THE ELECTRIC VEHICLE TRANSITION
An Analysis of the EV Value Chain and Market Entry Strategies for an Energy Client

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Executive Summary

The increasing adoption of Electric Vehicles (EVs) will change the landscape of several industries including transportation, technology and electric power. EVs will impact the business plans and strategies of energy providers as they continue to provide energy to customers. An energy client is trying to capture the additional value that EVs are going to bring to the energy sector. This study analyzes and categorizes the current state of the EV market, both in Texas and nationally, organizes the current projections made from large industry reports, assesses the value chain of EVs and provides recommendations for an energy client about how to best proceed with a new strategy that incorporates EVs to make the firm successful in this quickly changing industry.

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Background

Client Background

The client is a large American energy company headquartered in [redacted]. They provide power to approximately [redacted] customers primarily in [redacted] and the [redacted] and operate approximately [redacted] of generation [redacted]. An energy client had a market cap of [redacted], total operating revenue of [redacted] in 2019, and a net income of [redacted], making it one of the largest energy companies in the United States [redacted]

[redacted]

[redacted]

An energy client is exploring the electric vehicle (EV) charging space to understand how the space is growing and how they will be affected. Our team is working with their EV task force to help inform them of trends and allow them to make recommendations that align with their strategy. They are particularly interested in learning more about the electric vehicle charging market and contracted the Duke team to help them better understand the state of affairs, the value chain, competitors, impacts on their business and potential market entry points for them.

Electric Vehicle State of Affairs

In the United States, transportation makes up the largest portion of greenhouse gas emissions, at 29% of all emissions, as seen in Figure 1 (US EPA, 2020). Further, in 2017, light-duty vehicles make up almost 60% of transportation emissions, as seen in Figure 2 (Penn State,

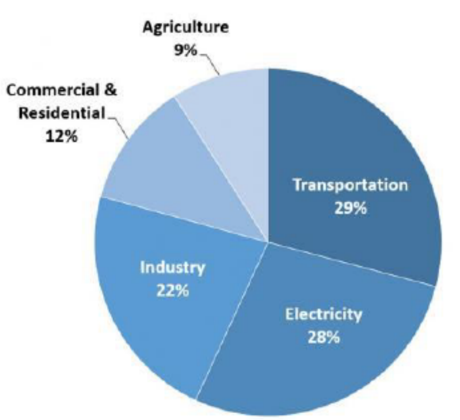


Figure 1 Total US Greenhouse Gas Emissions by Economic Sector, 2017 (Source: EPA)

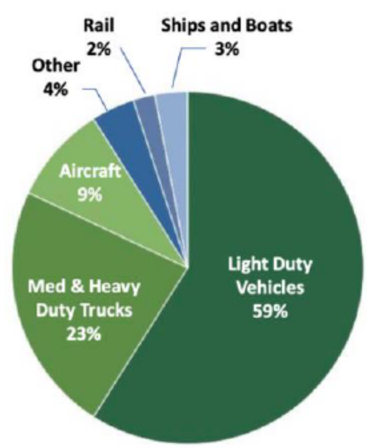


Figure 2 US Transportation Greenhouse Gas Emissions by Source, 2017 (Source: Penn State)

2017). Since the early 21st century, advancements in electric vehicles have made emissions-free transportation possible. As of March 2019, electric vehicles made up just 1.8% of all new car sales but this represents an 81% growth from 2017. Further, there are over 1.2 million EVs on the road in the US as of March 2019 (Edison Electric Institute, 2019).

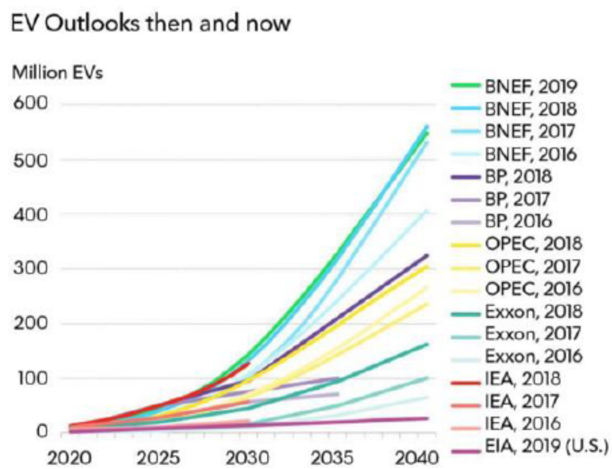


Figure 4 Changing EV Outlooks over Time (source: Quartz)

Globally, electric and plug-in hybrid vehicles are expected to see exponential growth over the next 20 years but there is wide debate around the scale of the growth, as we can see in Figure 4. In their 2019 Electric Vehicle Outlook, Bloomberg New Energy Finance estimated that by 2040, 57% of all passenger vehicles sold globally and 30% of all cars of the road would be electric (Bloomberg New Energy Finance, 2019). In the United States, this translates to 8% of all vehicles on the road, or around 22 million vehicles by 2030. JP Morgan seconds this opinion, estimating that by 2025, 30% of all new car sales in the United

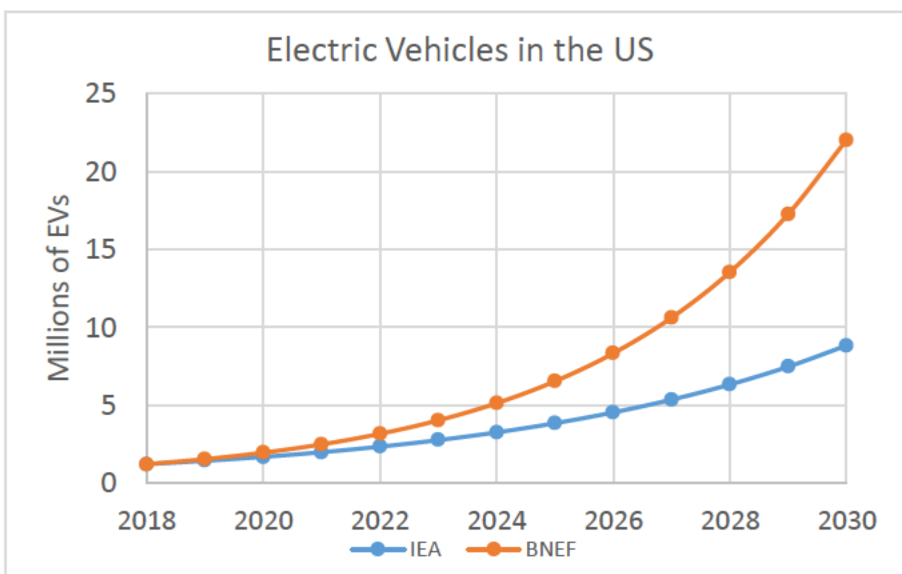


Figure 3 Electric Vehicles in the US (Source: Analysis of BNEF and IEA data)

States will be hybrid or electric, resulting in a 7.7% market share (JP Morgan, 2018). On the conservative side, the International Energy Agency estimates that alternative cars will represent just 8% of cars on the road in the United States, or around 9 million electric cars in the United States (International Energy Agency, 2019). We can see the disparity in these rates in Figure 3.

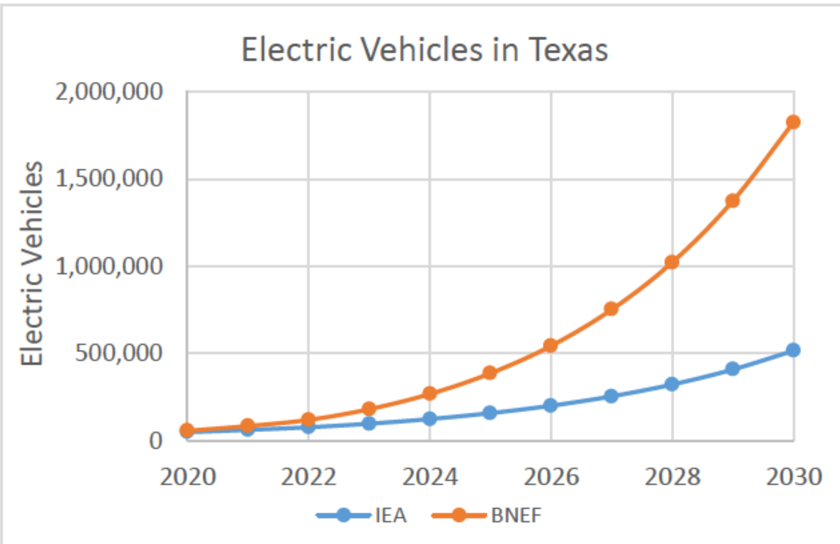


Figure 5 Electric Vehicles in Texas (Source: analysis of BNEF and IEA data)

In Texas, these two varying predictions lead to somewhere between 500,000 and almost 2 million electric vehicles on the road by 2030, which we can see in Figure 5. Other organizations, such as OPEC and Exxon are much more conservative in their estimates (Coren, 2019). All, however, agree that electric vehicles are a rapidly growing trend and utilities would be best served by paying attention.

