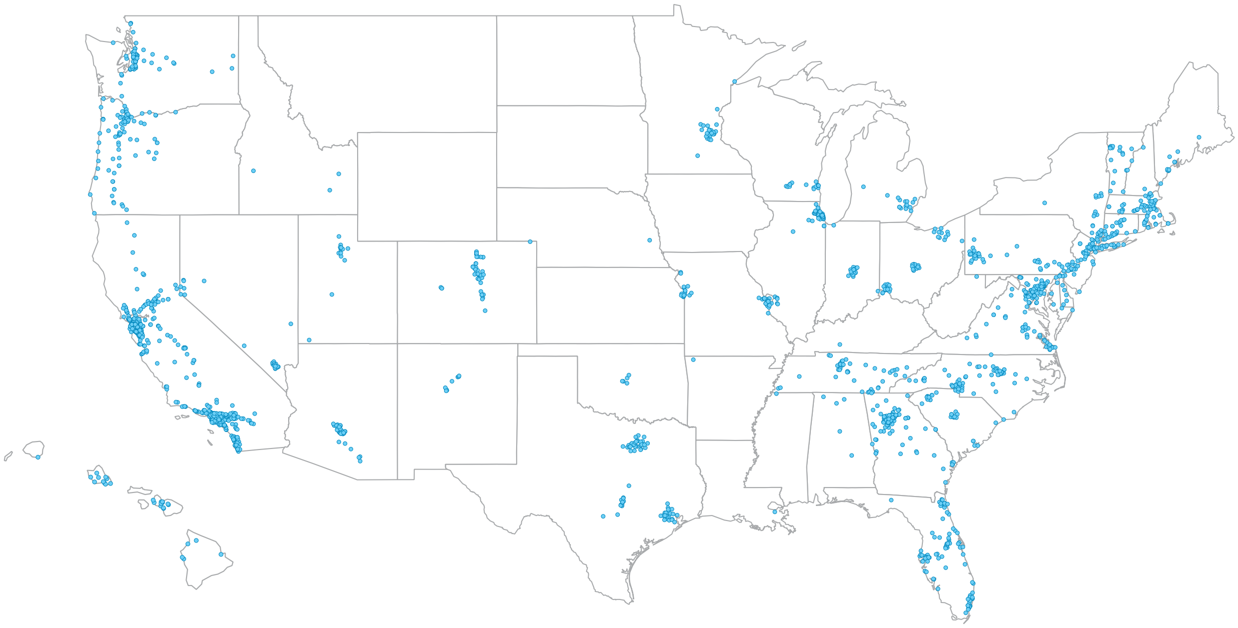


More than 16,000 Level 2 chargers are spread across the United States.

SOURCE: DOE 2017.

> ***[Level 2 chargers are available across the country, though they are most common in states with high EV sales.]***

