Birth of The New Dominion:

EV Charging in the Climates of Capitulation, 1995-2022.

Thomas Keith Balch

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Andrew J. Scerri – Chair

Binio S. Binev

Todd E. W. Schenk

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ABSTRACT

This thesis seeks to understand the relationship between government influence and market forces pertaining to the introduction of new technologies in the market. The thesis will do this by utilizing electric vehicle supply equipment (EVSE) in California and Virginia as a historical analysis case study to determine the historical catalysts for change in the public EVSE market since its introduction in 1995. Comparing the rate of change to historical timelines for both states, “market tendencies” and “government involvement” played the greatest role in EVSE growth, with there being a distinct shift from “market tendencies” to “government involvement” over time. Results show that California has fully embraced the interventionist role, with state and local actors playing a part. Virginia, on the other hand, has just begun to allow state intervention, so much of the change in the state has come from economic or business events. Data shows, however, that this could be changing, and that Virginia could be on the verge of allowing for market intervention based on equitable development and future economic opportunity.

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GENERAL AUDIENCE ABSTRACT

The 21st century is ripe with innovative technologies and ideas that influence the future of the world, but not all these ideas are fully embraced in the private market. This thesis looks to understand the different roles that the government can play in assisting with the development of markets by analyzing the introduction of electric vehicle supply equipment (EVSE) for public use in California and Virginia. Using a historical-analytic approach, I gathered data on the rate of increase in EVSE and compared that to the historical timelines to determine the variables with the most influence. After identifying four "pivotal moments" in the timeline, I discovered that the major catalysts for change were "market tendencies" and "government involvement." Looking at the progression, I determined that there is a distinct trend shifting from market tendencies, at the beginning of the timeline, to government involvement in modern changes. Evidence shows that not only is this trend embraced in California, with many state and local bodies working on the issue, but it also shows that Virginia, the laggard of the two states, could be on the verge of straying from its ideals of "free markets" to embrace change.

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INTRODUCTION

> *When we ask people, what's the biggest barrier for them to buy an electric car? The answer is almost always figuring out where and how to charge it. The Bipartisan Infrastructure Law will invest in a network of 500,000 chargers for All Americans for local & long-distance trips.*
>
> -Tweet from U.S. Vice President Kamala Harris
> 15 December, 2021[1]

It is no secret that the supply of Electric Vehicle (EV) chargers is not able to keep up with the growing demand. The above tweet from Vice President Kamala Harris shows it is a nationwide issue and certain people in the federal administration are attempting to provide a remedy. With a total of 126 EVs commercially available today in the U.S., there are continuously more EV options available for consumers.[2] Even with these numbers, a 2021 Pew research study found

[1] Harris, Kamala. Twitter Post. December 15, 2021, 11:30 a.m. Retrieved from https://twitter.com/kamalaharris/status/1471155606069334018?lang=en.

[2] "Alternative Fuel and Advanced Vehicle Search: All electric vehicles." *U.S. Department of Energy: Alternative Fuels Data Center.* Retrieved from https://afdc.energy.gov/vehicles/search/results/?view_mode=grid&search_field=vehicle&search_dir=desc&per_page=8&current=true&display_length=25&fuel_id=41,-1&category_id=27,25,29,9,-

that only 7% of American adults currently owned an electric vehicle[3], with the United States accounting for only 17% of the world's total amount of registered EVs.[4] California accounts for most U.S. EV sales and registrations, with 12 EVs registered per 1000 people. Most states have less than 2 per 1000.[5] One main reason, at least in the eyes of the Biden administration, is that there are not enough electric vehicle chargers, or electric vehicle supply equipment (EVSE), available for public use, lowering the confidence of potential buyers.

This paper offers a historical analysis of Virginia and California pertaining to EVs and EVSE to determine potential catalysts for change and reasons for stagnation over time. By

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1&manufacturer_id=365,377,355,211,231,215,223,409,219,213,209,351,385,275,466,424,361,387,243,227,469,229,239,425,263,217,462,391,349,470,383,237,221,347,395,67,117,394,426,415,201,113,205,5,408,9,13,11,458,81,435,57,195,416,141,197,417,121,53,397,418,85,414,17,21,143,403,23,398,27,399,31,207,396,107,465,193,460,125,35,419,115,37,147,199,-1.

[3] Spencer, Alison, Funk, Cary. "Electric Vehicles get mixed reception from American Consumers." *Pew Research Center.* 3 June, 2021. Retrieved from https://www.pewresearch.org/fact-tank/2021/06/03/electric-vehicles-get-mixed-reception-from-american-consumers/.

[4] Desilver, Drew. "Today's electric vehicle market: Slow growth in the U.S., faster in China, Europe." *Pew Research Center.* 7 June, 2021. Retrieved from https://www.pewresearch.org/fact-tank/2021/06/07/todays-electric-vehicle-market-slow-growth-in-u-s-faster-in-china-europe/.

[5] Ibid.

utilizing EVSE as a case study, it is the goal of this paper to demonstrate changes in U.S. state politics pertaining to the role of government in the economy and the "myth" of *laissez-faire* capitalism. This thesis utilizes an embedded case study in which EVSE is looked at in the context of both Virginia and California as sub-case studies, with multiple variables being analyzed in each.[6] The overall case study is instrumental in focus, with logic taken from this report representing a greater dynamic in the field of government and the economy.[7] The reasons for viewing Virginia and California are quite diverse, with both similarities and differences in the states playing a role, as well as the bias of the researcher. Virginia was chosen originally as a convenience case due to it being the home of the researcher. Looking beyond this to the similarities between the states, both Virginia and California host large ports, as well as advanced research and data facilities. These are Norfolk and San Diego, and Silicon Valley and NOVA (Northern Virginia), respectively. These similarities allow for the comparison of the two states due to similar access to technology and trade, as well as the ability for companies to manufacture products with cheap imported goods and minerals. Having high-tech development going on in an area could also be an indicator of more liberal minds, which leads to the potential difference in culture and esteem of universities.[8] This could lead to a difference in the type of technology that

[6] DePoy, Elizabeth and Gitlin, Laura. "Introduction to Research: Understanding and Applying Multiple Strategies 5 ed." *Elsevier Inc.:* St. Louis, Missouri. 2016.

[7] Yin, R. "Case study research: Design and methods 5 ed." *Sage Publishing:* Thousand Oaks, California. 2014.

[8] Moretti, Enrico. "The New Geography of Jobs." *Mariner Books:* Boston, Massachusetts. 2012.

is sought out for improvement or development. In differences, Virginia and California have differing population sizes, geographic sizes, and the esteem of colleges.

Ultimately, California was chosen due to its high ratio of EVSE to people, 1 for every 1100, while Virginia was chosen as the laggard, 1 for every 3125. Looking into these two cases shows the potential deviations that may account for the difference in EVSE rollout that is present today. This, in turn, offers insights into the effectiveness of different economic development strategies employed by governments.

There are approximately 150,000 gas stations across the country, most with multiple pumps.[9] Even with the conservative estimate of only two to three pumps per station, there are at least 300,000 to 450,000 gasoline pumps in the United States. In comparison, the statistics given by the Alternative Fuels Data Center run by the U.S. Department of Energy show there are currently 46,000 EVSE stations, which have a total of 113,752 charging ports.[10] California has the most out of any state, with 13,651 EVSE stations and 35,384 ports, or a ratio of roughly 1 port for every 1100 people. Virginia has 1023 EVSE stations and 2763 ports, or a ratio of

[9] "Convenience Stores Sell the Most Fuel." *National Association of Convenience Stores.* 24 March, 2021. Retrieved from https://www.convenience.org/Topics/Fuels/Who-Sells-Americas-Fuel.

[10] Information gathered from the AFDC "Alternative Fueling Station Locator found at https://afdc.energy.gov/stations/#/find/nearest.

roughly 1 port for every 3125 people. This difference is likely why the Biden administration determined that charging stations were one of the biggest challenges to EV sales.

Green technologies have had a challenging time cementing themselves into the mainstream in Virginia. Looking at the Virginia Clean Economy Act of 2020 as an example, one potential answer is that there is simply too much disparity between Northern Virginia and Southwest Virginia, with Northern Virginia having too much economic diversity and opportunity and Southwest Virginia typically being of a poorer populous.[11] This leads to Virginia passing legislation that assists these individuals or not passing legislation that will cause them problems. This act of "not passing legislation" is a policy stance on the part of the legislators, one which allows for the "freedom" of the markets and the power of big corporations. Mariana Mazzucato, Political Economist at the University College London, states that markets are always driven by government involvement. One example of this is the U.S. involvement in First Solar, a solar power start-up that received extensive funding and support from the U.S. government, allowing it to become a leader in its field.[12] While the federal government is involved in multiple research projects and funding opportunities for EVs and EVSE, state governments also have a part to

[11] Vogelsong, Sarah. "Virginia Clean Economy Act passes, as debate reveals deep partisan and regional divides." *Virginia Mercury.* 11 February, 2020. Retrieved from https://www.virginiamercury.com/2020/02/11/virginia-clean-economy-act-passes-as-debate-reveals-deep-partisan-and-regional-divides/.

[12] Mazzucato, Mariana. *The Entrepreneurial State.* Public Affairs: New York, 2015.

play, since most of the financial decisions for states are left for state-level initiatives and policymakers.

Another potential cause for the lack of EVSE infrastructure in Virginia is derived from Vivian Thomson and her book, *Climate of Capitulation.* Thomson describes Virginia as having a "climate of capitulation", defined as a system where "politicians and civil servants tend to give in to the regulated community's desires for weak standards."[13] What she means is that Virginia, with a history of large corporations and their involvement in policymaking and campaign financing, is not willing to adopt legislation that goes against these companies for fear of losing funding and being ostracized by the deep pockets of the corporations. In a sense, nothing happens in Virginia without corporation approval. California does not have this history. Along the lines of Thomson, David Vogel, Professor Emeritus at the University of California Berkeley, states that California was able to achieve more "green" legislation than any other state due to the overall community's desires for better standards.[14] This desire for better environmental policies by the populous did not allow businesses and corporations to gain enough footing and traction in the policymaking process, allowing California to pass legislation without needing corporate approval. Whether or not these are the true roots of the problem for Virginia's laggard

[13] Thomson, Vivian. *Climate of Capitulation: An Insider's Account of State Power in a Coal Nation.* MIT Press: Cambridge, 2017. p.15.

[14] Vogel, David. *California Greenin': How the Golden State became an Environmental Leader.* Princeton University Press: Princeton, 2018.

performance with EVSE infrastructure, it is apparent that Virginia's stance of "let the markets handle it" is not working towards the benefit of its environmental goals.[15]

All markets are driven by corporate interests and guided by government policy. Government policy and intervention in the economy should not be looked down upon but looked at as a simple fact of the market. Government intervention allowed for the advancement of such technologies like lithium-ion batteries, advanced solar panels, and the iPhone, to name but a few domestic products directly influenced by U.S. government funding.[16] Direct government regulation by the state government in California, since the Clean Air Act of 1970 and California's waiver to allow for more stringent regulations, has led to several economic successes, with the goal of lowering emissions and reducing the carbon footprint of the state.[17] By actively fighting the "climate of capitulation", California is a model for government guidance in the markets with the idea of maintaining the private economy. While the government places regulations and goals for the state and its citizenry, it is up to the private industries and corporations to meet those expectations. This is understood as the best way that the California

[15]House Bill 1965. 2021. VA.S10.1-1307.04. Retrieved from https://lis.virginia.gov/cgi-bin/legp604.exe?211+sum+HB1965.

[16] Information gathered from *U.S. Department of Energy* and Mazzucato's *The Entrepreneurial State.*

[17]Vogel, David. *California Greenin': How the Golden State became an Environmental Leader.* Princeton University Press: Princeton, 2018.

government can help its communities. Virginia, on the other hand, has engrained itself in the "climate of capitulation" by allowing corporations and big business to have control over both energy policies and state communities. It has a blind faithfulness to the ideas of neoliberalism, which favor deregulation of the economy and little government involvement. This has become a hindrance when it comes to meeting state environmental plans and emissions goals. The neoliberal school of thought believes that the freedom of the market is the apparatus by which people gain their individual freedoms, such as the freedom of speech and press.[18] The role of the government is very small, designed to protect the property rights of individuals and allow the market to move at peak efficiency through deregulation. In a sense, the government is simply there to uphold the market while it wanes and grows naturally.[19]

The overall addition to the literature of Political Science that this paper brings is that Virginia could be seeing a turn away from its neoliberal economic policies. With its direct proximity to Washington D.C., there is an assumption that Virginia is a progressive state that will have more liberal tendencies, in the domestic sense. Using EVSE as a case study, it is possible to see that leaving it up to the "invisible hand" of the markets is not permitting supply to keep up with demand, and it is not offering the supply equitably. This demand for EVSE also reflects the desires of the governing administrations at all levels. Government desires and goals are usually met through the action or inaction of policy. Federal desires are usually brought about

[18] Harvey, David. *A Brief History of Neoliberalism.* Oxford University Press: New York, 2007.

[19] Ibid.

through regulations, incentives, and grant opportunities, while state desires are met with more localized regulations and incentives. [20] At the local level, desires are met through incentives and finite regulations, such as zoning requirements.[21] Federally, there are shifts toward more environmentally-conscious legislation, such as the INVEST in America Act, the bipartisan infrastructure bill promised by the Biden administration.[22] At the state level, Virginia has politicians who typically are on the side of "free markets" and big businesses advocating for funding for EV and EVSE programs, which could prove to be a gateway into new technologies and investment opportunities.[23] Promoting direct government involvement in these sectors would allow for the artificial surge in EVSE growth that would put it on track with state objectives and be equitable for all citizens. California has already implemented laws and regulations that assist

[20]Stone, Deborah. Policy Paradox: the art of political decision making. W.W. Norton & Company: New York, 2012.

[21]Information gathered during time working for Prince Edward Economic Development department through work with the Virginia Cardinal Program.

[22]"H.R. 3684 - 117th Congress (2021-2022): Infrastructure Investment and Jobs Act." 15 November, 2021. Retrieved from https://www.congress.gov/bill/117th-congress/house-bill/3684.

[23]Vogelsong, Sarah. "Democrats push electric car infrastructure bill as a solution to rural gaps." Virginia Mercury. 4 February, 2022. Retrieved from https://www.virginiamercury.com/2022/02/04/democrats-push-electric-car-infrastructure-bill-as-a-solution-to-rural-gaps/.

in EVSE growth, but Virginia is only recently recognizing that it is a sector that needs assistance to meet both the economic and environmental demands. It is for that reason that California was chosen as the second demographic since comparing a laggard to a model in the field could potentially lead to finding the key differences that set them apart. This will help to determine the level at which government intervention plays a role in both states and how that dynamic might lead to different outcomes.