Within the United States, California is the clear leader, with EVs making up 7.8% of all car sales in 2018, as we can see in Figure 6 (EV Adoption, 2020). This is likely due to the strong regulatory support EVs enjoy in California. In 2018, Governor Jerry Brown signed into law an executive order calling for 5 million EVs by 2030 and allotted $2.5B to building out charging and hydrogen fueling stations (California Governor Signs Executive Order to Expand EV Charging Infrastructure, 2018).

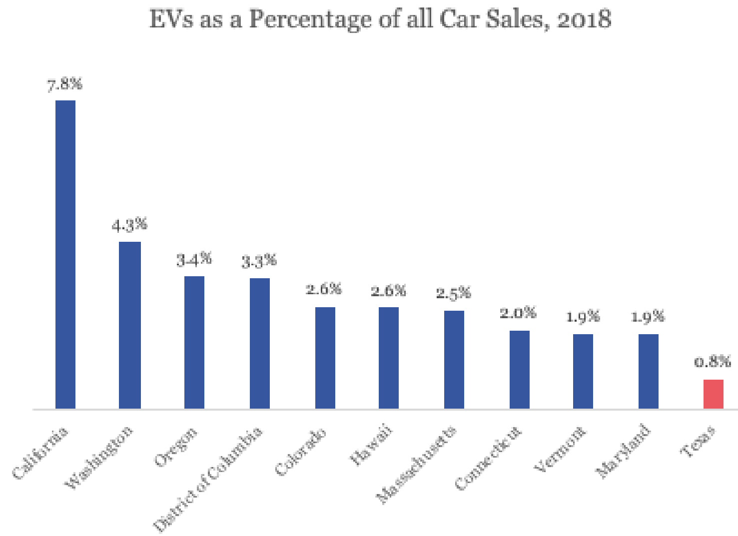


Figure 6 EVs as a percentage of all new car sales, 2018 (Data source: EV Adoption)

Outside of California, EV sales are accelerating rapidly as we see in Figure 7, with states with smaller EV populations seeing the most growth: Tennessee saw 288% Year-over-Year (YoY) EV sales growth while many other southern and midwestern states saw over 100% YoY growth. This suggests that EVs are beginning to move out of their core markets of large urban centers along the costs and into the mainstream (EV Adoption, 2020).

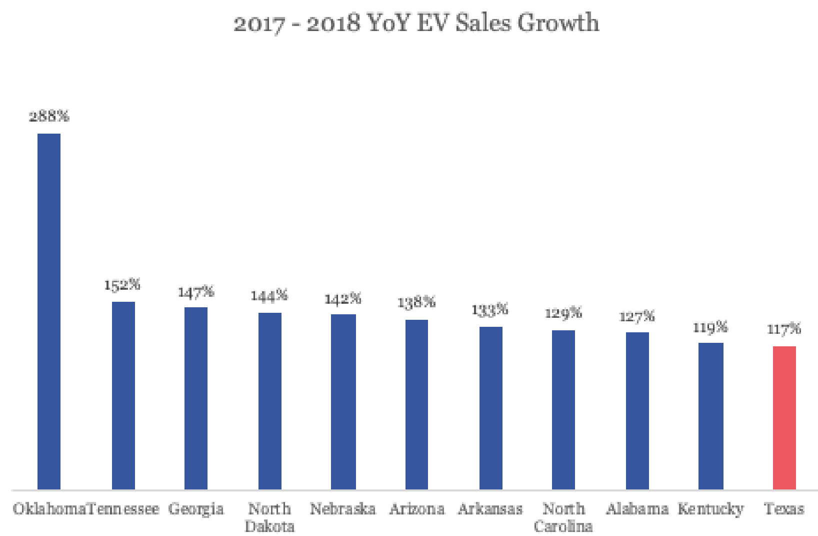


Figure 7 2017-2018 Year over year EV sales growth (data source: EV Adoption)

Cities are supporting electric vehicle growth in their municipalities through a variety of measures. New York has a goal to reach 20% EV sales by 2025, up from less than 1% today (Bellan, 2018). They are also aiming to transition to an all-electric fleet by 2040 (NY MTA, 2018). Atlanta is mandating that all new residential homes and public parking lots must include the appropriate infrastructure to accommodate EVs. Further, all new commercial lots buildings must make 20% of their parking "plug-in ready" in order to pre-empt increasing EV adoption (Bellan, 2018). In Austin, TX, the municipal authorities are already working to transition their 300-vehicle fleet to all-electric over the next 3 years (Bellan, 2018).

Electric vehicles have seen large and accelerating growth over the past decade and will likely continue to do so well in to the middle of the century. This growth will have profound impacts on the electric grid and power producers, and so should be carefully analyzed and included in utility's plans going forward.

Electric Vehicle Charging Background

Electric vehicles require regular charging to ensure they have their full range. There are three types of EV charging: level 1, level 2 and direct current (DC) fast charging, as laid out in

Figure 8. Level 1 is the lowest power and slowest of the options, while DC fast charging is the highest power and fastest of the options (Nelder, 2017).

TYPES OF CHARGERS

TYPE	VOLTAGE (V)	CAPACITY (KW)	MINUTES TO SUPPLY 80 MILES OF RANGE
LEVEL 1	120	1.4–1.9	630–860
LEVEL 2	240	3.4–20	60–350
DCFC (LEVEL3)'	480	50–400	3–24

Figure 8 Types of charging (source: RMI From Gas to Grid)

Consumers use a mix of charging options to charge their vehicle. Home charging, the most cost-effective and easiest option for most consumers, is typically level 2 charging, although some EV drivers use level 1 charging at home. Home charging often takes place during night, which can therefore help utilities boost demand during underutilized time periods. EV owners often also charge at work when it is available. This is important for employees who drive long distances and need to "top-up" for their commute home. When EV drivers have access to workplace charging they do 15-25% of their charging at work. Public charging is the least common type of charging. While this most closely resembles traditional fueling at gas stations, it often takes much longer. Even the fastest charging (DC fast charging or DCFC) often takes up to 30 minutes to get a full charge. The availability of public charging infrastructure is often a large factor in people’s confidence in purchasing an EV, even though it is rarely used. DCFC is most likely to take place during the day and along crowded corridors, such as freeways (Nelder, 2017).

In order to support the growing electric vehicle population and resulting electricity demand, states are passing measures to support EV charging infrastructure. The NC Clean

Energy Technology Center's 50 States of Electric Vehicles reports that in Q2 of 2019, 43 states took actions relating to electric vehicle charging, as we see in Figure 9 (NC Clean Energy Technology Center, 2019).

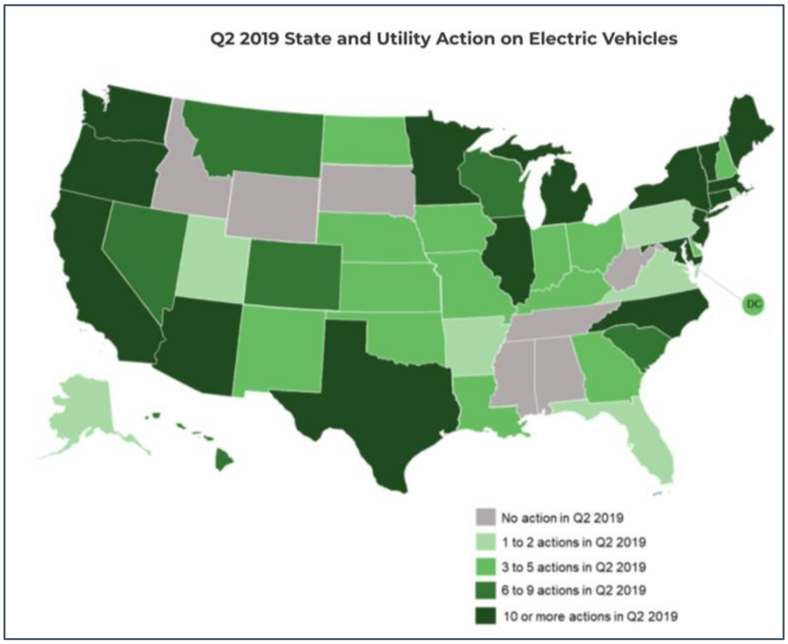


Figure 9 Q2 2019 State and Utility Actions on EVs (source: NC Clean Energy Technology Center)

These actions by public utility commissions include measures such as exempting charging stations from utility regulations or allowing charging stations to use electricity generated on-site, making utility ownership simpler and reducing roadblocks to charging infrastructure rollout. Seven states, including North Carolina, exempted charging stations from public utility regulation altogether (NC Clean Energy Technology Center, 2019).