FIGURE 7. Public DC Fast Chargers – Non-Tesla

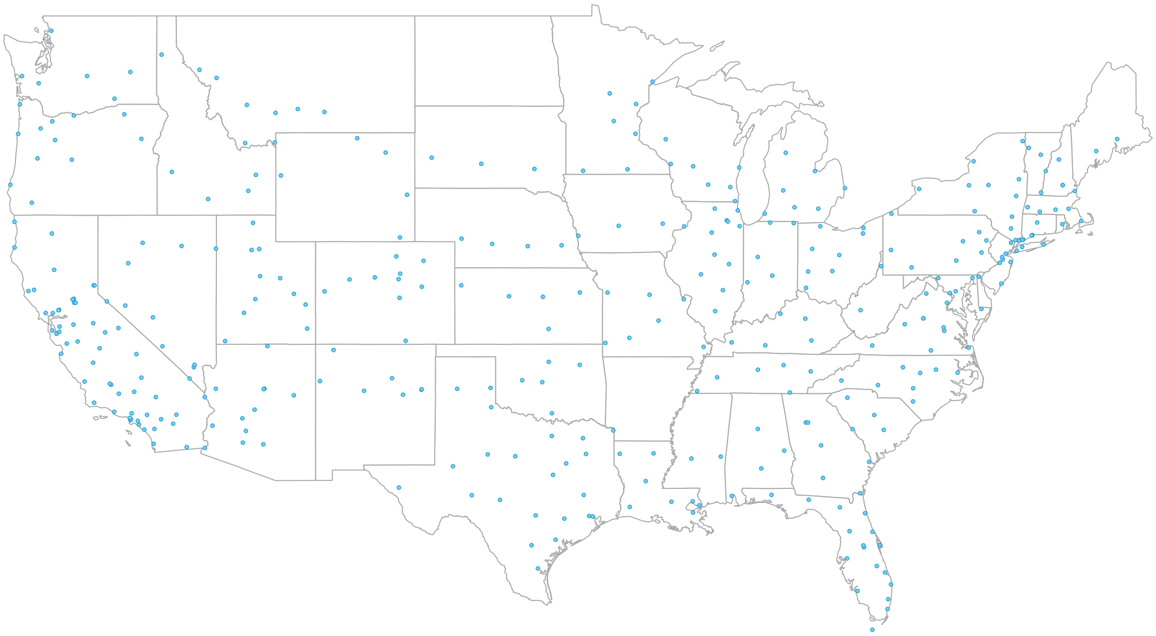


DC fast chargers (non-Tesla) are less common and concentrated in coastal states and urban areas.

Note: As of publication, there are no DC fast chargers in Alaska.

SOURCE: DOE 2017.

FIGURE 8. Public DC Fast Chargers – Tesla



Tesla DC fast chargers (also called Superchargers) cover major cities and are spaced along many interurban highways.

Note: As of publication, there are no DC fast chargers in Alaska and no Tesla DC fast chargers in Hawaii.

SOURCE: DOE 2017.

To increase the rate of EV adoption, other automakers could coordinate with charging providers to improve the DCFC infrastructure. Volkswagen is taking steps in this direction, investing in a network of DC fast chargers in cities and along highway corridors (ARB 2017b, VW 2017). These investments, mandated as part of the settlement over illegal emissions from Volkswagen's diesel vehicles, may not be applicable to other automakers.

Purchase Costs

Declining vehicle costs, combined with savings on vehicle maintenance and fuel, are making electric vehicles more affordable.

On average, the manufacturer's recommended retail price (MSRP) of an electric vehicle is higher than that of a comparable non-plug-in vehicle. The average transaction price for EVs (excluding Teslas) is about $4,000 higher than the overall average for new vehicles (Table 2) (KBB 2017). However, MSRP and transaction price data do not include significant incentives from manufacturers and federal and state governments.

Incentives vary in amount and type. For example, Colorado offers a $5,000 income tax credit; California provides rebates of $1,500 to $4,500, depending on the vehicle type and the purchaser's income. EV buyers also qualify for a federal income tax credit of up to $7,500. After incentives, the net MSRP for an EV can be similar to or even lower than that of a comparable gasoline car (Table 3).

In the case of a lease, the federal tax credit typically goes to the leasing company and allows for significantly lower lease costs. Deals vary quite a bit, but some manufacturers offer EVs at low rates using both the federal incentive and dealer incentives (Table 4). For example, dealers have offered Nissan LEAF and Fiat 500e leases for less than $150 per month, inclusive of down payment (Charge!!! 2017). When paired with fuel savings of $50 to $80 per month and potential state incentives, the net price of some leased EVs could be cheaper than a mobile phone plan or a cup of coffee every day for a month.

The cost to produce the EV's battery pack leads to higher manufacturing costs for EVs than for gasoline vehicles and hence higher EV prices. Over time, though, the cost of batteries will fall, as it has in recent years, due to increased production and technological advances. Lower battery costs and the availability of more EV models will likely bring the selling prices of EVs in line with those of gasoline vehicles, gradually reducing the need for incentives (Reichmuth and Goldman 2017).

An additional cost for some EV buyers is the purchase and, potentially, installation of a home charger unit (also known as EV supply equipment or EVSE).

> ***EV buyers qualify for a federal income tax credit of up to $7,500.***

TABLE 2. Average Transaction Price for New Cars, August 2017

Vehicle Type	Average Transaction Price
Subcompact Car	$16,442
Compact Car	$20,377
Subcompact SUV/Crossover	$24,387
Midsize Car	$24,782
Hybrid/Alternative Energy Car	$25,922
Compact SUV/Crossover	$28,416
Sports Car	$30,069
Midsize Pickup Truck	$32,473
Minivan	$33,872
Van	$34,529
Average New Gasoline-Powered Vehicle	**$34,646**
Full-Size Car	$34,699
Midsize SUV/Crossover	$37,421
Average New Electric Vehicle Before Federal Tax Credit (up to $7,500) and Potential State Incentives	**$38,701**
Entry-Level Luxury Car	$41,797
Luxury Compact SUV/Crossover	$43,175
Full-Size Pickup Truck	$46,464
Luxury Midsize SUV/Crossover	$53,915
Luxury Car	$57,061
Full-Size SUV/Crossover	$60,933
Luxury Full-Size SUV/Crossover	$81,880
High-Performance Car	$92,009
High-End Luxury Car	$95,219

EVs are priced competitively with comparable gasoline-powered cars, even before rebates and other incentives.