To determine the key factors at play in the economic development of EVs and EVSE, I have identified four "pivotal moments" in the history of EVSE. Pivotal moments are moments in time that have occurred in a way that has changed the course of history.[24] For the purposes of this thesis, pivotal moments will be defined as moments in history that have led to significantly higher growth rates of EVSE. They will not be used as a measure of analysis or the object of the analysis, but as singular points in time that offer source material for the analysis. These moments are identified by rates of at least 40% growth each year, with particular attention paid to those that surpass 50% growth, defined by UCLA Professor Emeritus Eric Flamholtz as "hyper-

[24] Poe, Marshall. "Moscow, the Third Rome: The Origins and Transformations of a 'Pivotal Moment'." *Jahrbücher für Geschichte Osteuropas* , 2001. pp. 412-429. Retrieved from https://www.jstor.org/stable/pdf/41050783.pdf?casa_token=9yOiHKj3aCkAAAAA:5ajsdbE9mqtpmGEbzhqV3qeS_JJuYGves_SI-rKTkWYRFB5Cck_8qUibqBax0e9pMcFwiUPQSKRVcEtK4YQ-t5tqlt_ynO0zislfd2AOjCkWNEht8pZq

growth."[25] To determine a scale to measure EVSE growth, it was necessary to look outside of the normal market and industry growth to that of small businesses and Information Technology companies since those typically have higher growth rates than other sectors.[26] Dr. Flamholtz's book, *Growing Pains*, discusses the differences between expected growth rates in various industries. EVSE infrastructure has experienced drastic growth in a short period of time, which warrants the industry be looked at in a different light than the normal expected growth. This growth rate will be the dependent variable of the study, offering a backdrop with which to compare potential catalyst events. If I had chosen to look at the number of EVSE installed each year in the states, it would not have accounted for the gradual increase of the market in motion. Since the objective of this study is to determine catalysts for change, it is important to nullify the normal rate of change that comes from the expanding economy and advancement of the sector. Large businesses that are stable and solidified within the market tend to generate rates of change far beneath that of small businesses. By these measures, I decided to categorize EVSE with the small businesses and IT corporations, since they have similar rates of growth. Once I determined the rates of change, I collected data covering numerous different fields, including, business events, state GDP and finances, state and federal party identifications, state and federal

[25] Flamholtz, Eric and Randle, Yvonne. "Growing Pains: Transitioning from an Entrepreneurship to a Professionally Managed Firm 4 Ed." *Jossey-Bass:* Hoboken, New Jersey. 2007.

[26]"What's Your Growth Rate: Too Fast, Too Slow, or Just Right?" *Revenue Rocket.* 1 August, 2021. Retrieved from https://www.revenuerocket.com/whats-growth-rate-fast-slow-just-right/.

legislation, and the influence of Non-Governmental Organizations (NGOs). After collecting the historical data, I compare the pivotal moments with data that is relevant in the surrounding years. This shows where the main drivers of the EVSE market are and if they are related to certain catalyst events. Since California has had EVSE registered since 1995 and Virginia gained its first charger in 2010, there will be significantly more data with California, however, it should not change the analysis of the data since all that is being done regarding time is the identification of significant rates of change and potential corresponding catalysts.

I begin by giving a detailed account of both Virginia and California, leading into a history of each states' development of EV and EVSE technology. I base this history around the pivotal moments mentioned previously, which correlate to 1995, 2002, 2011, and 2019-2020. At each moment, I will delve into various events and facts that pertain to the history around that time, at which point I will choose one of the following aspects to serve as the overarching influence of the moment: Government Intervention, Market Tendencies, and Outside Forces. After this, I go through each of the variables investigated in the study and determine which individual variables hold the most significance overall. Utilizing theories from Brown, Vogue, Thomson, and Mazzucato, I will determine the theoretical reasoning behind each of these catalysts and what that means for the overall topic of government involvement in the economy. Using this data, I then discuss the topic of Virginia straying away from the neoliberal policies of the past and embracing more interventionalist ideals.

My theory proposes that government intervention and guidance are necessary for economies to achieve specific goals. Without intervention and guidance of the government,

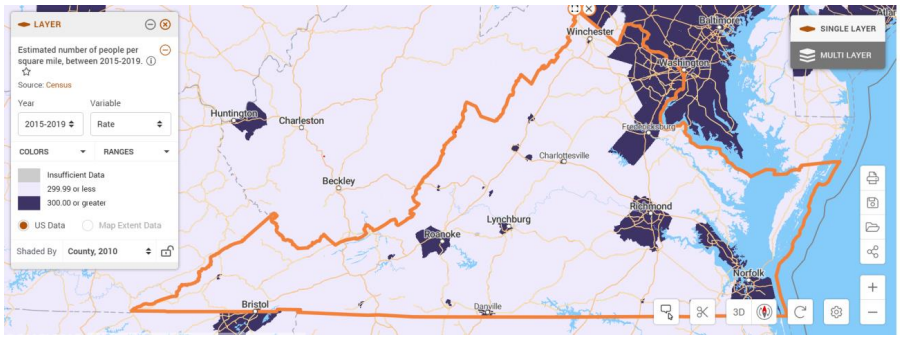
corporations can act freely and control markets, which leads to less innovation and more consolidation of power. To achieve goals that require new technologies and procedures, the government must enact regulations and incentives for the economy to go in the direction that it intends. The movement towards decarbonization and lower emissions is a perfect example of this situation, with Virginia's climate of capitulation leading to the laggard tendencies seen in the state's environmental policy development.

LITERATURE REVIEW

Virginia and California

Virginia is on the east coast of the United States. With a current population of 8.6 million people, it is home to the largest naval base in the world at Norfolk and it is in direct contact with the nation's capital, Washington D.C.[27] The majority of the population in Virginia resides in the metropolitan areas around Fairfax in the north, Richmond in the central, and Norfolk in the east, with various cities throughout boasting sizeable populations.[28]

Figure 1-A - Virginia Population Densities



[27] "Quickfacts: Virginia; California." *U.S. Census Bureau.* Retrieved from https://www.census.gov/quickfacts/fact/table/VA,CA/PST045221.

[28] *Estimated number of people per square mile, between e2015-2019.* PolicyMap, https://vt-policymap-com.ezproxy.lib.vt.edu/data/our-data-dictionary/#Census:%20Decennial%20Census%20and%20American%20Community%20Survey%20(ACS) (based on data from PolicyMap and U.S. Census Bureau; Accessed 2 March 2022).

Virginia's government seems to be centrist, with party authority shifting constantly over periods of a few years. The most recent elections have the Republicans controlling the Governor's Office, as well as the House. The Democrats currently control the Senate.[29] Virginia's economy has seen a steady growth rate from 2010 to 2019, with the Covid-19 Pandemic causing a negative trend in the state economy. The state budget has continued to rise, with the 2010 budget at roughly $37 Billion and the most recent 2022 proposed budget at $72 Billion, double that of 2010.[30] Virginia's Gini Coefficient rating, a scale measuring 0-1 on the inequality between citizens, where 1 signifies total inequality and 0 signifies total equality, is rated at a .47.[31] Compared to national statistics, Virginia has 57.75% of its citizens living above the national median household income, while only 49.55% of its citizens are living above the

[29] "Party control of Virginia state government." *Ballotpedia*. Retrieved from https://ballotpedia.org/Party_control_of_Virginia_state_government.

[30] "Virginia: Regional Data: GDP and Personal Income." *U.S. Department of Commerce: Bureau of Economic Analysis*. 1 October, 2021. Retrieved from https://apps.bea.gov/itable/iTable.cfm?ReqID=70&step=1&acrdn=1.

[31] *Estimated inequality of household income according to the Gini Index, between 2015-2019.* PolicyMap, https://vt-policymap-com.ezproxy.lib.vt.edu/data/our-data-dictionary/#Census:%20Decennial%20Census%20and%20American%20Community%20Survey%20(ACS). (based on data from PolicyMap and the U.S. Census Bureau; Accessed 2 March 2022).

state median household income.[32] Pertaining to EVSE, Virginia began mentioning EVSE in the 2015 budget, where funds were allocated to invest in research.[33] The first laws passed were in 2017 and 2018, when the state made it legal for schools and local governments to charge citizens for using EVSE on their property.[34] Virginia passed the "Right to Charge" laws in 2020, which gave citizens the right to buy EVSE for their private use against Home Owners' Associations and rental companies.[35] The majority of VA legislation on EVSE has only been passed since 2021, with bills setting up rebate programs, incentives programs, and clean energy and automobile

[32]*Local Median Household Income as a share of Area Median Household Income between 2015-2019.* PolicyMap, https://vt-policymap-com.ezproxy.lib.vt.edu/data/our-data-dictionary/#PolicyMap%20&%20American%20Community%20Survey%20(ACS). (based on data from ACS and PolicyMap; Accessed 2 March 2022).

[33]"H.B. 1400 - 2015 Session: Budget Bill." 26 March, 2015. Retrieved from https://budget.lis.virginia.gov/bill/2015/1/.

[34]Please see Code of Virginia 22.1-131 and Code of Virginia 15.2-967.2 located at https://law.lis.virginia.gov/vacode/.

[35]McGowan, Elizabeth. "Virginia law cleared a path for condo owners to install charging stations." *Energy News Network.* 27 April, 2021. Retrieved from https://energynews.us/2021/04/27/virginia-law-cleared-a-path-for-condo-owners-to-install-charging-stations/.

emissions plans.[36] While Virginia has some of these programs, there is no funding or administration designated for the tasks laid out. Virginia currently has few active Non-Governmental Organizations working on the topic of EVSE, with two being Virginia Clean Cities and Generation180.[37] Both actively engage in EV and EVSE promotion and provide information to citizens and policymakers regarding their areas of expertise.

California is on the west coast of the United States. As shown in Figure 1-B on page 18, it has a current population of 39 million people[38], which is centered mainly around the Sacramento, San Francisco, and San Diego areas.[39] There are a few areas in the northern portion of the state that have significant populations, but none that rival that of the southwest. It is home

[36]Please see Figure 1-B in Appendix for relevant information. All information pertaining to laws retrieved from https://law.lis.virginia.gov/vacode/ and https://lis.virginia.gov/.

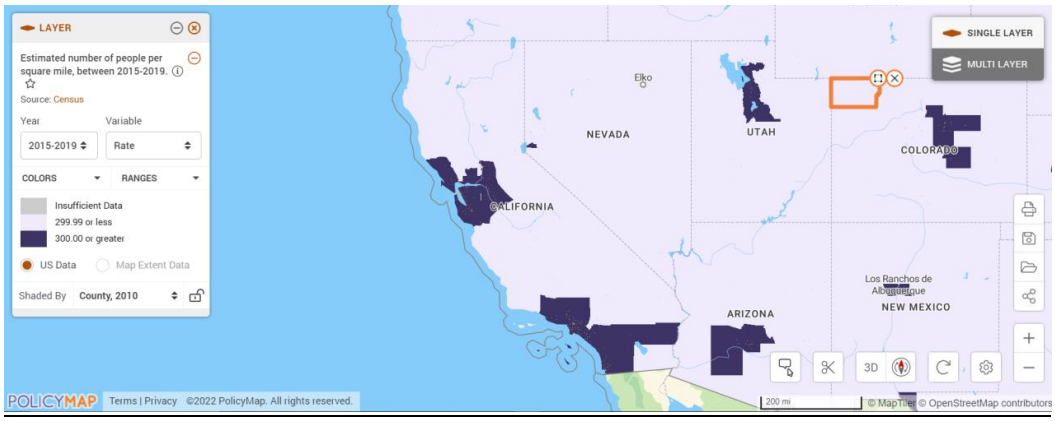
[37]"About." *Virginia Clean Cities.* Retrieved from https://vacleancities.org/about/.

[38] "Quickfacts: Virginia; California." *U.S. Census Bureau.* Retrieved from https://www.census.gov/quickfacts/fact/table/VA,CA/PST045221.

[39]*Estimated number of people per square mile, between 2015-2019.* PolicyMap, https://vt-policymap-com.ezproxy.lib.vt.edu/data/our-data-dictionary/#Census:%20Decennial%20Census%20and%20American%20Community%20Survey%20(ACS). (based on data from PolicyMap and the U.S. Census Bureau; Accessed 2 March 2022).

to the fourth-largest naval base in the world, San Diego, and Silicon Valley, the technology innovation capital of the world.[40]

Figure 1-B - California Population Densities



California's governing bodies have historically been Democratic, but the Republicans held the Governor's Office for a few years in the mid-90s and mid-2000s. Democrats have almost entirely controlled the House and Senate since 1995.[41] California's GDP has seen entirely

[40]"Economy of California." *Britannica.* Retrieved from https://www.britannica.com/place/California-state/Economy.

[41]"Party control of California state government." *Ballotpedia.* 25 February, 2022. Retrieved from https://ballotpedia.org/Party_control_of_California_state_government.

consistent growth, with only two years turning deficits from 1995 to 2019.[42] Like Virginia, the Covid-19 Pandemic led to significant deficits in GDP in recent years. California's budget in 1995 was $45 Billion and has since grown to $196 Billion, which is the proposed 2022 budget.[43] This is more than four times the budget in 1995, with California seeing its budget more than double since 2010.[44] The Gini Coefficient for California is .49[45], with 57.88% of its citizens living above the federal median household income and 50.13% living above the state median household income.[46] California's legislative history with EVSE started in 2009, with incentives

[42]"California: Regional Data: GDP and Personal Income." U.S. Department of Commerce: Bureau of Economic Analysis. 1 October, 2021. Retrieved from https://apps.bea.gov/itable/iTable.cfm?ReqID=70&step=1&acrdn=1.

[43]"Historical Data." *California Legislative Analyst's Office.* Retrieved from https://lao.ca.gov/PolicyAreas/state-budget/historical-data.

[44] Ibid.

[45]*Estimated inequality of household income according to the Gini Index, between 2015-2019.* PolicyMap, https://vt-policymap-com.ezproxy.lib.vt.edu/data/our-data-dictionary/#Census:%20Decennial%20Census%20and%20American%20Community%20Survey%20(ACS). (based on data from PolicyMap and the U.S. Census Bureau; Accessed 2 March 2022).

[46]Local Median Household Income as a share of Area Median Household Income between 2015-2019. PolicyMap, https://vt-policymap-com.ezproxy.lib.vt.edu/data/our-data-

being brought about for EVSE infrastructure investments.[47] Laws continued to roll out in 2013, 2014, and the following years, with the majority of laws coming out in 2019, 2020, and 2021.[48] These include, but are not limited to, grants, incentives, rebates, regulations, emissions plans, and training and certification programs.[49] At the local level, certain California counties began to pass their own EVSE regulations and incentives programs in 2021, with more than half a dozen localities participating.[50] Regarding the presence of NGOs in California, numerous organizations are working on the dispersion of information about EVs and EVSE. One advantage that California has is that its NGOs are mainly based in local areas and do not govern the whole state,

dictionary/#PolicyMap%20&%20American%20Community%20Survey%20(ACS). (based on data from ACS and PolicyMap; Accessed 2 March 2022).

[47]"Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program." California Energy Commission. 30 April, 2009. Retrieved from https://www.energy.ca.gov/publications/2009/investment-plan-update-alternative-and-renewable-fuel-and-vehicle-technology.