Increased focus on the importance of EV charging of all kinds will reduce anxiety for potential EV owners and ultimately allow for increased EV adoption at the lowest cost.

Texas EV State of Affairs

For the purposes of this report, we decided to dive deeply into one state, Texas, in order to understand trends in electric vehicle adoption and charging technology.

Table 1 EV Penetration and Charging Demand Estimation for Emerging Technology Scenario (Source: ERCOT)

Type	Number of Vehicles in 2033	Per Vehicle Charging (kWh)	Peak Charging Demand (MW)
Cars	3,000,000	20	5,940
Short Haul/Buses	80,000	350	2,800
Long Haul Trucks	200,000	600	10,200

In Texas, a 2018 Electric Reliability Council of Texas (ERCOT) Long-Term System Assessment (LTSA) completed an electric vehicle scenario for the state. They assumed that by 2033, Texas could have 3 million light-duty EVs as well as 280,000 buses and trucks, as we see in Table 1 (ERCOT, 2018). In this scenario, the level of EV adoption may lead to an 18.5TW increase in nightly demand by 2033 (ERCOT, 2018).

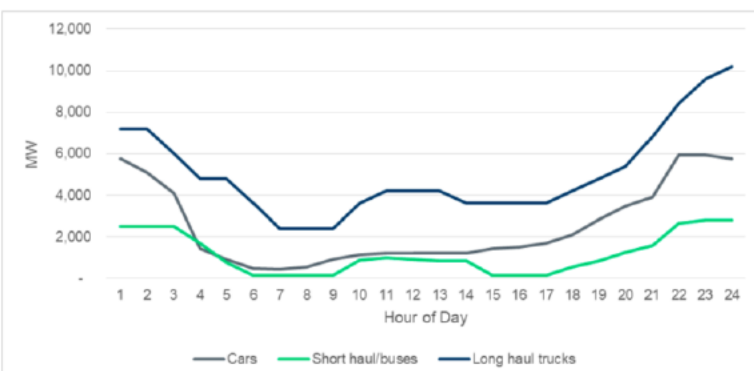


Figure 10 Estimated Total Charging Demand by EV Type in 2033 (Source: ERCOT LTSA)

Interestingly, in Texas, charging an electric vehicle, even at a DC fast charger, is less expensive than driving a gasoline vehicle, as we see in Figure 11. This is abnormal – typically home charging is indeed less expensive than gasoline but DC fast charging is typically more expensive per mile.

Charging infrastructure in Texas is currently robust enough to handle the current EV penetration. Texas currently has almost 2,000 level 2 chargers (likely located in homes and workplaces), as well as 260 DC fast chargers (located in high-traffic areas, such as on freeways) (Nelder, 2017).

ChargePoint used EVI Pro Lite to evaluate the current infrastructure against the estimated infrastructure against the charging needs and deemed the state of affairs more than sufficient for the 55,000 electric vehicles currently in Texas (ChargePoint, 2020). However, given the forecasted rise to over 3 million EVs projected in the next 10 years, large infrastructure investments will have to be made.

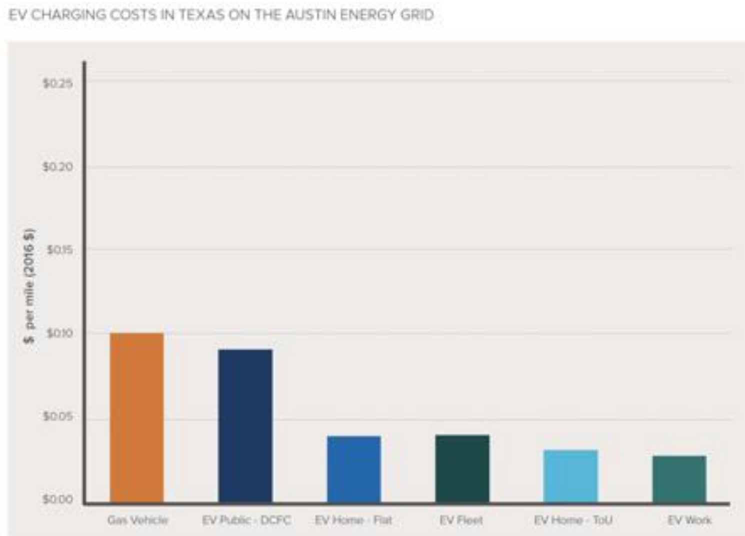


Figure 11 EV Charging Costs in Texas on the Austin Grid (Source: RMI Gas to Grid)

Texas EV Study

In 2019, the Public Utilities Commission of Texas (PUCT) kicked off a project to study the issues relating to electric vehicles and collected comments from all EV and EV-related businesses and non-profits in Texas. Through this study, several key findings emerged. First, little is known about EV adoption rates in Texas. Beyond the ERCOT LTSA, no other companies have made predictions on EV adoption or demand growth. In fact, charging providers and EV companies rely on utilities to provide data around hot spots and charging behaviors. This is a potential area for an energy client to partner with a charging provider for a mutually beneficial relationship. Utilities can proactively identify local hot spots such as fulfillment centers, commercial fleet depots, transit or school bus yards, ports, office campuses, shopping malls, etc. and reach out to them. For example: short haul fleets are expected to electrify in early to mid 2020's. Proactively reaching out to short-haul and long-haul fleets in ’s customer base could help them manage demand growth and maintenance.

The PUCT review also made clear that EVs are beneficial to both utilities and customers. Consumers save money by driving electric: RMI estimates ratepayer savings per EV ranged from $744 to $9,607 over the lifetime of the vehicle (Nelder, 2017). Further, utilities increase their revenues via EV charging: a Synapse study suggests a possible margins of 50-60% on EV charging as we see in Figure 12 (Jason Frost, 2019).

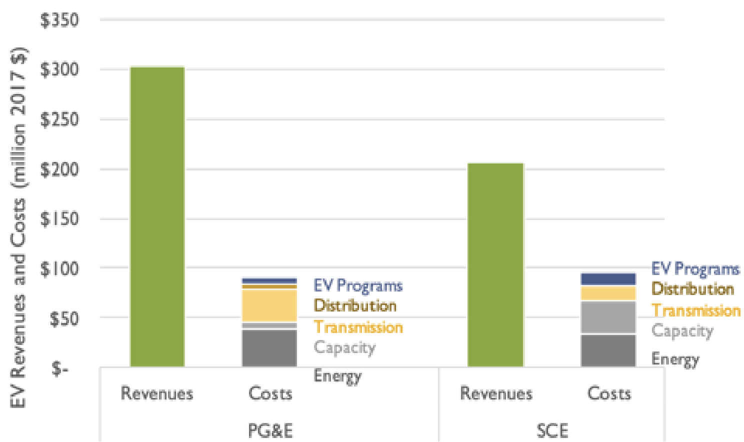


Figure 12 PG&E and SCE Revenues and Costs of EV Charging, 2012-2017 (Source: Synapse)

On a more practical note, the PUCT filing helped identify siting best practices as well. When constructing parking lot chargers, putting parking stalls as close to electric panel as possible can help reduce installation costs by avoiding costly trench digging and long cables. Further, mounting EV chargers on a wall can also help avoid digging trenches. In a parking lot, signage only need be installed in the last hundred feet or so as most EV drivers find charging stalls via smartphone apps and don't need excessive signage. Finally, allowing site hosts to build "make-ready" infrastructure in anticipation of future demand growth can reduce costs down the line when more EV chargers are needed (Nelder, 2017).

The responses also outline how utilities can best incentivize EV drivers to charge during low-impact times of the day. Given that most EV drivers charge during the night, EV charging can be particularly well suited for overnight wind. Incentivizing charging during low-load period of the day increases overall utilization of grid resources and removed the need for capacity expansion to accommodate load growth (Nelder, 2017). Utilities can offer DR programs to directly mitigate the localized and system-level impacts of EV charging, which can obviate the need for service or system upgrades. Utilities should also consider creating rate structures to attract EV drivers. Time of use rates can help shift charging patterns in EV drivers and encourage them to charge overnight, minimizing system impacts.

Expected Power System Impacts of Vehicle Electrification

As electric vehicles begin to represent larger fractions of the US transportation fleet, the associated increased load on electrical grids has created concern about how the grid will be affected (F. Todd Davidson, 2018). Projections of EV penetration vary widely with Bloomberg New Energy Finance (Bellan, 2018) projecting that EVs may represent up to 11% of total electric demand by 2050 (Bloomberg New Energy Finance, 2019). While this would represent a significant increase in EV energy demand and risks do exist, the effects on wholesale distribution and generation are predominantly predicted to be negligible or potentially even positive in coming decades.