Notes: Prices include both lease and purchase transactions but not taxes, fees, or customer incentives. Tesla EVs are not included in the average transaction price for EVs due to lack of data from nondealership sales.

SOURCE: KBB 2017.

TABLE 3. Comparing the Purchase Prices of EVs and Comparable Gasoline Vehicles

	Ford Focus EV	Ford Focus Titanium	Toyota Prius Prime Plus	Toyota Prius One	VW eGolf	VW Golf S	Chevy Bolt LT	Chevy Sonic Hatchback Premier
Powertrain	Plug-in EV (BEV)	Gasoline	Plug-in EV (PHEV)	Gasoline Hybrid	Plug-in EV (BEV)	Gasoline	Plug-in EV (BEV)	Gasoline
MSRP	$31,075	$24,074	$27,100	$23,475	$28,995	$19,895	$37,495	$22,170
Federal Tax Credit	$7,500	-	$4,502	-	$7,500	-	$7,500	-
Total Before Manufacturer Incentives, Taxes, and Fees)	**$23,575**	**$24,074**	**$22,598**	**$23,475**	**$21,495**	**$19,895**	**$29,995**	**$22,170**
EV Cost Difference	**(-$499)**	-	**(-$877)**	-	**$1,600**	-	**$7,825**	-
Additional California State Rebate Available	$2,500	-	$1,500	-	$2,500	-	$2,500	-

EVs are affordable, with pricing that compares favorably with that of similar gasoline vehicles when federal incentives are available. Some EVs have a list price below the comparable gasoline car after applying the federal income tax credit.

Note: BEV stands for battery electric vehicle; PHEV stands for plug-in hybrid electric vehicle. Some states make additional incentives available to further reduce the cost of an EV. California is shown as an example. All numbers represent the 2017 model year.

Plug-in hybrids (PHEVs), especially those with lower-capacity batteries (and shorter ranges), may not require the installation of a charging unit; they can fully recharge in less than eight hours using the included Level 1 charging cable and a standard grounded 120V outlet. Many drivers of BEVs, especially those with higher-than-average daily driving needs, will require a dedicated home-charging unit installed on a 240V circuit. Level 2 charging units for home use typically cost $400 to $800, depending on power level and features like internet connectivity. Installation costs vary, depending on the existing home electric circuit, the potential need to upgrade or add a circuit, and any permits or professional electrician services required. In California, the median cost for the equipment and installation is $900 (ARB 2017a).

TABLE 4. EV Lease Offers

EV	Lease Term (months)	State	Effective Monthly Cost	Effective Monthly Cost after State Incentive
Nissan LEAF S	24	MA	$144	$144*
Fiat 550e	36	CA	$147	$78
Chevrolet Volt	36	MA	$148	$79
VW e-Golf SE	30	CA	$170	$87
Chevrolet Bolt EV	36	CA	$193	$124

EV lease offers are available for well under $200 per month.

Note: The monthly cost includes the down payment and monthly payment but not taxes or fees. Lease offers may include conditional manufacturer incentives such as discounts for new college graduates or current company lessee. Not all buyers will meet the income eligibility requirements for the California rebate.

* 36-month lease term required for Massachusetts rebate

SOURCE: CHARGE!!! 2017.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With purchase incentives and lower maintenance costs, EVs can be cost-competitive with conventional gasoline-powered vehicles.

Lower Maintenance Costs

Maintenance presents further potential savings for the owners of plug-in EVs, especially battery electric vehicles, because they have no gasoline engine to maintain. Electric motors require no routine maintenance, and EVs often have much simpler gearing and transmission systems than do gasoline cars. Therefore, BEVs avoid most periodic changes of oil, oil filters, and transmission fluid.

Compared with the similarly sized, gasoline-powered Chevrolet Sonic, the recommended maintenance for the Chevrolet Bolt EV costs more than $1,500 less (Table 5). EVs do require some upkeep, of course, such as replacing worn-out tires and brake pads. The tires may require replacement slightly earlier due to the battery packs' additional weight.