[48]Please see figure 4-C in Appendix for relevant information. All information pertaining to laws retrieved from https://oal.ca.gov/ and https://www.treasurer.ca.gov/.

[49] Ibid.

[50]"California Laws and Incentives." *U.S. Department of Energy: Alternative Fuels Data Center.* Retrieved from https://afdc.energy.gov/laws/state_summary?state=CA&technologies=ELEC,PHEV.

as shown by their 12 Clean Cities Coalitions to Virginia's one.[51] Outside of NGOs, there are organizations such as the Zero Emissions Vehicle (ZEV) Task Force that were created in partnership with the California government, as well as other state governments, industry officials, and NGOs.[52]

History of EVSE in Virginia and California: Pivotal Moments of EVSE Growth

To tell the history of Electric Vehicle Supply Equipment (EVSE), one must first look at the broader history of the electric vehicle (EV). William Morrison developed the first EVs in the United States around the year 1880.[53] These first electric cars had batteries that used a simple household outlet to charge, which led to an extremely short range. This made them useless outside of areas with high population densities where the distance traveled was short.[54] Electric vehicles, due to reasons such as the affordability of gasoline and the increased range of internal

[51]"Clean Cities Coalition Network: California." *United States Department of Energy.* Retrieved from https://cleancities.energy.gov/coalitions/search?search_for=California.

[52]"ZEV Collaboration." *California Air Resources Board.* Retrieved from https://ww2.arb.ca.gov/zev-collaboration.

[53] "History of the Electric Car." *U.S. Department of Energy.* 15 September, 2014. Retrieved from https://www.energy.gov/articles/history-electic-car.

[54] Ibid.

combustion engine (ICE) vehicles, dwindled after the turn of the 20th century. It was not until the environmental push and the OPEC scare of the early 1970s that auto manufacturers again looked at the viability of EVs.[55] Even with numerous entities trying to gain traction in the field, it was not until Toyota unveiled the Prius in 1997 and released it for international sales in 2000 that EV technology took root.[56]

While the Prius was a hybrid-electric vehicle and not a true EV, it brought a lot of attention to the field of fuel-efficient cars and cars running on alternative fuels. The introduction of lithium-ion batteries in the mid-1990s also aided in the development of these new stage EVs, allowing them to hold significantly larger amounts of electricity than their predecessors, which typically ran on lead-acid batteries.[57] The modern age of EVs is typically credited with having begun in 2003, the year that Tesla Motor Co. was established, but Tesla Motors had to wait for

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[55] Simpson, Joseph and Van Barlingen, Wesley. "The history of electric cars." *EVBox.* 2 November, 2021. Retrieved from https://blog.evbox.com/electric-cars-history#:~:text=The%20history%20of%20electric%20cars%20can%20be%20broken%20up%20into,(2003%2D2020)%2C%20and.

[56] Ibid.

[57] Wilson, Kevin A. "Worth the Watt: A Brief History of the Electric Car, 1830 to Present." *Car and Driver.* 15 March, 2018. Retrieved from https://www.caranddriver.com/features/g15378765/worth-the-watt-a-brief-history-of-the-electric-car-1830-to-present/.

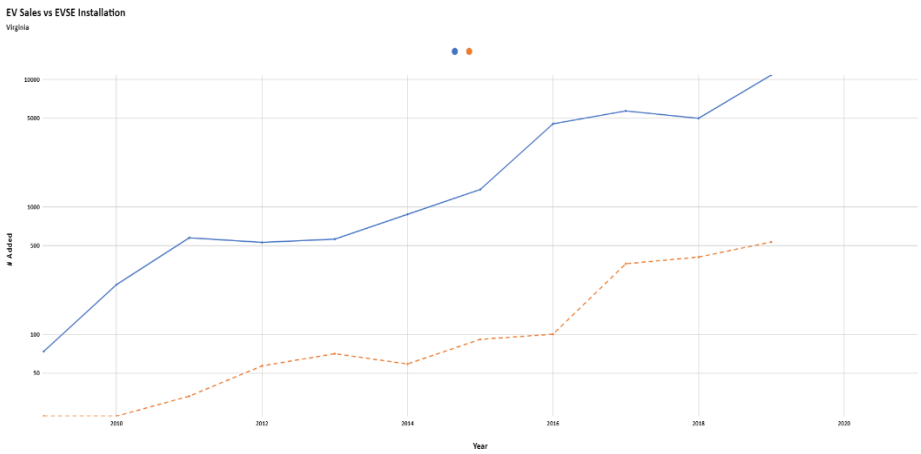
investor Elon Musk to join in 2004 until they could effectively begin research and development, leading to their first car, the Tesla Roadster, being sold in 2008.[58] Soon after this, the Chevrolet Volt and Nissan Leaf were released in 2010, although sales of the Leaf remained outside the United States until 2013. Directly following these two, Tesla Co. released its Tesla Model S in 2012, bringing the total amount of commercially viable battery electric vehicles (BEVs) to three.[59] Since then, almost all auto manufacturers have had EVs and hybrids in their lineups, with many discussing plans to completely phase out internal combustion engines (ICEs) soon.[60]

[58] Ibid.

[59] Kuchta, David M. "The History of the Electric Car: A Timeline." *Treehugger*. 13 January, 2022. Retrieved from https://www.treehugger.com/history-of-the-electric-car-trials-and-triumphs-5193009.

[60] Motavalli, Jim. "Every Automaker's EV Plans Through 2035 And Beyond." *Forbes: Wheels*. 4 October, 2021. Retrieved from https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement#partners.

Figure 2 – EV Sales vs. EVSE Installations: Virginia



The solid blue line shows the average rate of change in EV sales, while the dotted orange line shows the average rate of EVSE installations.

One question that arises from looking into the different aspects of EVSE is whether EVSE differences are caused by the change in EVs on the road. There is no simple answer to this question. As part of the background data for this study, I collected sales rates of EVs and installation rates of EVSE in both California and Virginia. In Figure 2, there are certain time periods, such as 2013-2014, where there seems to be a complete disconnect between EV sales and EVSE installation. The sales of EVs rose, while the rates of EVSE installations dropped. There does, however, seem to be a distinct pattern to the rates of sales and installations when looking at the installations as being one to two years behind the sales. What I mean by this can be seen in the jump in EV sales during 2015-2016, whereas one year later, in 2016-2017, there was a very similar surge in EVSE installations. This could also help to explain the findings

derived from Figures 3-A and 3-B, where California saw a jump in sales starting in 2017 but did not see a surge in EVSE installation until 2019.

Figure 3-A – EV Sales: California

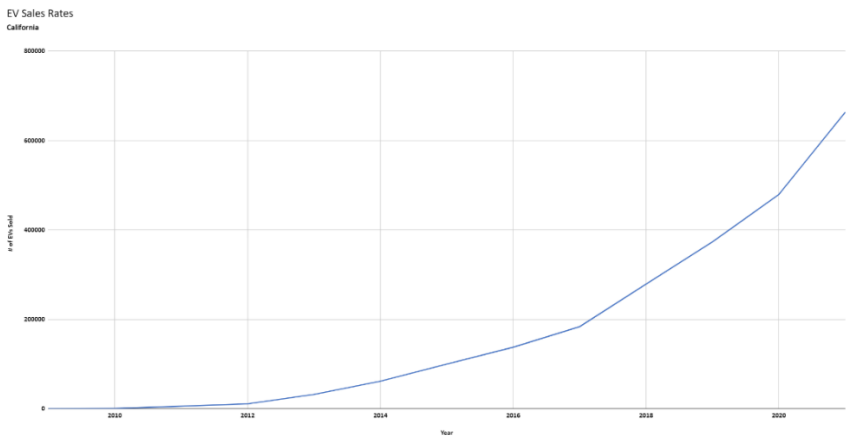
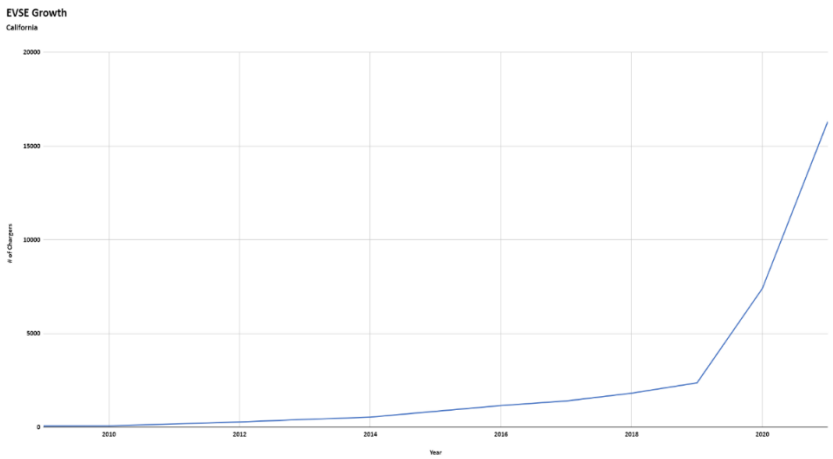


Figure 3-B – EVSE Installations: California



Behind the scenes is the charging technology used to keep the EVs on the road. These chargers vary between levels, types, and companies. The first charging equipment in the U.S.

was available at Level-1 and Level-2 with the higher having two modes, an inductive paddle-charger developed in 1994 by the company Magne Charge, and a male-female conductive charger developed by Avron, which would later be developed into the J-1772 charging port.[61] I will not be focusing or deliberating on Level-1 charging since it is simply plugging the car into a household power outlet. One year after this California had its first Level-2 charger installed.[62] This is what I deem the first pivotal moment. As the first moment when a Level-2 charger was made available for public use, it is the origin of the entire study and the beginning of the investigation into distribution catalysts and mechanisms. Aside from the development of the Level-2 charger in 1994, new technologies were being developed that assisted in the installation of EVSE. General Motors was developing their prototype EV1 in the early 1990s, which was an electric car that never hit the market due to budget constraints and low practicality.[63] It was also

[61] Shah, Vivek. "Electric car charging standards: What does your EV use?" *CarExpert.* 22 August, 2021. Retrieved from https://www.carexpert.com.au/car-news/electric-car-charging-standards-what-does-your-ev-use.

[62]Information received via US Department of Energy AFDC "EV Charging Station Locations" database located at https://afdc.energy.gov/fuels/electricity_locations.html#/analyze?region=US-CA&fuel=ELEC.

[63]Kuchta, David M. "The History of the Electric Car: A Timeline." *Treehugger.* 13 January, 2022. Retrieved from https://www.treehugger.com/history-of-the-electric-car-trials-and-triumphs-5193009.

right around the mid-1990s that the lithium-ion battery was first developed for EVs, much in part due to federal research grants offered by the U.S. Department of Energy.[64] Since the catalyst for the beginning of EVSE in California, and the catalyst for the first pivotal moment, seems to be completely dependent on the initial development of Level-2 charging in the early 90s, as well as the research and development of prototype EVs in the mid-1990s, I determine that the major influence for the first moment is technological advancements.

In the following years, the J-1772 was chosen as the federal standard for charging in the U.S., with the only companies deviating from this being Tesla Motors, GM, and Toyota, with GM and Toyota using the Magne Charge paddles until the early 2000s.[65] This leads to the second pivotal moment, which takes place for California in 2002. This year, California saw EVSE installation rates reach 40%, with 17 new chargers being added to the 26 already available for use.[66] Roughly around this time, Ford released their Ranger EV, Chevrolet released their S-10

[64]"History of the Electric Car." *United States Department of Energy.* 15 Sep. 2014. Retrieved from https://www.energy.gov/articles/history-electric-car.

[65] Shah, Vivek. "Electric car charging standards: What does your EV use?" CarExpert. 22 August, 2021. Retrieved from https://www.carexpert.com.au/car-news/electric-car-charging-standards-what-does-your-ev-use.

[66]Information received via US Department of Energy AFDC "EV Charging Station Locations" database located at https://afdc.energy.gov/fuels/electricity_locations.html#/analyze?region=US-CA&fuel=ELEC.

Electric, and Toyota released their RAV-4 Electric, which was developed and sold as fleet vehicles for locally-based organizations and companies.[67] Also in developmental stages was the tZero, an EV developed by AC Propulsions that was the first EV to contain a lithium-ion battery. The tZero never entered into production due to high production costs and inadequate range tests, but the public interest in EVs was growing due to these projects, along with the domestic release of hybrid vehicles like the Toyota Prius.[68] Also in 2002, California passed the Clean Transportation Program, a piece of legislation that laid out regulations for low-emission vehicles for the years 2005-2008. While this is not likely to have had a significant impact on the development of EVSE in that year, it does show that the California government was beginning to see EVs as a viable option for lowering carbon emissions.[69] Due to the multiple technological

[67] "DISCONTINUED ELECTRIC VEHICLES." *Evadoption.* Retrieved from https://evadoption.com/ev-models/discontinued-electric-vehicles-evs/.

[68]Simpson, Joseph and Van Barlingen, Wesley. "The history of electric cars." *EVBox.* 2 November, 2021. Retrieved from https://blog.evbox.com/electric-cars-history#:~:text=The%20history%20of%20electric%20cars%20can%20be%20broken%20up%20into,(2003%2D2020)%2C%20and.

[69]"Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program." *California Energy Commission.* 30 April, 2009. Retrieved from https://www.energy.ca.gov/publications/2009/investment-plan-update-alternative-and-renewable-fuel-and-vehicle-technology.

advancements in the late 90s and early 2000s, I determine that the main catalyst for the second pivotal moment, similarly to the first, was Market Tendencies.

The third pivotal moment does not occur until 2011, when we see the domestic production and sale of the Chevrolet Volt, the Tesla Roadster, and the Tesla Model S. The Chevrolet Volt and Tesla Model S were the first EVs marketed at the middle-class, with the Tesla Roadster costing more than $100,000 for the base model.[70] Importantly, the Tesla Roadster was the only one of the four previously mentioned to be available for sale before 2010. This is the first year that Virginia installed publicly available EVSE[71]. California also saw a dramatic change this year, with a 55% increase in EVSE chargers leading to a total of 174 for the state.[72] Occurring one year before the moment, in 2010, the United States Department of Energy signed

[70]Wilson, Kevin A. "Worth the Watt: A Brief History of the Electric Car, 1830 to Present." *Car and Driver*. 15 March, 2018. Retrieved from https://www.caranddriver.com/features/g15378765/worth-the-watt-a-brief-history-of-the-electric-car-1830-to-present/.

[71]Information received via US Department of Energy AFDC "EV Charging Station Locations" database located at https://afdc.energy.gov/fuels/electricity_locations.html#/analyze?region=US-VA&fuel=ELEC.