In the United States, the IEA 2019 Global EV Outlook estimated that by 2030, electric vehicle charging could account for an additional 150 TWh of demand, with approximately 100 TWh of that demand being served by private level 1-2 (slow) charging, most likely at EV owners' homes, as seen in Figure 13 (International Energy Agency, 2019).

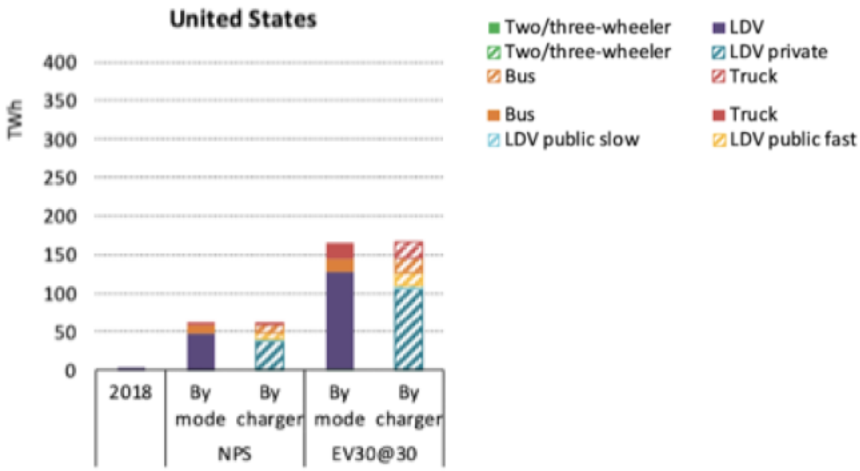


Figure 13 EV electricity demand by charger and scenario, 2018 and 2030 (Source: IEA)

One risk of an increase in electricity demand driven by EVs is that supply will not rise proportionally. Texas (one of an energy client's primary territories) already sees tighter than normal supply-demand balance on its electricity grid (Walton, EVs could drive 38% rise in US electricity demand, DOE lab finds, 2018). If demand grows more quickly than additions to generation, grid reliability could be negatively affected.

More subtly, if utilities do not properly account for growing EV demand growth, then they could face numerous grid consequences due to load timing and increased peaks. These include the need to add additional peaker plants that could even raise overall grid emissions and increase electricity costs for users. Uneven load could also lead to accelerated degradation of grid components and increased curtailment of renewables if charging loads cannot be matched with renewables supply (Rocky Mountain Institute, 2016).

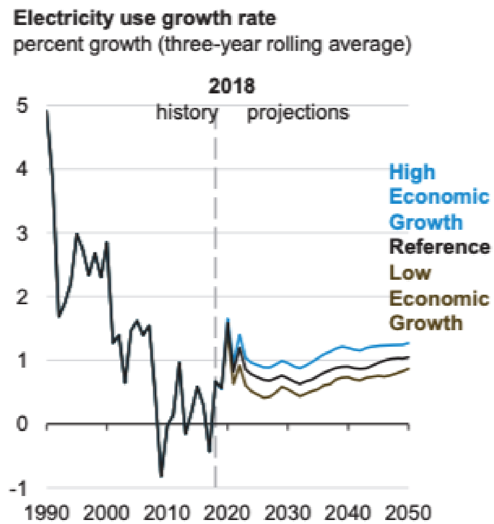


Figure 14 Electricity Use Growth Rate (Source: EIA)

While these risks exist, they are unlikely to cause major issues. The EIA predicts that power demand will rise only about 1% per year on average in the coming decades (US EIA, 2020), which does not represent the kind of sharp demand spike that new supply would be unable to meet. US electricity demand has been mostly flat in recent years (US EIA, 2020), so EV growth is not expected to drive problematic increases in new generation requirements. A McKinsey report confirmed that EVs will likely not drive significant increases in near- to mid-term energy demand, thereby reducing need for significant new generation (Hauke Engel, 2018).

In addition to having limited downside risk, increased EV adoption may drive a number of benefits to utilities and the grid. These benefits will accrue passively through effects like evening demand throughout the day and driving demand growth, and actively through opportunities like vehicle to grid storage or by using EVs as demand response tools to add ancillary grid services and facilitate renewable energy incorporation onto the grid.

Passively, EVs represent one of the greatest potential drivers of electricity demand growth in the coming decades (Utility Dive). The NREL predicts that EVs could drive growth rates from predominantly static to 1.6% per year, allowing utilities to earn returns from expanding generation assets. Similarly, EVs can represent a significant passive benefit to load flattening by creating significant load at night when demand typically drops off significantly, requiring costly ramping of generation assets every day (Stockton, 2018).

EV growth also offers the opportunity for a number of active benefits if properly incorporated and utilized. If sufficient EV penetration is achieved, EVs collectively will represent a significant manageable load that can be turned on or off to meet the needs of the grid. By properly managing and timing this load, utilities can more closely match grid demand to those times when renewables are most available. Matching demand to renewables generation allows utilities and grid operators to reduce renewables curtailment and therefore reduce average grid emissions. Additionally, flattening load allows utilities to reduce wear on infrastructure and saves ratepayer money by delaying the need for infrastructure expansion. Finally, vehicle to grid storage and discharge could one day allow electric vehicles to act as a generation resource as well as adjustable demand. Doing so would allow EVs to supply ancillary services to the grid such as frequency regulation or even avoid peaker demand by discharging significant amounts of electricity at times of peak demand.

Electric Vehicle Purchase Drivers and Demographic Trends

A Cleantechnica poll of approximately 3,000 EV drivers revealed that the primary drivers of EV purchases were their environmental benefits and financial savings (Crider, 2020). Primary factors differentiating model choices were access to public charging network like Tesla's and level 3 charging capability. While buyers recognized the advantages of EV's, they maintained concerns about range and access to charging as well as charging times. Further hindrances to EV uptake include lack of familiarity with the technology, the inconvenience of installing a home charger, and an overall lack of understanding among dealers who may be more likely to suggest ICE vehicles with which they are more familiar (McMahon, 2019). Other utilities have instituted programs to overcome these barriers and incentivize customers to buy EV's, and a sample of these programs is collected in Appendix 2.

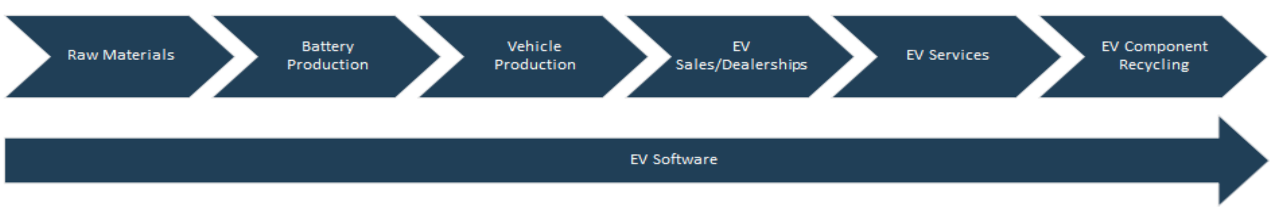
Current electric vehicle purchasers tend to be men with high levels of education and high income (Crider, 2020). According to Cleantechnica's poll, approximately 70% of EV owners had a 4-year or graduate degree compared to approximately 35% for the entire US population. Additionally, 70% had incomes over $100k/year while only about 30% of the US population does. Finally, survey respondents were significantly more likely to be male than the general US male population of 49%.

An energy client also provided data from a survey of Houston-area EV drivers. Demographics of this group were similar to the national study published by Cleantechnica and once again trended toward higher-income, higher-education men. They were also significantly more likely to be in the 35-54 age bracket. These data are expanded further in appendix 1. In the future, as the price of batteries continues to drop and up-front prices for EV's become more in-line with those of ICE vehicles, these demographics are expected to shift (Butler, 2019). Specifically, Millennials, who may be unable to afford EV's at current prices, are expected to represent a growing fraction of EV buyers in coming years.

Overall, several of these trends can be explained in part by the higher initial purchase price of electric vehicles relative to internal combustion cars, even if energy savings may result in a lower overall cost of ownership over the life of the car. Higher education and even age are correlated with higher income, and those with lower incomes may be less willing or less able to pay higher up-front costs for EVs. The high skew towards male buyers was seen across the significant majority of brands in the Houston data. As a result, women may be an under-served demographic for EV sales worth targeting to promote new buyers.