> ***Unlike gasoline motors, electric motors require no routine maintenance.***

TABLE 5. Lower Maintenance Costs for Electric Vehicles

Service	Frequency (per 150,000 miles)	Cost per Occurrence	Cost for Chevrolet Bolt EV	Cost for Chevrolet Sonic
Tire rotation	20	$30	$600	$600
Engine oil and oil filer replacement	20	$45	0	$900
Cabin air filter replacement	6	$45.50	$273	$273
Engine air filter replacement	3	$69	0	$207
Spark plug replacement	2	$219.50	0	$439
Coolant flush and replacement	1	$110	$110	$110
Total	**–**	**–**	**$983**	**$2,529**

The manufacturer's recommended services are $1,500 more expensive for a Chevrolet Sonic than for a similarly sized Chevrolet Bolt EV when driven for 150,000 miles.

SOURCE: UCS ANALYSIS OF REPAIRPAL 2017.

However, an EV's brake pads should last considerably longer because EVs have regenerative braking systems that reduce friction braking and therefore pad wear. Overall, the average EV will save $2,100 over a medium-sized, gasoline-powered sedan for maintenance, repairs, and tires when driven 150,000 miles, according to estimates from the American Automobile Association (AAA 2017).

Findings

- **Driving an EV instead of a gasoline-powered car can lead to significant fuel cost savings.** In every city examined in the UCS study, an electric rate plan would allow for EV charging at an effective cost lower than that of gasoline. Estimated annual savings range from $443 to $1,077, depending on the electricity provider and the local cost of gasoline. In general, the savings are higher if providers offer time-of-use rate plans with cheaper off-peak rates, but even a standard rate plan leads to savings for all but five California electricity providers. Using paid public charging for a portion of EV recharging can increase the cost of fuel for an EV, but total costs remain lower than those for the average new gasoline vehicle.
- **The initial cost of an EV compared with that of a gasoline vehicle is a barrier to adoption, but federal and state incentives make EVs affordable to more buyers.** After applying the federal income tax credit, the effective MSRP of an EV is often less than that of a comparable gasoline car. In states that offer additional EV purchase incentives, EVs are even more affordable. In addition, a number of manufacturers offers attractive EV leases, with effective lease prices sometimes less than $100 per month. Incentives and policies that make the initial cost of an EV affordable enable more drivers to take advantage of maintenance and fuel cost savings.

Consumer Recommendations

EVs enable drivers to realize significant fuel cost savings, but determining the cost of purchasing and charging a specific model can be complex. Prospective EV buyers should consider the following actions:

- **Evaluate the availability of electric power in the area where you intend to park.** A shorter-range PHEV (or a BEV driven shorter distances) may only need access to an unused 120 volt outlet. If you intend to install a higher-power, Level 2 charger and do not have a 240 volt circuit available, an electrician can help you evaluate options and costs.
- **Get information on rate options available for charging an EV.** You can get this from your local electricity provider's website or by contacting the provider. In particular, find out if your electric provider offers TOU rates. Some providers offer personalized assessments to help you choose the right plan.
- **Research the availability of state, local, and electricity provider incentives for buying an EV or EV charging equipment.** The US Department of Energy's EV incentives database is a good starting point for federal and state incentives: *https://energy.gov/eere/electricvehicles/electric-vehicles-tax-credits-and-other-incentives*. Your local electric provider may also be able to provide information.

Policy Recommendations

EVs reduce harmful emissions from transportation and can save drivers from high and unpredictable fuel prices. More EV models are becoming available and EV sales are rising, which are encouraging signs of the transition from petroleum to cleaner fuels like electricity. Policymakers, automakers, and electric service providers can accelerate this necessary transition.

ELECTRICITY POLICIES

- **Regulators and electric service providers should ensure that EV owners can access lower-cost electricity.** This is key to making EVs a reliable and affordable alternative to gasoline vehicles. The providers can help by offering TOU rates—to EV owners or more generally to all customers—with lower-cost charging during off-peak periods when use of the electric grid is lower.
- **Public policies that encourage the deployment of charging stations in urban areas and multi-unit dwellings (like apartment parking facilities) can help address the needs of those who cannot charge at home and those who drive long distances.** Access to reliable and affordable public charging, especially DC fast charging, will broaden the base of drivers who can choose an EV.
- **Electricity providers and regulators should ensure the availability of separate rates for EV use and household electricity use.** This would lower charging costs for those whose electricity needs would not benefit

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EVs are the right choice, both for the environment and for the wallet, and government policies and stronger incentives can help more people make the switch.

from TOU rate plans. Normal household electricity usage could remain on regular rates while EV charging could move to lower-cost off-peak rates.