[72]Information received via US Department of Energy AFDC "EV Charging Station Locations" database located at https://afdc.energy.gov/fuels/electricity_locations.html#/analyze?region=US-CA&fuel=ELEC.

a $465 Million loan for Tesla Motors to continue EV research, which led to the mass production capability of the Model S, and likely years later, the Model 3.[73] From this, the Tesla charging infrastructure, discussed shortly, was bolstered as well. Based on the numerous releases of EVs and the influence of the federal government in the years leading up to the moment, I believe that both events played catalyzing roles in the moment. While the release of multiple EVs in 2010-2011 was an undeniable catalyst, those releases, and the increase in chargers to drive them, would not have been possible so quickly without influence from the federal government. Therefore, the catalysts for the third pivotal moment are both Market Tendencies and federal Government Intervention. At the time of the third moment, there were three main charging options available to consumers in the United States. Tesla Motors had a proprietary system of Tesla chargers that were only available to its customers, the J-1772, also known as the CCS charger, and the CHAdeMO charger, which was utilized a lot by foreign auto manufacturers, such as Nissan.[74] These three chargers then grew to have their own respective Level-3 DCFC

[73]"History of the Electric Car." *United States Department of Energy*. 15 Sep. 2014. Retrieved from https://www.energy.gov/articles/history-electric-car.

[74] Shah, Vivek. "Electric car charging standards: What does your EV use?" CarExpert. 22 August, 2021. Retrieved from https://www.carexpert.com.au/car-news/electric-car-charging-standards-what-does-your-ev-use.

variants, with Tesla owners being able to purchase adapters and gain access to all three.[75] Level-3 DCFC are significantly more powerful than both Level-1 and Level-2 chargers, being able to fully charge most EVs in less than an hour.[76]

The fourth, and most recent, pivotal moment is the years 2019-2020. EVSE growth rates have remained relatively higher than they have in many years, with California seeing thousands of additional chargers built per year since 2020.[77] Virginia, on the other hand, saw an increase of 360 chargers in 2020, totaling 43% of their total chargers that year.[78] In the years leading up to the fourth pivotal moment, many different events could have played a part in the increase of EVSE infrastructure rates. In 2016, Volkswagen (VW) had a lawsuit brought against them for fraudulently reporting emissions in their vehicles, which led to the founding of Electrify

[75] Ferris, David. "Tesla: We'll open our charging network for federal cash." *Energy Wire News.* 24 February, 2022. Retrieved from https://www.eenews.net/articles/tesla-well-open-our-charging-network-for-federal-cash/.

[76] "Supercharger." *Tesla.* Retrieved from https://www.tesla.com/supercharger.

[77]Information received via US Department of Energy AFDC "EV Charging Station Locations" database located at https://afdc.energy.gov/fuels/electricity_locations.html#/analyze?region=US-CA&fuel=ELEC.

[78]Information received via US Department of Energy AFDC "EV Charging Station Locations" database located at https://afdc.energy.gov/fuels/electricity_locations.html#/analyze?region=US-VA&fuel=ELEC.

America, an EVSE company that was created by VW as one of its reparations.[79] Another major change that was seen between the third and fourth moments was the increase in commercially available EVs. As stated, there were only three EVs available to consumers at the time of the third moment. The data for the time surrounding the fourth juncture shows that the number of commercially available EVs was much higher than that of the third moment.[80]

One other potential catalyst to the fourth moment is federal intervention, such as seen in 2011. In 2019, the United States began the EV Watts and Drive Electric USA projects, aimed at educating the populous on EV matters and pushing the idea that EVs were not just for the upper class.[8182] Another federal intervention could have to do with the 2020 Presidential Election, where Joe Biden announced that he would push forth a bill that would invest in the infrastructure

[79]"Volkswagen Clean Air Act Civil Settlement." *United States Environmental Protection Agency.* Retrieved from https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement#partners.

[80]"BEV MODELS CURRENTLY AVAILABLE IN THE US." *Evadoption.* 9 January, 2021. Retrieved from https://evadoption.com/ev-models/bev-models-currently-available-in-the-us/.

[81]"Join the EV WATTS Project and advance EV adoption." *Virginia Clean Cities.* Retrieved from https://vacleancities.org/reports-2/join-the-ev-watts-project-and-advance-ev-adoption/.

[82]"VCC Current Projects." *Virginia Clean Cities.* Retrieved from https://vacleancities.org/category/current-projects/.

of the country which he called the American Jobs Plan.[83] By the presidential candidate pushing this issue during the campaign, it likely had an effect on markets and expectations for the sector, driving up production. Ultimately, once Biden was elected into the office, the American Jobs Plan was changed to the INVEST in America Act, which was a more comprehensive bill, part of which mentioned funding for EVSE development in underrepresented communities.[84] Government intervention can also be seen at the state level, where Virginia Democrats gained the majority in both houses of their General Assembly, something that had not happened since before Virginia installed the first charger back in 2010.[85] Given the generally positive trend of development in the sector and the understood production of more EVs, the main catalyst for the fourth moment seems to be Government Intervention.

Since the fourth pivotal moment in 2019-2020, as stated above, Virginia has seen a drop in the overall rate of EVSE growth and California has seen consistently higher rates of EVSE growth. Virginia started passing state-level legislation regarding EVSE in 2017 and 2018, but the

[83]"FACT SHEET: The American Jobs Plan." *The White House: Briefing Room*. 31 March, 2021. Retrieved from https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/31/fact-sheet-the-american-jobs-plan/.

[84]"H.R. 3684 - 117th Congress (2021-2022): Infrastructure Investment and Jobs Act." 15 November, 2021. Retrieved from https://www.congress.gov/bill/117th-congress/house-bill/3684.

[85]"Party control of Virginia state government." *Ballotpedia*. Retrieved from https://ballotpedia.org/Party_control_of_Virginia_state_government.

majority of laws regarding EVSE in Virginia did not enter into effect until 2021.[86] California saw state-level incentives first introduced in 2009, with the majority of their programs and legislation about EVSE beginning to be passed in 2018.[87] On the business side of things, in 2021, Nissan announced that it would discontinue the CHAdeMO charging ports on all of its new EVs, instead opting for the CCS J-1772 charging port, which is more widely available.[88]

Another major announcement of 2021 was that Tesla Co. has plans to make all its chargers available for public use, although they did not announce exactly how they would be doing this. One solution would be to install CCS charging ports at Tesla stations, however, another may be to sell adapters that would allow the general public to access the infrastructure already in place.[89] This could prove to help the drive towards EVs by allowing all consumers access to the widest charging network in the U.S., although there could be significant issues depending on the logistics. In the future, automakers are making plans to completely phase out

[86]Please see Figure 6-B in the Appendix for reference material on VA laws.

[87]Please see Figure 6-C in the Appendix for reference material on CA laws.

[88]Halvorson, Bengt. "Nissan's move to CCS fast-charging makes CHAdeMO a legacy standard." *Green Car Reports.* 16 July, 2020. Retrieved from https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement#partners.

[89] Ferris, David. "Tesla: We'll open our charging network for federal cash." Energy Wire News. 24 February, 2022. Retrieved from https://www.eenews.net/articles/tesla-well-open-our-charging-network-for-federal-cash/.

their lines of ICE vehicles, instead of moving in favor of the EV market, which will increase the demand for EVSE to significantly higher levels than it currently is.[90]

[90] Motavalli, Jim. "Every Automaker's EV Plans Through 2035 And Beyond." *Forbes: Wheels.* 4 October, 2021. Retrieved from https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement#partners.

ANALYSIS

For the analysis, I look at the correlations between the potential independent variables of the study and the rate of change variable denoting the rate of EVSE growth per year. These independent variables are broken down into all potential events that could have played a role in the stimulation of EVSE infrastructure growth rates. I then look at the main variables and catalysts that correlated with the pivotal moments and relate those variables to the larger literature on influences on the market. All the potential independent variables that were gathered during the historical analysis and have meaningful change and influence will be analyzed for each of the instances that they took place to figure out the likelihood that each individual factor plays into the historical context.

The first group of variables that I will analyze are those under the category of Government Intervention. This category will consist of the more interventionist roles and influences on the growth of EVSE that are expected to be showcased in recent years. The variables that fall under this category are as follows: federal legislation, state legislation, and national programs. Federal legislation was chosen to determine the level of influence that the national government has when it passes legislation on a certain subject. This would also allow for the differentiation between levels of government involvement to help determine which has more of an effect. Federal legislation has been sparse regarding the importance of EVSE infrastructure since the first charger was made public in 1995 in California. The Energy Independence and Security Act of 2007 set up funding for research and development grants and

programs.[91] The money from these programs was used to develop EV technology, specifically that of batteries and charging capabilities. The American Recovery and Reinvestment Act (ARRA) of 2008 provided some funding for the advancement of charging-related technology.[92] The last piece of national legislation that deals with EVSE, and the most directly influential, was the INVEST in America Act, signed into law in 2021.[93] As part of the Act, the federal administration plans on pumping roughly $14 Million into EVSE infrastructure that would add roughly half a million charging stations across the country. Since these pieces of legislation seem to occur around the same times as spikes in the growth rates of EVSE, I believe they have a high correlation.

State legislation was chosen to see if there was a more significant impact on EVSE growth when legislation was passed at a more localized level where public well-being and infrastructure are usually handled. State legislation has played a much more involved role than that of the federal government. Though EVSE was not mentioned in California until 2013, the

[91] "Advanced Technology Vehicles Manufacturing Loan Program." U.S. Department of Energy. Retrieved from https://www.energy.gov/lpo/products-services/advanced-technology-vehicles-manufacturing-loan-program

[92] "ARRA and PEV Infrastructure." *Los Angeles County Economic Development Corporation.* 14 January, 2013. Retrieved from https://laedc.org/2013/01/14/arra-and-pev-infrastructure/.

[93] "H.R. 3684 - 117th Congress (2021-2022): Infrastructure Investment and Jobs Act." 15 November, 2021. Retrieved from https://www.congress.gov/bill/117th-congress/house-bill/3684.

first laws on EVs were passed in 1995 with the California Air Resources Board (CARB) expenditure requirements that laid out EVs as a potential option for emissions reduction, and in 2002, where emissions standards were set for the 2005-2008 period and EVs were a required asset to achieving the goals set by the standards.[94] Starting in 2013, legislation was being developed at the state level pertaining to EVSE rebates and incentives, as well as protections for businesses and consumers when it comes to the sale of electricity during charging.[95] The Volkswagen lawsuit of 2016 had legislation passed in 2016 for California that laid out specific funding and plans for its charging network through its new company, Electrify America.[96] The following years saw Virginia pass its first legislation on EVSE, which gave localities and schools the ability to generate revenue from EVSE on their properties.[97] California began a large rollout of EVSE legislation in 2018, with numerous laws and programs at the state level, including multiple sets of regulations, grant and incentive funds, and logistical plans for revenue

[94]Please see Figure 6-C in the Appendix for reference material on CA laws. All information pertaining to laws retrieved from https://oal.ca.gov/ and https://www.treasurer.ca.gov/.

[95] Ibid.

[96] "Volkswagen Clean Air Act Civil Settlement." United States Environmental Protection Agency. Retrieved from https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement#partners.

[97] Please see Figure 6-B in Appendix for relevant information. All information pertaining to laws retrieved from https://law.lis.virginia.gov/vacode/ and https://lis.virginia.gov/.

generation and training opportunities. California also saw the emergence of local incentives and regulations regarding EVSE start to emerge in 2021.[98] Virginia started a significant rollout in 2021 for its EVSE plans, beginning with rebate and incentive programs, as well as EV and EVSE production requirements.[99] Since these laws and incentives tend to correlate to times with larger than average rates of EVSE growth, I believe that they provide an important influence on the sector.

The last variable discussed in the Government Involvement category is national programs. This variable looks at any programs held at the national level that are directly or indirectly involved in the development of the EVSE sector. It does not include individual research grant opportunities from the government, such as those found in the mid-1990s that led to the development of the lithium-ion battery. The reason that this variable was included within the Government Involvement category is that programs run by the government can have widespread publicity and offer significant boosts to public knowledge and involvement in different fields. The first national program that had a significant impact was the Advanced

[98] Please see Figure 6-C in the Appendix for reference material on CA laws. All information pertaining to laws retrieved from https://oal.ca.gov/ and https://www.treasurer.ca.gov/.

[99] Please see Figure 6-B in Appendix for relevant information. All information pertaining to laws retrieved from https://law.lis.virginia.gov/vacode/ and https://lis.virginia.gov/.

Technology Vehicles Manufacturing Loan Program (ATVM).[100] This program's goal is to develop technology that would aid in the development of alternative fuel vehicles. The second program that would play a significant role is the ARPA-E (Advanced Research Projects Agency-Energy) research program, which began in 2005 but did not start researching until 2009.[101] This led to research in advanced battery technology, including how to give batteries a faster charge, which led to the Level-3 chargers. In 2013, the federal government launched its EV-Everywhere Grand Challenge, aimed at raising awareness of EVs and the technology that goes into them.[102] Its goal was to increase the sales of EVs by educating the populous. The EV WATTS program did not begin until 2019, although its main goal was to gather information on EV usage throughout the country and determine the best way to rollout EVSE development.[103] It also

[100] "Advanced Technology Vehicles Manufacturing Loan Program." U.S. Department of Energy. Retrieved from https://www.energy.gov/lpo/products-services/advanced-technology-vehicles-manufacturing-loan-program

[101] "ARPA-E History." U.S. Department of Energy: Advanced Research Projects Agency - Energy. Retrieved from https://arpa-e.energy.gov/about/arpa-e-history.

[102] "EV Everywhere Grand Challenge Blueprint." *U.S. Department of Energy.* 31 January, 2013. Retrieved from https://www.energy.gov/sites/prod/files/2014/02/f8/eveverywhere_blueprint.pdf.

[103] "Project: Electric Vehicle Widescale Analysis for Tomorrow's Transportation Solutions." *Energetics: Clean Energy Consulting.* August 2019. Retrieved from

aimed at informing the public about EVs, but this was a secondary mission that was an indirect advantage. The final program that has been started at the national level is Drive Electric USA, which is aimed at informing the public about EV technology, as well as connecting them with avenues to purchase an EV.[104] It goes much further than EV-Everywhere in the sense that it has individual state programs that report to the national program, which leads to more involvement with the people and policymakers. They likely saw the lack of grassroots infrastructure as a problem under the EV-Everywhere program. Since these programs have been so scarce, it is unlikely that they have played an extremely key role in the growth rate of EVSE.

The second group of variables that I will analyze is those that fall under the category of Market Tendencies, which contains the following variables: state GDP and major industry events. The first variable looked at under this category is state GDP growth. State GDP is a variable that needs to be included because the rate of change in the states could be determined by the amount of money that is flowing through the states. GDP data allows for the simulation of smaller markets, where a larger GDP growth could see a larger increase in the EVSE growth rates, while a smaller GDP could be seen as stagnation, which would cause a lull in the installation of EVSE. California has seen anywhere between 1% and 6% growth since 1995, with very few instances of seeing a decline in GDP growth. Covid-19 led to the largest deficit since

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https://www.energetics.com/projects/electric-vehicle-widescale-analysis-for-tomorrows-transportation-solutions.

[104] "Project Overview." *Drive Electric USA.* Retrieved from https://www.driveelectricusa.org/.

the 2008 recession, at -2.80%.[105] The GDP of California does not seem to have any spikes at the pivotal moments of EVSE growth. Virginia sees a smaller increase in GDP, with anywhere from 0.40% to 3.20% since 2010. There was one instance of a decline in 2014, but the growth continued until 2020 and Covid-19, when Virginia saw a loss of -2.80%.[106] As with California, there do not seem to be any major spikes around the pivotal moments. Based on that, I do not believe GDP correlates with EVSE development rates.