Electric Vehicle Value Chain

The value chain for electric vehicles spans many industries and can be divided and dissected in many ways. This report offers a framework for considering the value chain of electric vehicles from the perspective of a firm interested in entering the EV landscape. Selecting such an entry point will require the consideration of various criteria and largely be based on an analysis of how EVs impact a firm's current lines of business. As such, the value chain is a great place to begin this analysis because it lays out the different potential interactions a firm can have in the EV space and the ways a firm's customers may interact with EVs. The EV value chain was divided into several different parts: Raw Materials, Battery Production, Vehicle Production, EV Sales & Dealerships, EV Services, EV Component Recycling and EV Software. The map below demonstrates the flow of the value chain, with EV software running throughout the value chain.



Organization of the Value Chain

This analysis took parts of the EV value chain and assigned a work stream: upstream, manufacturing, downstream and cross-stream. Upstream activities focus mainly on sourcing raw materials for both lithium ion batteries (only chemistry currently used in EVs) and vehicles.

The manufacturing stream covers both battery production and vehicle production. Vehicle sales and EV services were considered downstream along with EV component recycling, though not much has been studied for end-of-life uses of EV batteries but it is anticipated that these materials could feed back into the upstream workflow. EV software was the trickiest part of the value chain to categorize. Software plays a critical role throughout the entire EV value chain and there are many interesting entry points for firms throughout. As a result, for the purposes of this analysis, software was considered cross-stream.

EV Value Chain	Stream	Energy Client Opportunities
Raw Materials – Mining	Upstream	Metals Trading
Battery Production	Manufacturing	Supply Materials
Vehicle Production		Fleet Orders/Offtake
EV Sales & Dealerships	Downstream	Partnerships with local dealers & Customer Incentives
EV Services		Charging Programs, Vehicle to Grid services
EV Component Recycling	Downstream to Upstream connection	Vehicle Buyback from customers, resell to OEMs
Software – Interface Battery/Grid/User	Cross-stream	App, Smart Home Management, EV Data

Upstream – Raw Materials/Mining

Firms with existing commodities trading platforms for power, oil, gas or coal could fairly reasonably enter the trading markets for battery metals like Lithium, Cobalt or Nickel and base metals like Aluminum, Copper and Zinc. The main benefit of entering upstream metals trading would be to diversify a firm's commodities trading book, away from just fuels/power or to hedge other EV related activities from other parts of the value chain. Effectively, if a poor investment is made on an EV services platform, a firm might still win overall from the proliferation of EVs if they are involved in trading metals heavily used for EV production. In the event that EVs take off faster than expected, metals traders in the Cobalt and Nickel markets might find themselves with outsized market power if supply begins to become an issue.

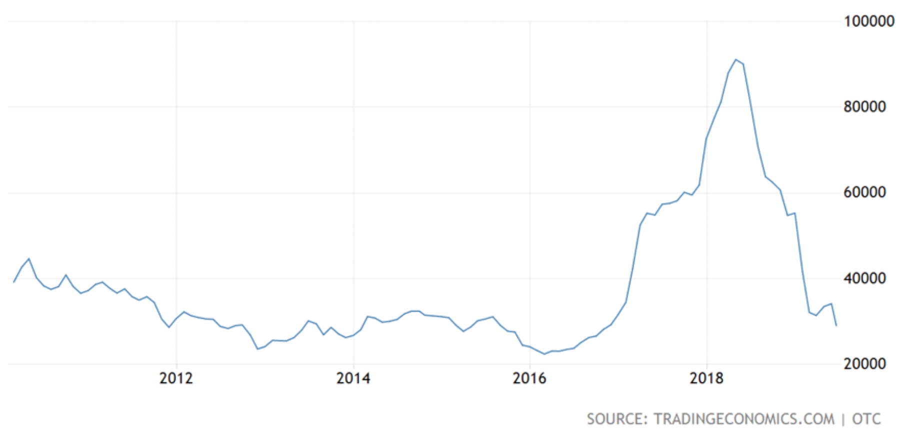


Figure 15 Cobalt Price Volatility (Source: Larsen, 2019)

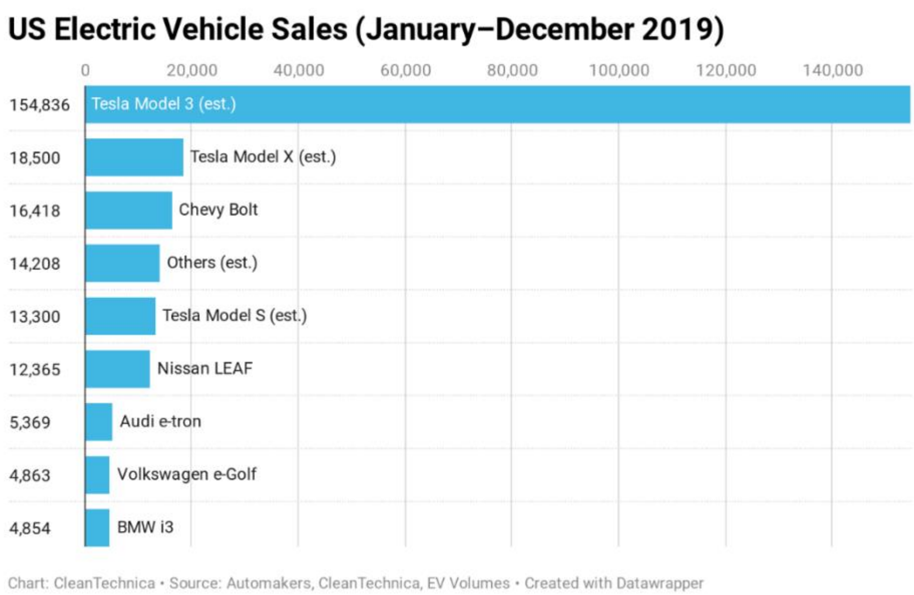
Metals trading comes with inherent risk to firms as well. They are likely to force key-person dependencies within an organization because the markets are so specific. Bulk commodities also trade significantly differently than power and gas do. Prices have been incredibly volatile, as seen above in the plot for Cobalt prices over the last two years (Larsen, 2019). Prices do not simply rise with the expected increase in demand for EVs. This could add a lot of commodity risk to a firm's balance sheet, which may be difficult to hedge. In summary, firms that already trade commodities may be well-suited to enter this space but for other firms, barring an acquisition of this knowledge, it seems like a difficult place in the value chain to play, but certainly one to remain aware of.

Manufacturing – Battery Production

Global manufacturing firms could be interested in partnering in the battery production process. Currently, 60% of lithium ion battery production takes place in China (Pyper, 2019), so a firm would need to be open to the Chinese market if they intend to engage in this part of the value chain. Additionally, any firm that takes the metals trading part of the value chain could become a critical supplier of raw materials to the manufacturing segment, allowing for long-term commodity transactions to support the production of new batteries.

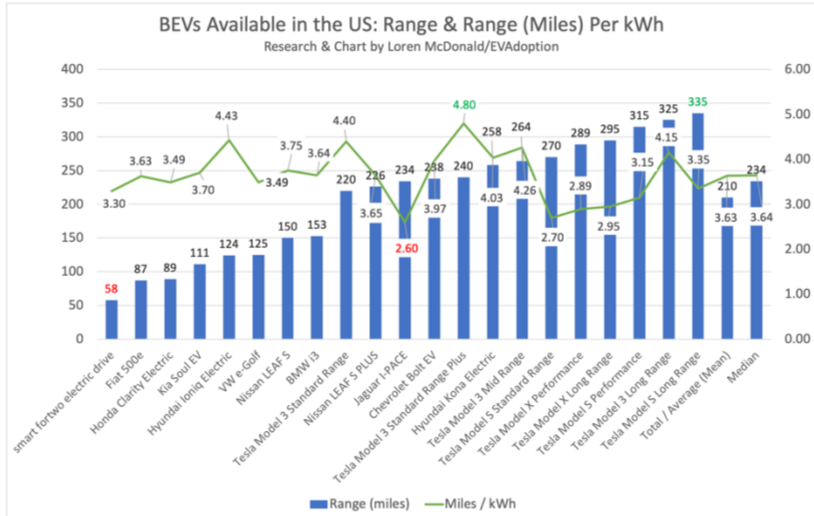
Manufacturing – Vehicles

The electric vehicle market includes both full battery electric vehicles as well as hybrid and plug-in hybrid electric vehicles and includes models from all the major car companies. In the United States, the most popular EV brands were Tesla, Nissan, and Chevrolet, with Tesla selling almost 80% of all electric vehicles in 2019 (Crider, 2020).