- **Electricity providers and regulators should explore rate plans and charging technologies that encourage the coordination of EV charging with the availability of renewable electricity.** This could reduce the cost of charging, minimize emissions from EV recharging, and support additional renewable electricity integration onto the grid.

VEHICLE POLICIES

- **Policymakers, consumers, and automakers should advocate for extending the federal income tax credit and encourage more states to provide purchase incentives.** Purchase incentives are vital to making EVs an affordable and competitive option for car buyers at this time. The cost differential between producing an EV and a comparable gasoline vehicle is dropping and will continue to do so as sales volumes increase and EV technology improves. However, it is too soon to remove these important policies.
- **Policymakers should encourage programs targeting communities and demographics that could best benefit from lower fuel costs yet lack the ability to purchase EVs.** EVs offer significant savings on fuel costs, but the upfront cost can be a barrier to adoption, especially for lower-income households.
- **Public policies should encourage manufacturers to produce both more EVs and a greater diversity of models and sizes.** Increasing production volumes will help drive down costs and drive up investment in charging infrastructure. Adding EV models and vehicle types will increase the number of choices for consumers who want to take advantage of electricity as a fuel that saves money and reduces emissions.

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APPENDIX: METHODOLOGY

Costs for Home Charging

Rate design and costs were obtained via the US Department of Energy's Utility Rate Database (*https://openei.org/wiki/Utility_Rate_Database*), with confirmation using the websites of the electric service providers. The marginal volumetric rate including adjustments (taxes and fees) was determined for each service provider. Fixed charges (meter charges) were not included. Seasonal rates were averaged based on the proportional length of the season, with the assumption that EV electric use occurs at a constant rate throughout the year.

Demand charges were added if they were applied at all hours, assuming 30A, 240V (7.2 kW) charging with 1.4 hours of charging required per day (11,440 miles per year, 0.325 kWh per mile). If demand charges were applied only on peak hours, then no demand charges were added; it is assumed that charging would be avoided during peak periods. Tiered non-TOU rates assumed that EV charging was above the average household consumption as reported by the Energy Information Administration or more than 100 percent of baseline (if data were available). EV monthly charging was assumed to require 310 kWh/month (10.2 kWh/day). When both tiered and non-tiered TOU/EV rates were available, the non-tiered rates were used. If multiple TOU/EV rates were available, the rate with the lowest nighttime rate was chosen. Rates that required installation of an additional meter were not considered due to the difficulty in quantifying the expense and charges associated with installation and use of a second meter.

Rates for Texas and other deregulated markets were estimated by selecting representative rate plans with a 12-month contract period. Because the rate structures in deregulated markets can vary significantly between electricity providers, rates available in these markets may have resulted in lower electricity costs than those presented in this report.

For each rate where a per kWh charge (and per kW demand charge, if applicable) was known, the $/gasoline gallon equivalent was calculated using $/kWh × kWh/mile × miles/gallon, where the EV efficiency was the sales-weighted US EV efficiency (0.325 kWh/mi) and miles per gallon were 25.6, the average new vehicle efficiency for all vehicles manufactured in 2016 (EPA 2016).

The price for gasoline in each city was determined using data from GasBuddy (*www.gasbuddy.com/Charts*), using prices on October 24, 2017.

Cost for Public (Away from Home) Charging

The cost distribution for public charging stations was determined using the proprietary Plugshare database purchased from Recargo. To determine the number of free and pay public charging stations (Figure 4, p. 9), stations marked as "restricted" access were excluded from the totals. Additionally, stations that were identified as located at dealerships were excluded; access to these stations can be restricted to specific EV brands.

To determine the cost to charge at DC fast charge stations, a 30-minute session with 25 kWh electricity delivered was assumed. Per minute EV charging costs were included, but additional daily parking fees were not included in the charging costs. Several charging networks offered subscription or membership plans that reduced the cost of DC fast charging; however, this analysis assumed pay-as-you-go charging without a membership.

Scheduled Maintenance Cost Analysis

Scheduled maintenance costs for a 2017 Chevrolet Bolt EV and 2017 Chevrolet Sonic Premier Hatchback (1.4L turbo engine) were calculated using the schedule from the respective owner manuals, assuming ordinary driving conditions. Maintenance costs were estimated using the median national estimates for part and labor costs according to RepairPal (*www.repairpal.com*).

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