The other variable I examine under the Market Tendencies category is major technological and business events. These include new inventions and business events, such as a new EV release. Including information on the business and technological advancements in the field lets us determine if the market was already desirable but waiting on the technology to catch up. It also tells us if jumps in EVSE growth were made in correspondence to the need for more charging. Noteworthy events for this variable begin in 1996, with the unveiling of the GM EV1, and continue into the early 2000s with the release of the Toyota Prius Hybrid and RAV-4 EV, Honda Insight, and Ford Ranger EV.[107] Lithium-ion batteries were first used in EVs in 1997,

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[105] "California GDP." Department of Numbers. Retrieved from https://www.deptofnumbers.com/gdp/california/.

[106] "Virginia GDP." Department of Numbers. Retrieved from https://www.deptofnumbers.com/gdp/virginia/.

[107] Wilson, Kevin A. "Worth the Watt: A Brief History of the Electric Car, 1830 to Present." Car and Driver. 15 March, 2018. Retrieved from

which significantly increased the range and battery capacity of prototypes. Tesla was founded in 2003 but did not release its first vehicle until 2006.[108] They then received a significant loan from the U.S. Department of Energy in 2010, which allowed them to release the Model S the year after.[109] Also in 2010, Chevrolet released the Volt to domestic markets and Nissan released the Leaf to foreign markets. These were the first affordable EVs to hit the commercial market. Auto manufacturers continued to roll out EV models, such as the Chevy Bolt and Tesla Model 3.[110] In 2016, Volkswagen was involved in a major lawsuit due to an emissions scandal that led to the creation of EVSE company Electrify America, as well as financial reparations to many markets.[111] More recently, Covid-19 greatly decreased the release of EVs due to computer chip scarcity across the globe. Also very recently, Tesla announced the opening of all of their

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https://www.caranddriver.com/features/g15378765/worth-the-watt-a-brief-history-of-the-electric-car-1830-to-present/.

[108] Ibid.

[109] "History of the Electric Car." United States Department of Energy. 15 Sep. 2014. Retrieved from https://www.energy.gov/articles/history-electric-car.

[110] Ibid.

[111] "Volkswagen Clean Air Act Civil Settlement." United States Environmental Protection Agency. Retrieved from https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement#partners.

Supercharger Level-3 chargers to all EVs[112], and Nissan, phasing out the CHAdeMO charger that was present on many of their EVs since the Leaf in 2010.[113] This action leaves the Tesla and J-1772 CCS chargers as the only Level-3 chargers in America for EV models produced after 2022. Based on the correlations between years including multiple events and years of significant EVSE growth, there is a high correlation between industry events and EVSE growth rates.

The last group of variables that I analyze is those under the category of Outside Forces, which contains any influences that cannot be attributed to either of the two previous categories. These variables include federal and state party controls, as well as the involvement of NGOs. Party controls were investigated in order to exemplify the political stance of both the government and the general public for each specific year. For instance, if the state-level government offices were all controlled by Democrats, but the federal levels were controlled by Republicans, it may explain differences in the data that may not be accounted for if the communities' ideologies are not considered. For the political party control variables, the positions looked at were, at the national level, the President, House of Representatives, Senate, and Head of the EPA. For the

[112] Ferris, David. "Tesla: We'll open our charging network for federal cash." Energy Wire News. 24 February, 2022. Retrieved from https://www.eenews.net/articles/tesla-well-open-our-charging-network-for-federal-cash/.

[113] Halvorson, Bengt. "Nissan's move to CCS fast-charging makes CHAdeMO a legacy standard." loanGreen Car Reports. 16 July, 2020. Retrieved from https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement#partners.

House of Representatives data point, the majority party was taken as the controlling party with no consideration of the Speaker of the House. Looking at federal parties, both California and Virginia began to introduce EVSE during the term of a Democratic president.[114] This is where the similarity ends at the federal level, since the House, Senate, and Heads of the Environmental Protection Agency (EPA), were of different parties. In 1995, when California introduced EVSE, there was a Republican House and Senate and a Democrat as the Head of the EPA.[115] In 2010, the year Virginia introduced EVSE, there were Democratic majorities in both the House and the Senate, as well as the Head of the EPA being a Democrat.[116] There were shifts in control of all four positions analyzed, but the only one that correlates with a pivotal moment is the 2020 election year, where there was a Democratic head in all positions that coincided with a spike in EVSE growth rates. Outside of this instant, however, there were no shifts that correlated with spikes in EVSE growth. Based on that, I do not believe that federal party affiliation plays a significant role in EVSE growth.

[114]Please see Figure 4 in the appendix for detailed party authority since 1995.

[115] "Party control of California state government." *Ballotpedia.* 25 February, 2022. Retrieved from https://ballotpedia.org/Party_control_of_California_state_government.

[116] "Party control of Virginia state government." Ballotpedia. Retrieved from https://ballotpedia.org/Party_control_of_Virginia_state_government.

Figure 4 - Federal and State Party Affiliation

	California		Virginia		Federal				State Governor		State Senate		State House		State Env Head	
Year	Number of Chargers	Rates of Change	Number of Charger	Rates of Change	President Party	Fed House Party	Fed Senate Party	Head of EPA	CA	VA	CA	VA	CA	VA	CA	VA
1995	1	--			dem	rep	rep	dem	rep		dem		dem		rep	
1996	2	+100%			dem	rep	rep	dem	rep		dem		rep		rep	
1997	8	+75%			dem	rep	rep	dem	rep		dem		dem		rep	
1998	22	+64%			dem	rep	rep	dem	rep		dem		dem		rep	
1999	23	+4%			dem	rep	rep	dem	dem		dem		dem		dem	
2000	26	+12%			dem	rep	rep	dem	dem		dem		dem		dem	
2001	26	+0%			rep	rep	rep	rep	dem		dem		dem		dem	
2002	43	+40%			rep	rep	dem	rep	dem		dem		dem		dem	
2003	43	+0%			rep	rep	dem	rep	dem		dem		dem		--	
2004	54	+20%			rep	rep	rep	rep	rep		dem		dem		--	
2005	56	+4%			rep	rep	rep	rep	rep		dem		dem		--	
2006	58	+3%			rep	rep	rep	rep	rep		dem		dem		--	
2007	58	+0%			rep	rep	rep	rep	rep		dem		dem		--	
2008	72	+19%			rep	dem	dem	rep	rep		dem		dem		--	
2009	74	+3%			dem	dem	dem	dem	rep		dem		dem		--	
2010	78	+5%	23	--	dem	dem	dem	dem	rep	dem	dem	dem	dem	rep	--	rep
2011	174	+55%	46	+100%	dem	dem	dem	dem	dem	rep	dem	dem	dem	rep	dem	rep
2012	279	+38%	69	+50%	dem	rep	dem	dem	dem	rep	dem	rep	dem	rep	dem	rep
2013	417	+33%	96	+33%	dem	rep	dem	dem	dem	rep	dem	rep	dem	rep	dem	rep
2014	537	+22%	153	+37%	dem	rep	dem	dem	dem	dem	dem	dem	dem	rep	dem	dem
2015	850	+37%	224	+32%	dem	rep	dem	dem	dem	dem	dem	rep	dem	rep	dem	dem
2016	1156	+26%	283	+21%	dem	rep	rep	dem	dem	dem	dem	rep	dem	rep	dem	dem
2017	1403	+18%	375	+25%	rep	rep	rep	rep	dem	dem	dem	rep	dem	rep	dem	dem
2018	1817	+23%	476	+21%	rep	rep	rep	rep	dem	dem	dem	rep	dem	rep	dem	dem
2019	2365	+23%	836	+43%	rep	rep	rep	rep	dem	dem	dem	rep	dem	rep	np	dem
2020	7399	+68%	1442	+28%	rep	dem	rep	rep	dem	dem	dem	dem	dem	dem	np	dem
2021	16291	+55%	1975	+27%	dem	dem	dem	dem	dem	dem	dem	dem	dem	dem	np	dem
2022	--	--			dem	rep	dem	dem	dem	rep	dem	dem	dem	rep	np	rep

For state politics, the positions analyzed were the Governor, Senate, State House, and the Head of Environmental Policy in each state. As with the federal level, the Houses of Representatives was determined by the majority party, not speaker party identification. State parties are a little more varied, with California having a Republican Governor and Head Environmental Secretary in 1995, but a Democratic Senate and House.[117] Virginia, on the other hand, started EVSE growth under a Democratic Governor and Senate, but a Republican House

[117] "Party control of California state government." Ballotpedia. 25 February, 2022. Retrieved from https://ballotpedia.org/Party_control_of_California_state_government.

and Environmental Head in 2010.[118] There was a shift in the governor's party in both states at the 2010-2011 third moment, but that shift does not lead one to believe that EVSE growth was a result since Virginia started its growth during a year that coincided with a new Republican Governor. California, on the other hand, saw a spike in growth rates and a new Democratic Governor the same year. Outside of this shift, there are no shifts in party alignment that correlate with EVSE growth spikes.

NGOs have historically been involved in and assisted the growth and regulation of multiple sectors. Measuring the level at which NGOs influence EVSE growth is useful because they typically are more localized and can appeal to the communities in different ways than the government is able. They were included as a variable in the Outside Forces category because they are typically not run by state or national entities, which excludes them from the Government Involvement category, and they do not typically deal in terms of supply, demand, and profits, which excluded them from the Market Tendencies category. EVSE has a limited number of influential NGOs working on the topic of EVSE, with most of them coming in at the state level. Federally, there is the Clean Cities Coalition, an NGO organized with promoting the passing of green legislation, as well as informing the public and policymakers on matters about any topic

[118] "Party control of Virginia state government." Ballotpedia. Retrieved from https://ballotpedia.org/Party_control_of_Virginia_state_government.

that relates to environmental protection and environmental justice.[119] Even though this program is national, a lot of the work is carried out at the state level, since many states have Clean Cities Coalitions at the lower level. Since most of the work conducted by this NGO is at the state and local levels, I do not associate it with changes at the federal level. This is the only broadly active NGO that is working on EVSE that is not associated with an institution of higher education (IHE) or a private corporation. Since there is a severe lack of NGO influence at the national level, I have determined that this variable does not have a significant impact on the growth rates of EVSE.

State-level NGOs are more numerous, although again, there are not as many working specifically on EVSE. Since the Clean Cities Coalitions have completed most of their work at the state level, I have included them within this variable's umbrella. California has eight Clean Cities Coalitions throughout the state, with each one focusing on a specific locality or region.[120] They conduct symposiums that are aimed at educating the public and private sectors about EV technology, as well as working with policymakers to ensure environmental justice applications are factored into legislation. California also started an independent NGO with multiple other states throughout the United States, named the Zero-Emission Vehicles (ZEV) Task Force. This

[119] "A National Network of Local Coalitions." *U.S. Department of Energy.* Retrieved from https://cleancities.energy.gov/coalitions/.

[120] "Clean Cities Coalition Network: California." United States Department of Energy. Retrieved from https://cleancities.energy.gov/coalitions/search?search_for=California.

organization is made up of representatives from government, industry, NGOs, and local communities to determine the best conceivable way to promote the use of EVs and EVSE in their jurisdictions.[121] Their work began in 2012 and they release action plans every few years. Other than this, there are quite a few minor NGOs that work in specific localities, but their reach does not extend beyond the regional level. In Virginia, the number of NGOs working on EVSE programs is even smaller, with the main body of work coming from Virginia Clean Cities, the state body under the national organization.[122] They have been involved with EVSE since the first charger was unveiled in 2010 and have consistently been involved in policymaking, networking, and educational opportunities aimed at the public since that time. They are also the main body that supports Virginia in the national programs of Drive Electric and the regional Mid-Atlantic Electrification Partnership, which is a coalition of states in the Mid-Atlantic region of the U.S. working to promote EV adoption.[123] Other smaller organizations, such as Generation180 in Charlottesville, work to promote EVs and EVSE in their jurisdictions but have little opportunity

[121] "Zero Emission Vehicle Deployment Support." *U.S. Department of Energy.* Retrieved from https://afdc.energy.gov/laws/11081.

[122] "Success Stories." Virginia Clean Cities. Retrieved from https://vacleancities.org/about/success-stories/.

[123] "VCC Current Projects." Virginia Clean Cities. Retrieved from https://vacleancities.org/category/current-projects/.

for significant impact at the state level.[124] Since there are not a large amount of NGOs working on EVSE specifically, and since their actions and historical programs do not coincide with spikes in growth rates, I determined that NGO influence does not play a significant role in EVSE infrastructure growth.

In consideration of providing all data that was gathered, there are quite a few variables that were identified and investigated but proved to serve no significance to the field or dependent variable. Many of the variables omitted pertained to demographic information regarding the two states. The first was state budgets. It was not included in the review or analysis since state budgets do not show any direct indication that they influence the growth of specific markets. They could include information regarding grant directives or incentive and funding programs; however, those would be useless to study at this date and time since the projects funded by these initiatives take many years to implement. Another variable that was omitted was state-level programs. Much like the national programs discussed under Government Involvement, these programs would offer a more grass-roots avenue to work directly with the people of communities. The reason that it was withheld from the final analysis is that almost all state-level programs are merely branches of federal programs, so discussing the federal programs and their mechanisms for outreach was enough to logistically cover all information on state programs. The last variable that was investigated and deemed not worth looking into was population densities in

[124] "Electrify Your Ride." Generation180. Retrieved from https://generation180.org/pathways/electrify-your-ride/.

each of the two states. Both Virginia and California had major hubs of travel and areas where the population density was very large, but there were also areas in California where the population density was small and there were still large numbers of EVSE. Virginia, on the other hand, seemed to only have EVSE in areas of high population density, so there did not seem to be a correlation between EVSE growth and population densities worth further investigation and analysis. It is important to note that while these variables were not deemed significant within the analysis, they do carry useful demographic and background information for the two states that were investigated and therefore are included in this thesis.

The Big 3: Variables of High Correlation

Out of these three categories, it was determined previously that the Market Tendencies and Government Intervention played the biggest roles in causing significant surges in the growth rate of EVSE infrastructure when looking at the four pivotal moments. In the analysis, I have gone within each of these categories to determine which individual variables had the greatest correlation with spikes in EVSE growth. These individual variables were determined to be industry events, federal law, and state law. I now investigate each of these variables more deeply to determine the rationale behind their significance, as well as the possible implications that their presence at each of the pivotal moments means for the overall literature of government intervention in the market.