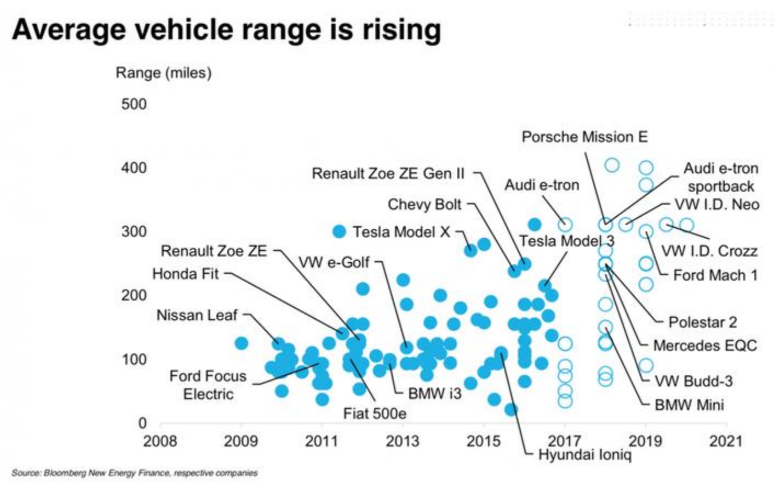


However, as the EV market heats up, other car brands are beginning to jump in, with Ford launching their electric Mustang SUV (the Mach-E), Porsche launching their electric Taycan, and VW creating the ID.4 (Hall, 2020). Further, new car brands are launching, hoping to capitalize on the growth in the electric vehicle market: Volvo created Polestar, an EV-focused spin-off, Rivian is a new electric truck company and Fisker is targeting the luxury EV market (Hall, 2020).

The largest challenge in the space is increasing the range of the vehicle. Electric vehicles vary widely in range offered, with some offering less than 100 miles while top of the line EVs offer over 300 miles.



However, as lithium ion technology has progressed, so too has EV range – the average range has risen drastically over the years, assuaging many potential buyer's range anxiety (McMahon, 2019).



Manufacturing – Charging Hardware

To support the increase of electric vehicles, many companies have entered the charging market. This includes large, electric parts manufacturers such as ABB and Eaton, oil majors such as Shell and BP, and new start-ups such as JuiceBox and ChargePoint. Charging hardware, especially level 2 home chargers have become a commodity item and are sold through such outlets as Amazon and Home Depot. We evaluated some of the most popular options in Appendix 3. Many companies are differentiating themselves by building in user interfaces that allow users to control charging remotely or 'delay charging' to correspond with more favorable utility rates.

Downstream – EV Sales & Dealerships

EV sales and dealerships is the point in the value chain where customers are finally introduced. As a result, there are many opportunities for firms to engage at this point of contact between EV manufacturers and customers. Incentive programs can be created at the dealership level to effectively bundle purchasing an EV with selecting a retail power provider, in deregulated areas with retail competition. The dealership gains auto sales, the power provider gains new, high margin customers and the EV driver gets the new car. While it is potentially risky to create a partnership that would be based on the cyclicality of auto sales, this seems like a good entry point in the value chain, if a firm is looking to go the partnership route.

Downstream– EV Services

EV services companies can span many different types of businesses from designing UI for charging or fleet management companies, EV investment services and EV consulting services. The services industry usually requires bespoke solutions for each customer and are typically high margin for the service provider. EV services providers will also gain valuable insight into the behaviors of EV drivers which can unlock more value for clients. Many lines of business in the services industry, such as vehicle-to-grid and charging-as-a-service are still in their infancy and it is unclear what customer and business preferences in these lines of service will be. However, the nascency of the field of EV services might make it a very attractive part of the value chain for a firm to enter.

Downstream – EV Component Recycling

There is not much of a market yet for recycled components of EVs, however, once EVs begin to reach the end of their useful life, there will likely be buyers for the batteries to begin to recycle the components and sell the raw materials back to the upstream raw materials players and manufacturers. A first mover advantage may exist in this space, however with the market being so untested and undefined, it is likely not going to be a winning investment in the short, and even medium term. It will be interesting to see how firms continue to react to EV component parts as time goes on.

Cross-Stream – Software

EV software solutions will exist throughout the EV value chain and each firm participating in the EV landscape will likely have some type of software interaction as a feature of their involvement. With so many different types of software solutions, it seemed easiest to categorize different software opportunities into two main buckets: Mass Market and Customer Specific.

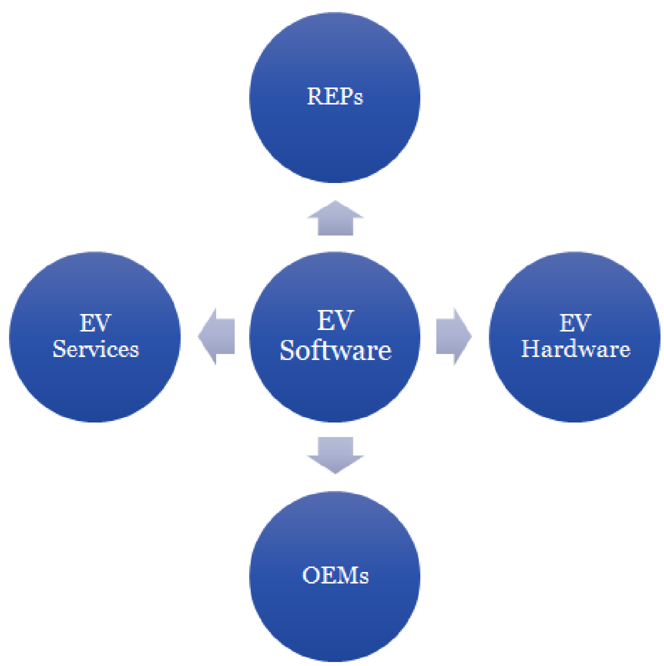


Figure 16 How Software Interacts with Players in the EV Value Chain

Mass Market software solutions refer to any apps that customers or end users of EVs or electricity can download themselves and use. These apps include charging company apps, the apps developed by the OEMs for their specific electric vehicles and retail electric provider apps.

Customer Specific EV software solutions include EV Services companies that design back end infrastructure and dashboards to help run EV companies and company-specific infrastructure. Fleet management apps and B2B applications would also fall into this category.

Retail Electricity Providers

Retail electric providers stand to gain a tremendous amount of new business from the increased adoption of electric vehicles. As EVs proliferate in communities, existing retail electric companies will begin to sell more electricity to their customers who have purchased EVs. Additionally, there will be a sales case to be made, especially in the competitive retail markets, for retail electric providers to pitch to customers that their service the most reliable or best service for electric vehicle drivers. The report highlights two main revenue streams for retail electric providers coming directly from EVs: first, to sell more power to their existing customer base by encouraging their existing customers to buy EVs and charge at home and second, to get new customers by positioning themselves as the best retail electric provider for EV drivers and acquire new customers (in deregulated markets).

Partnerships and Innovations

Many automotive and charging companies are partnering with cities and utilities to mutually benefit from data sharing, give customers more access and reduce EV charging impacts.

Utilities, particularly in managed charging, can use electric vehicles to reduce load during peak power events, reducing the need for expensive peaker plants, or shift charging load to overgeneration times when excess renewables would otherwise be curtailed.

Southern California Edison's (SCE) Charge Ready demand response pilot is a $22M pilot aiming to increase access to non-residential EV charging. Specifically, they are installing 1,500 level 1 and 2 chargers in workplaces, multi-unit dwellings, destination centers (e.g., malls) and fleets (Besaw, 2019). On their side, customers agreed to participate in demand response events, offsetting some or all of the installation and equipment costs. The program was designed so that opt-in was automatic: SCE notified customers and allowed them to opt-out ahead of events but the default option was to participate. This led to greater participation, as there was "had absolutely no thinking for the customer". Non-residential and commercial charging was of particular interest, as mid-day charging was better suited for absorbing California's excess solar generation: residential EV owners would often be at work during the middle of the day and therefore not charging at home. The pilot was a success and demonstrated the capability to reduce loads by an average of 42% through managed charging in 2018. However, the pilot was not successful in shifting load to overgeneration periods (11AM – 3PM) during demand response events (Smart Electric Power Alliance, 2019).

Avista, a utility in Washington state, launched an Electric Vehicle Supply Equipment pilot in 2016, aiming to install 136 charging stations (Spokane Journal). Avista installed chargers in residences and workplaces. In exchange, Avista tracked meter data and was able to curtail load during peak events. Customers were notified of the event a day in advance via an app and were allowed to opt out, again minimizing the thinking for customers. Avista saw high participation –

there was an 84% opt-in rate even though participation was totally voluntary and did not include any incentives. Avista was able to decrease their average load per EV by during curtailment periods. Through the pilot, Avita saw that EV loads were often "geographically clustered," meaning that one household would have more than one EV. This clustering increased the need for managed charging in order to avoid overloading transformer infrastructure. Avista found that customers strong internet connections were a pre-requisite – 30-45% of systems lost connections to their device (Nellis, 2019). They also received feedback that customers found their opt-out mechanism clumsy and difficult to use, hinting that perhaps their high participation rates were a function of the user interface rather than customer preference. Though the pilot was generally a success, Avista was unable to determine what level of EV penetration makes programs net positive and intends to continue testing managed charging with different customer groups (Smart Electric Power Alliance, 2019).