Figure 5 - Industry Events Timeline

	California		Virginia		Major Event
Year	Number of Chargers	Rates of Change	Number of Chargers	Rates of Change	
1995	1	--			
1996	2	+100%			GM EV1 (not for sale)
1997	8	+75%			Toyota Prius Hybrid JPN
1998	22	+64%			
1999	23	+4%			Honda Insight US
2000	26	+12%			Toyota Prius Hybrid US
2001	26	+0%			
2002	43	+40%			tZero + others being researched
2003	43	+0%			Tesla Founded
2004	54	+20%			
2005	56	+4%			
2006	58	+3%			T. Roadster Announced
2007	58	+0%			
2008	72	+19%			T. Roadster Released
2009	74	+3%			
2010	78	+5%	23	--	Tesla got $465M loan, Chevy Volt,
2011	174	+55%	46	+100%	T. Model S
2012	279	+38%	69	+50%	T. Superchargers
2013	417	+33%	96	+33%	Nissan Leaf US
2014	537	+22%	153	+37%	
2015	850	+37%	224	+32%	
2016	1156	+26%	283	+21%	T. Model 3, VW Lawsiut
2017	1403	+18%	375	+25%	
2018	1817	+23%	476	+21%	
2019	2365	+23%	836	+43%	
2020	7399	+68%	1442	+28%	T. Cybertrucks, Covid-19
2021	16291	+55%	1975	+27%	

In reference to understanding the "Rate of Change" column, the growth rates are separated into four groups, with the higher rates of change having a darker green shading and the lower rates of change having a lighter green shading. By looking at the major events (right column) of each year, you can see some correlation between major events and the rates of EVSE growth.

In order of appearance, the first variable, industry events, was present at the first three out of the four total junctures. By this, I mean that there was an abundance of events, whether business or technological, during or right before a major jump in EVSE infrastructure. To explain, Figure 5 shows that the third moment in 2011 corresponds with the production of the Nissan Leaf, Chevrolet Volt, and Tesla Model S. The introduction of EVs that were more affordable for consumers brought on a need for avenues to charge those EVs while drivers were away from home. This is significant because it shows that the field of EVSE has mostly come

about from necessity pertaining to advancements in EV technology and sales. The second moment was caused by research and development initiatives like the tZero, which never made it to factory production but was able to show that EV technology was on the rise.[125] This minor moment and the research that was being conducted during it finally culminated in the third moment in 2011. As stated previously, this was the most significant example of how industry events can promote the growth of EVSE, since there were three viable EV options for sale in the U.S. The sudden spike in EV options led manufacturers and third-party companies to realize the necessity for EVSE, leading to the large jump that we see on the graph and that I identify as the 3rd pivotal moment. For an example that did not make it on to the pivotal moments list, please refer again to Figure 5 on page 52, where it is visible that there was a significant correlation between the release of the Tesla Model 3, their cheapest model developed in 2015, and a spike in EVSE growth of 37% that year.

The fact that industry events did not play a significant role in the fourth moment of 2019-2020, despite numerous EVs being produced and the steady increase in EVSE infrastructure growth, shows that the early part of the industry was very heavily reliant upon the development of technology. There was no need for outside interference because the field was so small that it

[125] Wilson, Kevin A. "Worth the Watt: A Brief History of the Electric Car, 1830 to Present." Car and Driver. 15 March, 2018. Retrieved from https://www.caranddriver.com/features/g15378765/worth-the-watt-a-brief-history-of-the-electric-car-1830-to-present/.

was almost inconsequential. At the time of the third moment, there were only 78 EVSE stations in California and 23 in Virginia. That shows that the industry simply was not big enough to facilitate interference. It was looked upon as a hobby for investors and automotive corporations. The introduction of viable, affordable EVs in 2010 sprung the need for EVSE into the spotlight. Once the market officially took off in 2010, it was no longer dependent on EV technology breakthroughs, but on influences from the federal and state governments.

Figure 6-A – Federal Legislation Timeline

	California		Virginia		Federal Legislation
Year	Number of Chargers	Rates of Change	Number of Chargers	Rates of Change	
1995	1	--			
1996	2	+100%			
1997	8	+75%			
1998	22	+64%			
1999	23	+4%			
2000	26	+12%			
2001	26	+0%			
2002	43	+40%			
2003	43	+0%			
2004	54	+20%			
2005	56	+4%			
2006	58	+3%			
2007	58	+0%			Energy Independence and Security Act of 07
2008	72	+19%			
2009	74	+3%			ARRA (built chargers)
2010	78	+5%	23	--	
2011	174	+55%	46	+100%	
2012	279	+38%	69	+50%	
2013	417	+33%	96	+33%	
2014	537	+22%	153	+37%	
2015	850	+37%	224	+32%	
2016	1156	+26%	283	+21%	
2017	1403	+18%	375	+25%	
2018	1817	+23%	476	+21%	
2019	2365	+23%	836	+43%	
2020	7399	+68%	1442	+28%	
2021	16291	+55%	1975	+27%	INVEST in America Act
2022	--	--			

The second variable, federal legislation, was determined to have a high correlation with EVSE growth because there were significant pieces of legislation passed in the years leading up

to and during the pivotal moments, specifically the third and fourth moments found in 2010-2011 and 2019-2020. As shown, two pieces of federal legislation played a role in the 2010-2011 moment, which were the Energy Independence and Security Act of '07 and the ARRA in 2008. These bills allowed for the founding of ARPA-E, which promoted research into energy technologies, and allowed for EVSE infrastructure to be built up as testing opportunities and public works programs. Most recently, the INVEST in America Act of 2021 laid out specific funding and equity requirements for the development of EVSE infrastructure, offering roughly $2.5 billion of federal funding to jumpstart the field.[126] The implications of the decision go a long way in determining the current consensus in Washington that the federal government is comfortable in assisting certain markets of the economy to facilitate artificial growth.

I believe that legislation plays a significant role in the development of EVSE infrastructure during the third and fourth moments because of the ideas and implications of each piece of legislation. For the third moment in 2010-2011, there was a significant amount of money devoted to both researching and developing charger technology, as well as a large sum of money devoted to the actual infrastructure development of chargers starting in 2008. Without the assistance of the federal legislation, there would not have been enough technology to successfully roll out EVs at the time that they did. If that had been the case, the Chevy Volt,

[126] "H.R. 3684 - 117th Congress (2021-2022): Infrastructure Investment and Jobs Act." 15 November, 2021. Retrieved from https://www.congress.gov/bill/117th-congress/house-bill/3684.

Tesla Model S, and Nissan Leaf would have all fallen through the cracks because there was no way to efficiently charge them that did not inconvenience owners.

The magnitude of power that the federal government wields may be immense, but it is the state and local governments that can contribute and carry out many deals pertaining to specific development and infrastructure projects. California has seen more of an impact from state legislation than Virginia has simply due to the number of bills passed in California versus the number passed in Virginia. Given the information presented in Figures 6-B (page 57) and 6-C (page 59), it is apparent that there is a large amount of legislation passed right before or during years of major EVSE growth, specifically in California. That is why I have determined that state legislation is the third major IV that plays a major role in the development of EVSE. State government officials in California and Virginia have recently realized that this is a major opportunity for sustainable growth, with both passing a multitude of laws pertaining to EVSE within the past four years. Figure 6-B on page 57 shows the different laws pertaining to EVs and EVSE that Virginia has passed since 2010 when the first charger was made publicly available.

Figure 6-B - Virginia Legislation Timeline

	Number of Chargers	Rate of Change	Important State Legislation
Virginia			
2010	23	--	
2011	46	+100%	
2012	69	+50%	
2013	96	+33%	
2014	153	+37%	
2015	224	+32%	first mention of EVSE in budget
2016	283	+21%	
2017	375	+25%	CoV 22.1-131(schools can use EVSE for profit)
2018	476	+21%	CoV 15.2-967.2(localities can use EVSE for profit)
2019	836	+43%	
2020	1442	+28%	Right to Charge Laws
2021	1975	+27%	HB 1919, HB 1965, EV Rebate Advisory Council, CoV 67-1905(EV Rebate Fund), Commonwealth Clean Energy Policy, Virginia Energy Plan, HB2118 (EV rebates) Commonwealth Clean Energy Policy, Virginia Energy Plan, HB 2118 (EV rebates)
2022	--	--	

California, since 2019, has passed over a dozen bills that pertain to EVSE at the state level. Most of their laws before this dealt with planning and rebates for EVs, although 2014 did see a law that required EVSE infrastructure to allow for multiple types of payment.[127] At the end of 2021, the state boasted more EV and EVSE-related laws than any other state, with many of them offering incentives and rebates to investors and consumers. 2021 also saw the implementation of local-level laws in California, where individual counties and cities began to introduce EVSE legislation of their own to stimulate growth and invite developers to their areas.

[127] Please see Figure 6-C on page 59 or in the appendix for information regarding CA state laws.. All information pertaining to laws retrieved from https://oal.ca.gov/ and https://www.treasurer.ca.gov/.

Virginia, while not as far along as California, has also seen a rise in the past few years. In 2020, Virginia passed its "Right to Charge" laws that protect consumers from HOA regulations or rental contracts so that they can install EVSE on the property.[128] This does not always lead to public chargers, but many companies settle by installing EVSE at their facilities to accommodate these laws. The largest push in Virginia occurred in 2021, with H.B.1965 bringing about EV sales and production quotas for auto manufacturers and H.B.1919, which allows for a fund to be created that would allow the state to begin offering more extensive incentives and rebates for EVSE developers and EV consumers.[129] Many other laws were passed that year that set up a Rebate Advisory Council and the Virginia Energy Plan, which publishes mechanisms for the state to reach emissions reduction goals set forth by the administration.

The state legislation variable was non-existent at the first and second moments and played a small role in the third. The fact that it was so abundant at the fourth shows the shift of regulation and potential responsibility. States could feel like they must take it upon themselves to oversee this transition. The federal government does not have the power to successfully carry out the grants, incentives, rebates, regulations, and land concessions that state and local governments do. This is partly due to the large bureaucratic nature of the federal government and the "red tape" that goes along with large federally funded bureaucratic programs. Also, the federal government can offer grants and rebates for research and development; however, the state and

[128]Ibid.

[129]Ibid.

local governments are the ones that can pass land-use regulations, zoning codes, development incentives and tax deductions, and many other negotiable details regarding infrastructure development.[130]

Figure 6-C - California Legislation Timeline

	Number of Chargers	Rates of Change	Important Legislation
California			
1995	1	--	CARB Expenditure Requirements
1996	2	+100%	
1997	8	+75%	
1998	22	+64%	
1999	23	+4%	
2000	26	+12%	
2001	26	+0%	
2002	43	+40%	CCR tit.13sec.1962.2 (ZEV production 05-08)
2003	43	+0%	
2004	54	+20%	
2005	56	+4%	
2006	58	+3%	
2007	58	+0%	
2008	72	+19%	
2009	74	+3%	CCR tit.13chap.8.1 (CLean Trans. Program(setup of incentives))
2010	78	+5%	
2011	174	+55%	
2012	279	+38%	
2013	417	+33%	Greenhouse Gas Reduction Fund
2014	537	+22%	Charge Ahead California Initiative, CHSC 44268.2 (open access EVSE)
2015	850	+37%	
2016	1156	+26%	Electrify America (VW) investment plan
2017	1403	+18%	
2018	1817	+23%	CEC EVSE Programs, CVC 5205.5+21655.9 (HOV exempt)
2019	2365	+23%	CPUC sec.740.13 (EVSE grants), GGRF EV grants (CHSC o44274+44258), CPRC 25722.9 (parking incentives), Right to Charge Laws (CCC 4745+6713)
2020	7399	+68%	E.O. N79-20, A.B.841, California State Transportation Plan, Cal. Clean Fuel Reward
2021	16291	+55%	CCR. tit.13sec.1963 (medium+heavy trucks), CCR tit.4sec.4002 (charging rates), CPUC sec.740.13 (EVSE grants), ZEVs for companies, EVSE training+cert., *local EVSE revates begin*
2022	--		

[130]Information gathered from working at the Prince Edward County Economic Development Office, where similar work was conducted with the Virginia Cardinal Program to invite industry to the county through similar means.

The idea of governments stimulating the economy is not new, even when looking at infrastructure development, of which EVSE is a part. Political Economist Dani Rodrik discusses the ideas of "capital fundamentalism," where the government strategically enters money into the economy in areas that will stimulate further economic growth. In his book, *Straight Talk on Trade,* he gives numerous foreign examples of market stimulation, as well as discussing the U.S. after World War II, with public works programs that were financed by the federal government to reduce unemployment and bolster domestic infrastructure.[131] In terms of EVSE, this stimulation would lead to a faster shift towards EV technology for most Americans. The more chargers that are available, the more EVs will be purchased. The more EVs that will be purchased, the more informed the population is. Once the population is informed about the technology and fears of the unknown are mitigated, the true shift towards EVs will begin. While specialists theorize that this will eventually happen naturally[132], government investment in the area could be the leading factor in the speed by which it happens and the global standing that the U.S. holds when the transition is complete. This is the exact concept that Mazzucato mentions when she discusses the

[131] Rodrik, Dani. *Straight Talk on Trade: Ideas for a Sane World Economy.* Princeton University Press: Princeton, 2018.

[132] Talanstev, Anton. "Who Gains and Who Loses in the Shift to Electric Vehicles: Impact Assessment through Multi-criteria Multi-stakeholder Analysis." Green Urbanism, Volume 37, 2017. P. 257-268.

effects of government stimulation in certain areas of the economy and certain technologies.[133] Those that receive the stimulation typically see drastic changes in their production and development rates, which lead to overall headway in the sector. By doing this, governments select certain technologies and policies that benefit the nation and stimulate those areas. When the area has developed enough artificially to the point of government satisfaction, the government involvement in the sector typically reduces and is shifted to another area for development.[134]

By utilizing this method of both stimulation and regulation, the government can allow the corporations to make profits while making sure that administration goals are reached. Policy theorist Deborah Stone discusses the different types of legislation that governments can utilize when regulating the market and corporations, which include inducements and rules, her terms for incentives and regulations.[135] The combination of these different policy mechanisms allows for the involvement of government in the markets without displeasing the corporations or consumers who are poised to make a profit from the artificial growth.

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[133] Mazzucato, Mariana. *The Entrepreneurial State.* Public Affairs: New York, 2015.

[134] Rodrik, Dani. Straight Talk on Trade: Ideas for a Sane World Economy. Princeton Unive0rsity Press: Princeton, 2018.

[135] Stone, Deborah. *Policy Paradox: the art of political decision making.* W.W. Norton & Company: New York, 2012.

The Myth of the Free Market and the Birth of the "New Dominion"

I draw now to the claim that Virginia is entering into a new stage of economic thought. For many years, the Old Dominion State has prided itself on upholding the idea of free-market capitalism and neoliberalism.[136] Living within the "climate of capitulation,' Virginia sees companies as its largest benefactors, as well as its largest lobbying group. This has developed out of the ideas of free-market capitalism, where industries are allowed to grow and develop as they see fit, so long as they are bringing money into the economy and contributing to the job market. This idea that putting people to work and growing the economy is valuable and true, however, it is allowing the growth to be extremely inequitable, and it prevents any new developments into industries that are contradictory to the large corporations that have been allowed to reign.[137] EVSE is a prime example of this in the state of Virginia. Since EVSE is an alternative fuel source, the fossil fuel industry, being responsible for and profiting from the sale of gasoline, is understandably intimidated by the large-scale growth of EVSE infrastructure that is currently underway. In Virginia, these corporations can pool their resources into lobbying and campaigning on behalf of

[136] Thomson, Vivian. Climate of Capitulation: An Insider's Account of State Power in a Coal Nation. MIT Press: Cambridge, 2017.