Many other innovative partnership models are popping up, allowing various players to come together to create holistic solutions for customers.

One interesting model is the partnership between Ford, Amazon and Greenlots. In 2019, ahead of the launch of their electric Mustang SUV, Ford announced the creation of their Fordpass Charging Network. First, Ford provides new EV owners with a Ford Mobile Charger to provide all-voltage (120V or 240V) mobile charge. They have partnered with Amazon to provide residential installation services, reducing the burden in customers to hire their own installer. Ford also created an app, FordPass, that allows customers to monitor charging at home or find charging stations in Ford's network. Finally, Ford partnered with Greenlots to provide access to the largest charging network – customers have access to 12,000 stations under FordPass Charging Network (Lambert, 2019).

In 2019, DTE, a Michigan utility, announced Charging Forward, a partnership with EV Connect to build out 1,000 charging stations in Michigan. The program sets aside $10 million to build out charging ports to assist transit agencies and municipal buyers to go electric (EV Connect, 2019). For DTE, the program is a monetary commitment only but shows DTE's confidence in the value creation EV charging is capable of.

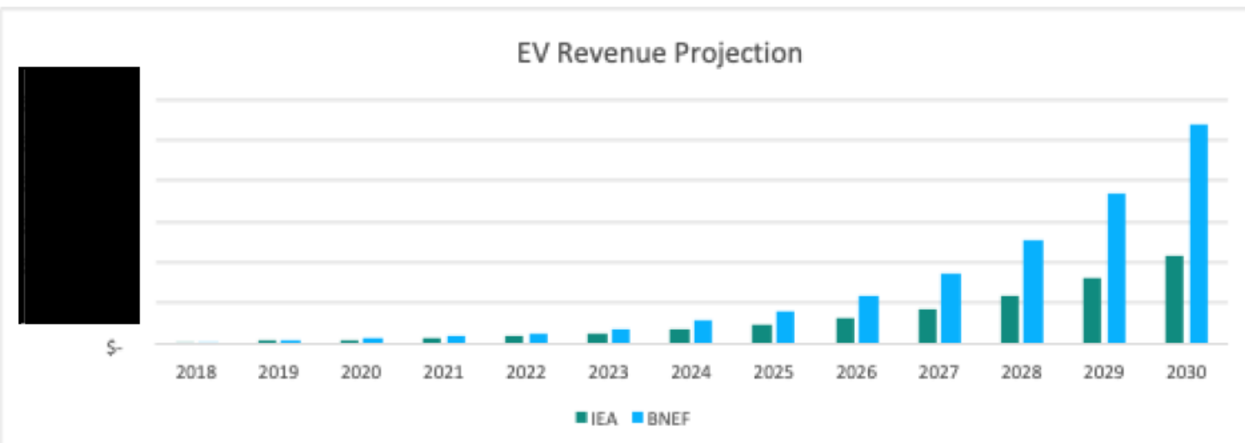
Similarly, Kansas City Power and Light is partnering with Nissan and ChargePoint to build out 1,000 public fast-charging stations. KCP&L will install and operate chargers. The newly created Clean Charge Network will offer two years of free charging at all stations. Natural Resources Defense Council Senior Energy Economist Ashok Gupta explained the benefits of the program, saying: "People generally charge their cars at non-peak periods when KCP&L's electrical grid is being underutilized. By stimulating electric vehicle adoption with their Clean Charge Network, what KCP&L is doing is encouraging people to use the electrical grid more efficiently and drive down the cost of electricity for everyone." (ChargePoint, 2020).

Austin Energy, a publicly owned utility in Austin, TX, created its own subscription EV charging service in order to reduce EV charging during peak periods (American Public Power Association, 2019). It allows subscribers to access Austin Energy's public EV charging network for a flat, monthly fee. Charging their vehicle during on-peak hours results in an on-peak adder which varies by season. The program has so far been extremely successful, with 99% of users avoiding on-peak fees and 63% of users giving the program a 10/10 rating for satisfaction (American Public Power Association, 2019).

Utility partnerships and pilot programs continue to increase as the benefits of EV adoption on utilities become clearer. Joint programs between utilities, charging networks and even automakers can boost EV adoption, save customers money, and reduce peak load.

An Energy Client Revenue Projection of Power Sold for EV Charging

The team modeled potential annual revenue predictions for an energy client based on multiple analyst predictions of EV penetration. These predictions ranged from 8% to 20% EV market share by 2030. Growth projections were modeled as geometric given an approximate 0.3% EV market share in Texas in 2018. As seen below, revenue projections vary significantly based on model assumptions and predictions used, but represent significant potential ([redacted] or more) in the coming decade.



Recommendations

Given the large, exponential growth in the electric vehicle market and the nature of customer choice in Texas, we believe promotion of electric vehicles offers a profitable growth strategy for an energy client. We recommend an energy client continue exploring ways to attract and retain electric vehicle customers which they can begin by modeling off of successful programs implemented by other states, municipalities, and utilities. We recommend they reach out to large fleets within their customer base, to learn more about their plans to electrify in order to forecast their future electricity demand and understand what their needs are. We also recommend an energy client continue to work closely with PUCT and ERCOT to understand the evolution of charging loads in their territory. Further, we recommend an energy client partner with a charging hardware and software provider to create a customized charging portal for their customers, which could also be used for managed charging or demand response. In order to attract customers, we suggest an energy client advertise these services at charging stations and car dealerships to attract current EV drivers to switch to an energy client. Finally, we believe that women represent a currently underserved market segment and that an energy client should consider targeting some of the company's promotional efforts at women if possible.

Conclusion

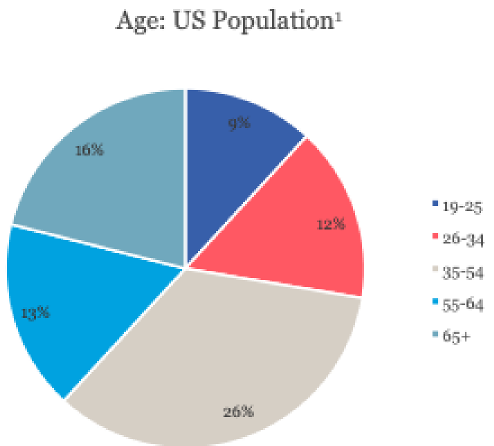
After analyzing the state of the EV market in the US, the implications of EV proliferation on the power system, the demographics of EV purchasers and the value chain for EVs, an energy client is left with a key decision about how to best participate in the EV value chain. There are two main options that an energy client can take: a passive strategy and an active strategy. The passive strategy does not require any additional effort or investment on an energy client's part. This plan simply means that as an energy client's customers become EV drivers, an energy client will sell those customers more power as they charge their EVs at home. As nationwide adoption of EVs increases, an energy client will be a natural beneficiary because their existing customers will require more power. The active strategy would require an energy client to make an entry and investment into the EV value chain, outside of just watching their customers begin to drive EVs. The active strategy will require an energy client to add new revenue streams to their business model as the firm figures out where in the value chain they can have the largest impact. The recommendations for which parts of the value chain will be most attractive for an energy client to find a partner or make an investment can serve as a good starting point for identifying strategic first steps for evaluation.

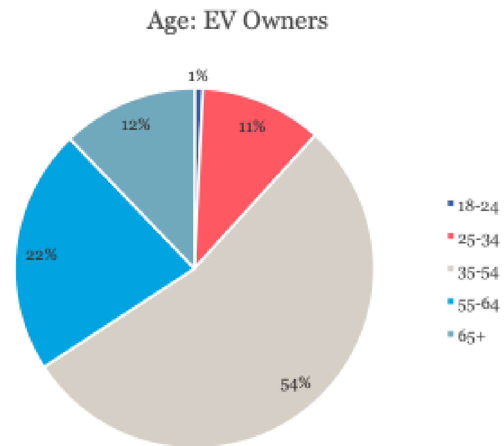
COVID-19 has disrupted all aspects of the global economy and daily life. The full impact of COVID-19 on the EV industry is still being played out in real time. It would be prudent for an energy client to consider short, medium- and long-term implications that the virus could have on the market and demand for EVs and EV services. In the short term, it is likely that the economic downturn in the US, with growing unemployment and businesses closing, will slow the growth of EV sales, as all new car sales slump. Additionally, a continued low oil price environment could make the internal combustion engine car more competitive over the life of the vehicle when compared to an EV. In the medium term, it is likely that firms involved and looking to get involved in the EV space might delay or suspend their innovation and investments into EVs to focus resources and attention on the firms' core businesses. It is also worth considering how the virus will play on the psychological state of potential EV buyers as the economy begins to reopen. It is possible that customers who were once in the market for an EV might delay the purchase of such a big-ticket item until the economy fully recovers. In the long term however, the outlook for EVs should remain largely positive. It seems unlikely that auto manufacturers would shift their strategies back to internal combustion engine vehicles and change their long-term push towards EVs. Likewise, carbon reduction will remain a large goal of both governments and the private sector, with EVs positioned as a critical part of the energy transformation.