[137] Hertel-Fernandez, Alexander. State Capture: How Conservative Activists, Big Businesses, and Wealthy Donors reshaped the American States- And the Nation. Oxford University Press: New York, 2019.

legislators and legislation that are in favor of bills that promote the status quo.[138] Since the current status quo is the deregulation of markets in favor of economic growth, this benefits large corporations and hinders the development of new technology sectors.

When Virginia started pushing for EVSE rebates and incentives in 2021, this showed that there was a potential for the regulation of certain economic sectors, which could take money away from the large corporations. Incentives and rebates, in this case, act as steppingstones to greater investment opportunities in the realm of clean energy. So, not only is the development of EVSE-related legislation detrimental to the fossil fuel industries, but it is also a step toward infringement on the energy production sector. With Virginia being a large player in the fossil fuel industry, these corporations can sense the unease as well and act to influence the rollout of these modern technologies.[139] By offering to assist with the research and development, fossil fuel corporations can stay on top of any new advancements in the field and manipulate them to offer more avenues for economic growth. This allows corporations to stay in power when they recognize that future technology could hinder their trajected economic growth.[140] This is a

[138] Thomson, Vivian. Climate of Capitulation: An Insider's Account of State Power in a Coal Nation. MIT Press: Cambridge, 2017.

[139] Ibid.

[140] Hertel-Fernandez, Alexander. State Capture: How Conservative Activists, Big Businesses, and Wealthy Donors reshaped the American States- And the Nation. Oxford University Press: New York, 2019.

concept that James Galbraith describes as the "Predator State", where the government is influenced by business and only passes regulations that do not harm corporate interests or are directly in the corporate interests.[141] He describes that any regulations or alterations to business practices on the part of the government must be approved by the corporations since those corporations are the ones that spend the money on lobbying, bill drafting, and getting the politicians elected into office. This concept is also found in Alexander Hertel-Fernandez's work, where he discusses how big businesses and corporate hegemons control state politics through their economic power and campaign contributions.[142] By looking at the power held by fossil fuel corporations and other corporations that have a lot of capital and influence, Hertel-Fernandez looks at the changes that they implement in state legislatures and the different kinds of legislation that they support or deny. In his accounts, these influences have direct power over the legislation passed in the states, and therefore have power over the state itself.

This predatory system, however, seems to be changing in Virginia. Politicians who are typically on the side of big business due to their campaign funding ties are increasingly more

[141] Galbraith, James K. *The Predator State.* Free Press: New York, 2008.

[142] Hertel-Fernandez, Alexander. *State Capture: How Conservative Activists, Big Businesses, and Wealthy Donors reshaped the American States- And the Nation.* Oxford University Press: New York, 2019.

likely to promote funding for EVs, EVSE, and alternative energy sources.[143] By doing this, they are tapping into Stone's ideas of government policy tools and systematically promoting legislation that promotes the welfare of the state, rather than the welfare of big businesses and "free markets."[144] Looking at the types of bills that are being passed and drafted, they seem to be stimulating both the production and consumption side of the EV market. By offering incentives through tax breaks and rebates to businesses that invest in EVSE, the government is assisting in the production of this sector of the market. By offering rebates to consumers who purchase EVs, the government is putting money into the hands of the people so that they can consume more of the products. Sociologist Rob Leighninger Jr. theorized this method as the fastest way to stimulate a slow market or economy.[145] By supplanting both the production and consumption sides of the market, you create artificial supply and demand for the commodity, which leads to vast investment and growth in that individual sector. While Leighninger attributed this system to the New Deal public works programs of the 1900s, the Virginia government seems to have

[143] Vogelsong, Sarah. "Democrats push electric car infrastructure bill as a solution to rural gaps." *Virginia Mercury.* 4 February, 2022. Retrieved from https://www.virginiamercury.com/2022/02/04/democrats-push-electric-car-infrastructure-bill-as-a-solution-to-rural-gaps/.

[144] Galbraith, James K. *The Predator State.* Free Press: New York, 2008.

[145] Leighninger Jr., Robert D. *Long-Range Public Investment: The Forgotten Legacy of the New Deal.* University of South Carolina Press: Columbia, 2007.

adapted it into a modern remedy for the EV market. One possibility is that they could be seeing the vast growth in the sector that is occurring in California and adapting it for themselves. Another is that they are simply unsatisfied with the current status quo. By this logic, Virginia could be seeing an end to the unyielding faith in free-market capitalism, leading to the birth of a "New Dominion."

CONCLUSION

This study was brought about due to federal and state opinions on the topic of electric vehicle supply equipment. Upon further research, it was determined that Virginia's government was on the verge of experiencing a pivotal shift in the way that it conducts itself in the economy. By looking at the topic of EVSE as a case study for government intervention and stimulation in the economy, there are significant surges in sectors that receive government attention. Comparing Virginia, a laggard in the field of EVSE infrastructure, to California, the ideal, was a calculated assessment to determine the potential differences between the states and find potential variables that played roles in EVSE growth. Utilizing a historical analysis as the method of comparison between these two states, I was able to determine four pivotal moments where there was a significant surge in the rate of EVSE growth: 1995, 2002, 2010, and 2019-2020. The catalysts for these four pivotal moments varied depending on specific variables, but the overall themes were determined to be Market Tendencies and Government Involvement.

After determining the pivotal moments and their respective catalysts, I singled out those variables that had a high correlation with spikes in EVSE infrastructure growth. I was able to do this by comparing IVs in each year with the growth rates of EVSE infrastructure in that given year. The first of these variables was industry events, under the category of Market Tendencies. Looking at the data, there was a high correlation between the first three pivotal moments and times when specific cars and companies made breakthroughs. Beyond the pivotal moments, there

was a correlation between the release of specific model electric vehicles and spikes in the growth rates, as seen by the spike in 2015 that accompanied the release of the Tesla Model 3.[146]

The second variable was federal legislation, which accounted for the last two pivotal moments. The research and funding programs that were established in the late 2000s led to breakthroughs in battery capacity and affordability, and the INVEST in America Act designated billions of dollars to EVSE infrastructure development in 2021. These occurrences coincided with spikes in the growth rate of EVSE and influenced the confidence of investors and developers in the field. Government stimulation typically creates artificial growth in certain fields, and the presence of both standards and regulations, on top of rebates and incentives, meant that there were multiple aspects of the sector being stimulated at the same time.

The last variable was state legislation. State legislation was not present for the first three pivotal moments, but the abundance of state legislation that occurred around the fourth moment in California, as well as the amount of legislation passed in Virginia right after the moment, lead me to believe that it cannot be ignored. While the federal government was passing legislation regarding standards and incentives, the state governments were busy passing legislation regarding the maintenance of the sector. Multiple laws were passed with rebates for consumers, as well as topics such as how to pay for electricity at EVSE and plans for future registration requirements. So, the federal government was working at the federal level to stimulate the entire

[146] Please see Figure 5 in the appendix for information regarding industry developments.

field, but the states were working on managing that growth and stimulation in ways that were beneficial to consumers and administrative objectives.

I then discuss the use of government intervention in the economy and how it can stimulate certain sectors to ensure artificial and stable growth rates. By taking notes from theorists such as Dani Rodrik and Mariana Mazzucato, I investigated the effectiveness of strategic investment on the part of the government. What I found is that many industries, such as the airline industry and companies in the information technology sector like First Solar, received funding and regulation from the federal government and state governments that allowed them to grow into the fields that they are today. Based on the data gathered in the analysis, there was beginning to be a shift towards more government involvement in the field of EVSE to facilitate a stable buildup of that sector of the economy.

After discussing this at the macro level, I painted a picture of Virginia through the lens of these ideas. Through the lens of theorists like Alexander Hertel-Fernandez, Vivian Thomson, and James Galbraith, I found that the current system in Virginia resembles the "climate of capitulation" described by Thomson and the "predatory state" laid out by Galbraith. From these ideas, I worked to prove that the idea of "free market capitalism" was a myth and that all capitalism is regulated. Even when a government decides to reduce regulations, it is only a form of regulation that favors large businesses and theorized economic growth. Virginia's EVSE sector was a ripe area for me to apply these ideas since the biggest actors in the state are corporations. By allowing the corporations to continue the transition to EVSE and cleaner energy, Virginia is allowing them to control the rate of transition and the distribution

mechanisms of the growing sector. However, the transition of select Virginia policymakers towards more interventionist ideas shows that there may be a change coming to the state, with market development under the control of the government and not that of big business.

From this study, I conclude that there seems to be a high correlation between government involvement in the economy and higher growth rates in certain sectors. Building on theorists Rob Leighninger Jr. and Dani Rodrik, strategic placements of government investment lead to artificial spikes in sector growth, which can then be rolled back when the market sector is at a stable capacity to regulate itself. By allowing markets that first start to govern themselves, aspects like equitability and environmental justice are neglected in favor of capital growth and revenue potential. Government regulation of these growing sectors allows for the stable and equitable development of sectors, which permits more consumers to participate in the market and allows the market to grow at a greater than average rate. Based on these principles, we will see more government regulation over the EVSE sector in the coming years, which will then be rolled back once the market has successfully integrated into the larger economy.

While the conclusions of this study are sound and based on empirical evidence gathered during the analysis, there remains the fact that this is all a correlational study. Without exact knowledge of every EVSE development project and the respective reasons and opportunities that led to it, there is no way to know for certain why the growth rates behaved as they did. Beyond this, there is still the debate of the "chicken and the egg," which, for the case of this study, would be the research and development or the funding. There were multiple times throughout the historical analysis that the government provided funding to the researchers, but it is impossible to

determine whether that funding was provided before or after there were any significant breakthroughs. While certain breakthroughs did occur due to funding, there could have been noteworthy events in the field that caused the government to offer the funding in the first place. The significance that this has on my study is that the "Government Involvement" and "Market Tendencies" categories are intertwined and overlap. The individual variables, industry events, federal legislation, and state legislation, did have high correlations with the pivotal moments, but this idea means that they could potentially all be derived from one source: government funding or industry events. Beyond this, there is little way to tell which came first. The last limitation of the study, and without a doubt the largest, is that the sector of EVSE, particularly in the state of Virginia, is still in its infancy. With a population of 8.5 million people, the state only reached above 1000 chargers in 2021. Also, with only 27 years of Level-2 and above EVSE, the evidence that I have gathered is potentially just circumstantial. To a point that I made earlier, the EVSE market only took off at the third juncture in 2011. This leaves only 11 years for the collection of this data. At best, this means that the transition from slow buildup to exponential growth will give this study a unique perspective in looking at the growth of a new industry. At worst, it will mean that all the findings of this study could potentially be circumstantial due to the lack of enough data to truly build a sound theory. The sector is going to continue to grow at an above-average rate, which may refute the findings that I have derived from this study.

Out of this, there are multiple avenues for which research could add to this field. For one, the development of EVSE needs to be compared to other emerging technologies, such as the laptop, smartphone, or looking back further, the airplane. An interesting study could be the

historical difference between the production of internal combustion automobiles and that of EVs. These would allow for the comparison of different significant factors in different industries, which could shed some light on the concept of government involvement in emerging markets. Another study would be the reproduction of this study at a later date. By looking at the state of Virginia in 10 years or more, researchers will be able to draw upon vast amounts of data that currently do not exist. Virginia first began the mass passing of EVSE legislation in 2021, which leaves this study with extraordinarily little to work with on the variable of state legislation. For that reason, I am currently unable to determine whether state legislation or federal legislation plays the largest role. The answer to this question could lead to drastic changes in the methods and level that NGOs and lobbyists work at, allowing them to pool their resources in areas that are more likely to give them better results. Overall, this study discusses government involvement in the markets by utilizing EVSE in Virginia and California as a case study, however, vast amounts of research will need to be conducted on the sector to understand its exponential growth and the catalysts that drive it.

BIBLIOGRAPHY

"About." *Virginia Clean Cities*. Retrieved from https://vacleancities.org/about/.

"Advanced Technology Vehicles Manufacturing Loan Program*." U.S. Department of Energy*. Retrieved from https://www.energy.gov/lpo/products-services/advanced-technology-vehicles-manufacturing-loan-program

"Alternative Fuel and Advanced Vehicle Search: All electric vehicles." *U.S. Department of Energy: Alternative Fuels Data Center.* Retrieved from https://afdc.energy.gov/vehicles/search/results/?view_mode=grid&search_field=vehicle&search_dir=desc&per_page=8&current=true&display_length=25&fuel_id=41,-1&category_id=27,25,29,9,-1&manufacturer_id=365,377,355,211,231,215,223,409,219,213,209,351,385,275,466,424,361,387,243,227,469,229,239,425,263,217,462,391,349,470,383,237,221,347,395,67,117,394,426,415,201,113,205,5,408,9,13,11,458,81,435,57,195,416,141,197,417,121,53,397,418,85,414,17,21,143,403,23,398,27,399,31,207,396,107,465,193,460,125,35,419,115,37,147,199,-1

"ARPA-E History*." U.S. Department of Energy: Advanced Research Projects Agency - Energy*. Retrieved from https://arpa-e.energy.gov/about/arpa-e-history.

"ARRA and PEV Infrastructure." *Los Angeles County Economic Development Corporation*. 14 January, 2013. Retrieved from https://laedc.org/2013/01/14/arra-and-pev-infrastructure/.

"BEV MODELS CURRENTLY AVAILABLE IN THE US." *Evadoption*. 9 January, 2021. Retrieved from https://evadoption.com/ev-models/bev-models-currently-available-in-the-us/.

"California GDP." *Department of Numbers.* Retrieved from https://www.deptofnumbers.com/gdp/california/.

"California Laws and Incentives." *U.S. Department of Energy: Alternative Fuels Data Center*. Retrieved from https://afdc.energy.gov/laws/state_summary?state=CA&technologies=ELEC,PHEV.

"California: Regional Data: GDP and Personal Income." *U.S. Department of Commerce: Bureau of Economic Analysis*. 1 October, 2021. Retrieved from https://apps.bea.gov/itable/iTable.cfm?ReqID=70&step=1&acrdn=1.

"Clean Cities Coalition Network: California." *United States Department of Energy.* Retrieved from https://cleancities.energy.gov/coalitions/search?search_for=California.

"Convenience Stores Sell the Most Fuel." *National Association of Convenience Stores*. 24 March, 2021. Retrieved from https://www.convenience.org/Topics/Fuels/Who-Sells-Americas-Fuel.

DePoy, Elizabeth and Gitlin, Laura. "Introduction to Research: Understanding and Applying Multiple Strategies 5 ed." *Elsevier Inc.:* St. Louis, Missouri. 2016.

Desilver, Drew. "Today's electric vehicle market: Slow growth in the U.S., faster in China, Europe." *Pew Research Center*. 7 June, 2021. Retrieved from

https://www.pewresearch.org/fact-tank/2021/06/07/todays-electric-vehicle-market-slow-growth-in-u-s-faster-in-china-europe/.