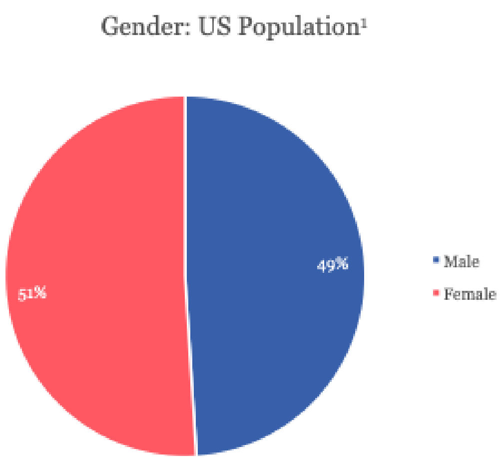
Given the current state of the global economy as a result of COVID-19, it does not seem prudent for an energy client to make any large investments in the EV sector at the given time. A less risky and costly plan would be to allow the passive strategy to continue to build additional EV revenue for an energy client right away. While it isn’t advisable to make an entry into the EV value chain at this time, an energy client can continue to assess opportunities throughout the value chain for a possible active strategy move in the medium to long term. The EV task force that an energy client has established should continue its work and could potentially benefit from an employee or team dedicated to the company’s overall EV strategy. Once the economy recovers and more data is available on EV adoption through the early 2020s, an energy client can revisit the investments and partnerships that would allow for the best entry into the EV market.

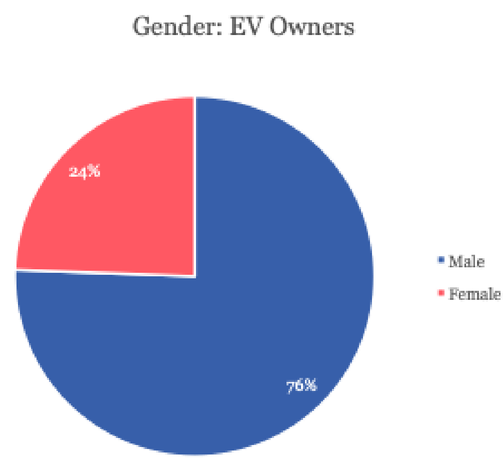
Appendices

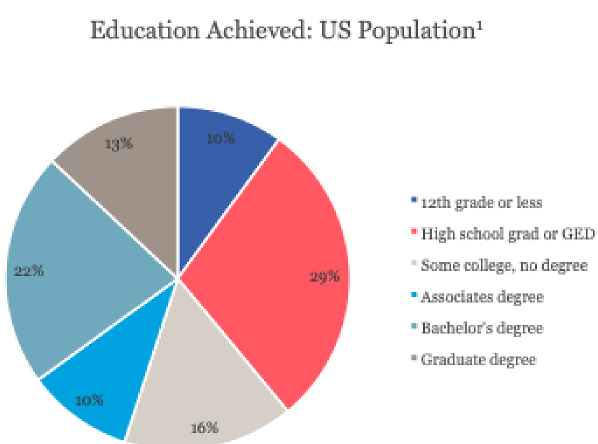
Appendix 1: Electric Vehicle Owner Demographics Relative to US Population

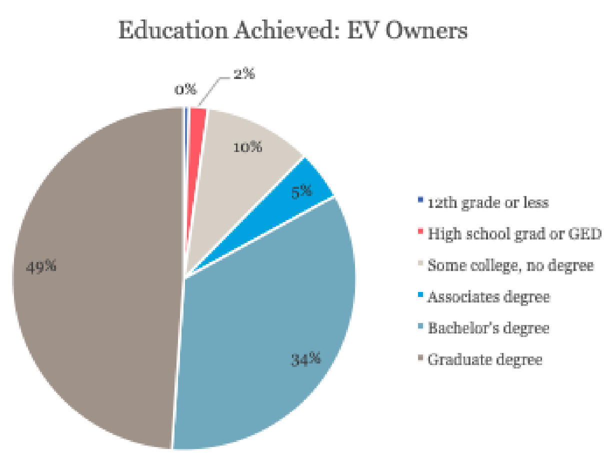




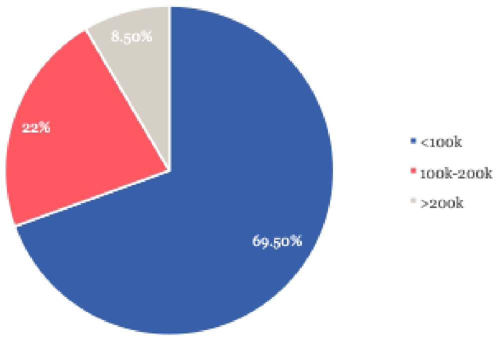




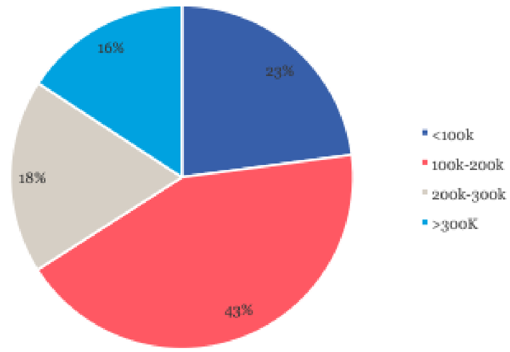




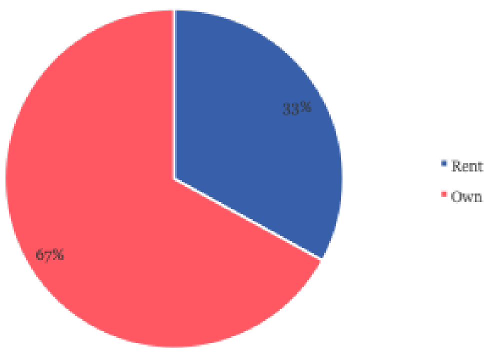
Income: US Population[1,2]



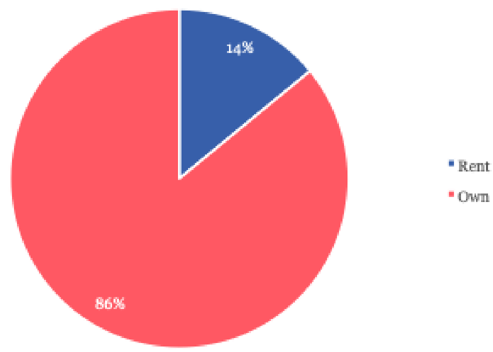
Income: EV Owners



Home Ownership: US Population



Home Ownership: EV Owners



Appendix 2: Sample Utility and Government EV Promotion Programs

Utility	Program Type	Details
PG&E	EV purchase rebate	PG&E has offered up to $10,000 rebates on some EV model purchases
Sacramento Municipal Utility District	Charging network access	Sacramento Municipal Utility District offers free charging for up to two years for EV owners
PG&E	Infrastructure investment	PG&E is installing 7,500 chargers at various C&I and apartment locations
SDG&E	Annual reward	SDG&E offered recurring rewards to EV and hybrid drivers
Numerous states and utilities	Time of use rates	Multiple states offer significantly lower rates at off-peak times to smooth demand curve, incentivizing overnight charging
Iowa	Home charger rebate	Iowa is one of several states that has offered rebates for home charger purchase or installation

Appendix 3: Evaluation of popular level 2 home chargers

Company	Product	Customer Segment	Specialization	Other Partners
Clipper Creek	16A	Residential, Commercial	Hardware Only	
JuiceBox/EnelX	32A	Residential, Commercial, Utilities	Hardware, software, utility programs (DR,etc.)	Yes – OtterTail and Xcel Energy
Aerovironment	32A	Residential, Commercial, Network	Hardware, Charging network in WA, OR, HI	
ChargePoint	32A	Residential, Commercial, Network	Nationwide charging network	Yes – KCP&L & Nissan is one example
Open EVSE	40A	Residential	Hardware only, customizable and programmable	
Siemens	30A	Residential, Commercial	Hardware only, includes app	
Eaton	32A	Residential, Commercial	Hardware only	
Bosch	16A	Residential, Commercial	Hardware only	
Leviton	30A	Residential, Commercial	Hardware Only	
Schneider	30A	Residential	Hardware Only	

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