"DISCONTINUED ELECTRIC VEHICLES." *Evadoption*. Retrieved from https://evadoption.com/ev-models/discontinued-electric-vehicles-evs/.

"Economy of California." *Britannica*. Retrieved from https://www.britannica.com/place/California-state/Economy.

"Electric Vehicle Sales Dashboard." *Alliance for Automotive Innovation.* Retrieved from https://www.autosinnovate.org/resources/electric-vehicle-sales-dashboard.

"Electrify Your Ride." *Generation180.* Retrieved from https://generation180.org/pathways/electrify-your-ride/.

Estimated inequality of household income according to the Gini Index, between 2015-2019. PolicyMap, https://vt-policymap-com.ezproxy.lib.vt.edu/data/our-data-dictionary/#Census:%20Decennial%20Census%20and%20American%20Community%20Survey%20(ACS). (based on data from PolicyMap and the U.S. Census Bureau; Accessed 2 March 2022).

Estimated number of people per square mile, between 2015-2019. PolicyMap, https://vt-policymap-com.ezproxy.lib.vt.edu/data/our-data-dictionary/#Census:%20Decennial%20Census%20and%20American%20Community%20Survey%20(ACS). (based on data from PolicyMap and the U.S. Census Bureau; Accessed 2 March 2022).

"EV Everywhere Grand Challenge Blueprint*." U.S. Department of Energy.* 31 January, 2013. Retrieved from https://www.energy.gov/sites/prod/files/2014/02/f8/eveverywhere_blueprint.pdf.

"FACT SHEET: The American Jobs Plan." *The White House: Briefing Room*. 31 March, 2021. Retrieved from https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/31/fact-sheet-the-american-jobs-plan/.

Ferris, David. "Tesla: We'll open our charging network for federal cash." *Energy Wire News.* 24 February, 2022. Retrieved from https://www.eenews.net/articles/tesla-well-open-our-charging-network-for-federal-cash/.

Flamholtz, Eric and Randle, Yvonne. "Growing Pains: Transitioning from an Entrepreneurship to a Professionally Managed Firm 4 Ed." *Jossey-Bass:* Hoboken, New Jersey. 2007.

Galbraith, James K. *The Predator State: How Conservatives Abandoned the Free Market and Why Liberals Should Too*. Free Press: New York, 2008.

Halvorson, Bengt. "Nissan's move to CCS fast-charging makes CHAdeMO a legacy standard." *Green Car Reports*. 16 July, 2020. Retrieved from https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement#partners.

Harris, Kamala. Twitter Post. December 15, 2021, 11:30 a.m. Retrieved from https://twitter.com/kamalaharris/status/1471155606069334018?lang=en.

Harvey, David. *A Brief History of Neoliberalism.* Oxford University Press: New York, 2007.

"H.B. 1400 - 2015 Session: Budget Bill." 26 March, 2015. Retrieved from https://budget.lis.virginia.gov/bill/2015/1/.

"Historical Data." *California Legislative Analyst's Office*. Retrieved from https://lao.ca.gov/PolicyAreas/state-budget/historical-data.

Hertel-Fernandez, Alexander. *State Capture: How Conservative Activists, Big Businesses, and Wealthy Donors reshaped the American States- And the Nation.* Oxford University Press: New York, 2019.

"History of the Electric Car." *U.S. Department of Energy*. 15 September, 2014. Retrieved from https://www.energy.gov/articles/history-electic-car.

House Bill 1965. 2021. VA.S10.1-1307.04. Retrieved from https://lis.virginia.gov/cgi-bin/legp604.exe?211+sum+HB1965.

"H.R. 3684 - 117th Congress (2021-2022): Infrastructure Investment and Jobs Act." 15 November, 2021. Retrieved from https://www.congress.gov/bill/117th-congress/house-bill/3684.

"Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program." *California Energy Commission*. 30 April, 2009. Retrieved from https://www.energy.ca.gov/publications/2009/investment-plan-update-alternative-and-renewable-fuel-and-vehicle-technology.

"Join the EV WATTS Project and advance EV adoption*." Virginia Clean Cities*. Retrieved from https://vacleancities.org/reports-2/join-the-ev-watts-project-and-advance-ev-adoption/.

Kuchta, David M. "The History of the Electric Car: A Timeline." *Treehugger*. 13 January, 2022. Retrieved from https://www.treehugger.com/history-of-the-electric-car-trials-and-triumphs-5193009.

Leighninger Jr., Robert D. *Long-Range Public Investment: The Forgotten Legacy of the New Deal*. University of South Carolina Press: Columbia, 2007.

Local Median Household Income as a share of Area Median Household Income between 2015-2019. PolicyMap, https://vt-policymap-com.ezproxy.lib.vt.edu/data/our-data-dictionary/#PolicyMap%20&%20American%20Community%20Survey%20(ACS). (based on data from ACS and PolicyMap; Accessed 2 March 2022).

Mazzucato, Mariana. *The Entrepreneurial State.* Public Affairs: New York, 2015.

McGowan, Elizabeth. "Virginia law cleared a path for condo owners to install charging stations." *Energy News Network.* 27 April, 2021. Retrieved from https://energynews.us/2021/04/27/virginia-law-cleared-a-path-for-condo-owners-to-install-charging-stations/.

Moretti, Enrico. "The New Geography of Jobs." *Mariner Books:* Boston, Massachusetts. 2012.

Motavalli, Jim. "Every Automaker's EV Plans Through 2035 And Beyond." *Forbes: Wheels*. 4 October, 2021. Retrieved from https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement#partners.

"A National Network of Local Coalitions." *U.S. Department of Energy*. Retrieved from https://cleancities.energy.gov/coalitions/.

"New ZEV Sales in California." *California Energy Commission.* 31 March, 2022. Retrieved from https://www.energy.ca.gov/data-reports/energy-almanac/zero-emission-vehicle-and-infrastructure-statistics/new-zev-sales.

"Party control of California state government." *Ballotpedia*. 25 February, 2022. Retrieved from https://ballotpedia.org/Party_control_of_California_state_government.

"Party control of Virginia state government." *Ballotpedia*. Retrieved from https://ballotpedia.org/Party_control_of_Virginia_state_government.

Poe, Marshall. "Moscow, the Third Rome: The Origins and Transformations of a 'Pivotal Moment'." *Jahrbücher für Geschichte Osteuropas* , 2001. pp. 412-429. Retrieved from https://www.jstor.org/stable/pdf/41050783.pdf?casa_token=9yOiHKj3aCkAAAAA:5ajsdbE9mqtpmGEbzhqV3qeS_JJuYGves_SI-rKTkWYRFB5Cck_8qUibqBax0e9pMcFwiUPQSKRVcEtK4YQ-t5tqlt_ynO0zislfd2AOjCkWNEht8pZq

"Project: Electric Vehicle Widescale Analysis for Tomorrow's Transportation Solutions." *Energetics: Clean Energy Consulting*. August 2019. Retrieved from https://www.energetics.com/projects/electric-vehicle-widescale-analysis-for-tomorrows-transportation-solutions.

"Project Overview." *Drive Electric USA*. Retrieved from https://www.driveelectricusa.org/.

"Quickfacts: Virginia; California*." U.S. Census Bureau*. Retrieved from https://www.census.gov/quickfacts/fact/table/VA,CA/PST045221.

Rodrik, Dani. *Straight Talk on Trade: Ideas for a Sane World Economy.* Princeton University Press: Princeton, 2018.

Shah, Vivek. "Electric car charging standards: What does your EV use?" *CarExpert.* 22 August, 2021. Retrieved from https://www.carexpert.com.au/car-news/electric-car-charging-standards-what-does-your-ev-use.

Simpson, Joseph and Van Barlingen, Wesley. “The history of electric cars.” *EVBox.* 2 November, 2021. Retrieved from https://blog.evbox.com/electric-cars-history#:~:text=The%20history%20of%20electric%20cars%20can%20be%20broken%20up%20into,(2003%2D2020)%2C%20and.

Spencer, Alison, Funk, Cary. “Electric Vehicles get mixed reception from American Consumers.” *Pew Research Center*. 3 June, 2021. Retrieved from https://www.pewresearch.org/fact-tank/2021/06/03/electric-vehicles-get-mixed-reception-from-american-consumers/.

Stone, Deborah. *Policy Paradox: the art of political decision making*. W.W. Norton & Company: New York, 2012.

“Success Stories.” *Virginia Clean Cities*. Retrieved from https://vacleancities.org/about/success-stories/.

“Supercharger.” *Tesla.* Retrieved from https://www.tesla.com/supercharger.

Talanstev, Anton. “Who Gains and Who Loses in the Shift to Electric Vehicles: Impact Assessment through Multi-criteria Multi-stakeholder Analysis.” Green Urbanism, Volume 37, 2017. P. 257-268.

Thomson, Vivian. *Climate of Capitulation: An Insider’s Account of State Power in a Coal Nation*. MIT Press: Cambridge, 2017.

“VCC Current Projects.” *Virginia Clean Cities*. Retrieved from https://vacleancities.org/category/current-projects/.

"Virginia Counties." *Virginia Association of Counties*. Retrieved from https://www.vaco.org/county-profiles/.

"Virginia GDP*." Department of Numbers*. Retrieved from https://www.deptofnumbers.com/gdp/virginia/.

"Virginia: Regional Data: GDP and Personal Income." *U.S. Department of Commerce: Bureau of Economic Analysis.* 1 October, 2021. Retrieved from https://apps.bea.gov/itable/iTable.cfm?ReqID=70&step=1&acrdn=1.

Vogel, David. *California Greenin': How the Golden State became an Environmental Leader*. Princeton University Press: Princeton, 2018.

Vogelsong, Sarah. "Virginia Clean Economy Act passes, as debate reveals deep partisan and regional divides." *Virginia Mercury*. 11 February, 2020. Retrieved from https://www.virginiamercury.com/2020/02/11/virginia-clean-economy-act-passes-as-debate-reveals-deep-partisan-and-regional-divides/.

"Volkswagen Clean Air Act Civil Settlement." *United States Environmental Protection Agency*. Retrieved from https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement#partners.

"What's Your Growth Rate: Too Fast, Too Slow, or Just Right?" *Revenue Rocket.* 1 August 2021. Retrieved from https://www.revenuerocket.com/whats-growth-rate-fast-slow-just-right/.

Wilson, Kevin A. "Worth the Watt: A Brief History of the Electric Car, 1830 to Present." *Car and Driver*. 15 March 2018. Retrieved from

https://www.caranddriver.com/features/g15378765/worth-the-watt-a-brief-history-of-the-electric-car-1830-to-present/.

Yin, R. “Case study research: Design and methods 5 ed.” *Sage Publishing:* Thousand Oaks, California. 2014.

“Zero Emission Vehicle Deployment Support.” *U.S. Department of Energy*. Retrieved from https://afdc.energy.gov/laws/11081.

“ZEV Collaboration.” *California Air Resources Board*. Retrieved from https://ww2.arb.ca.gov/zev-collaboration.

APPENDIX A

Figure 1-A

Virginia Population Densities

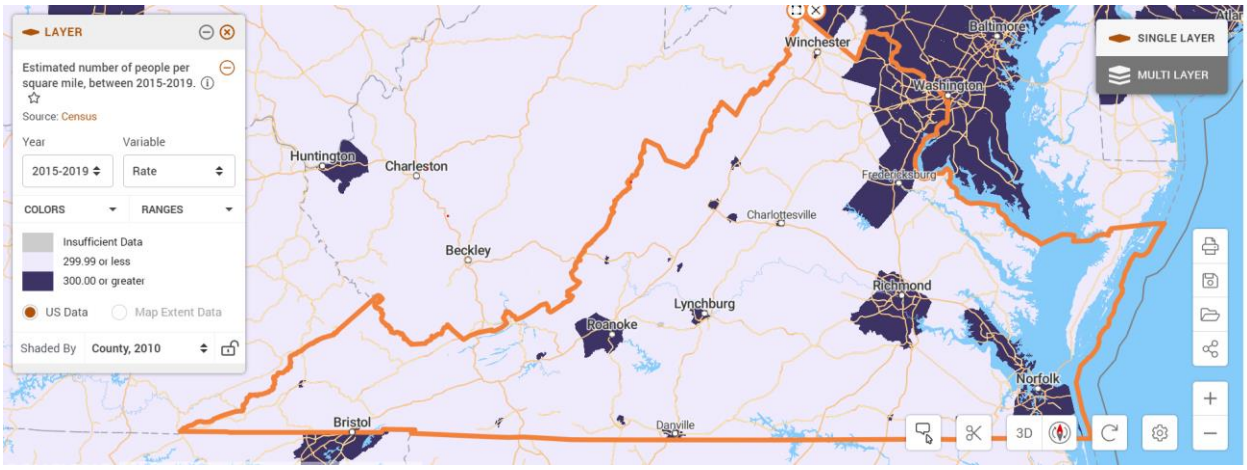

Figure 1-B

California Population Densities

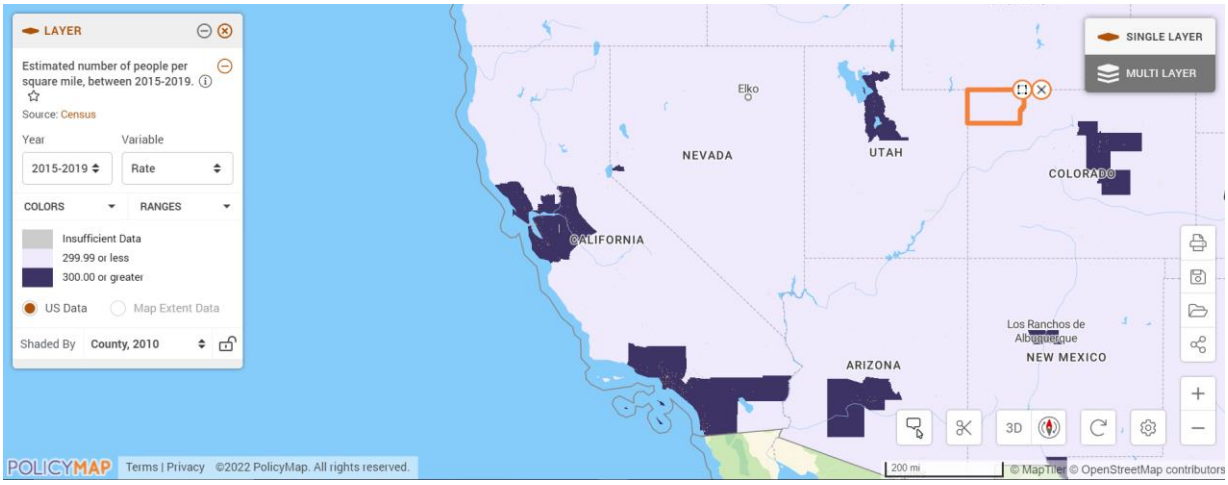

Figure 2

EV Sales vs. EVSE Installations: Virginia

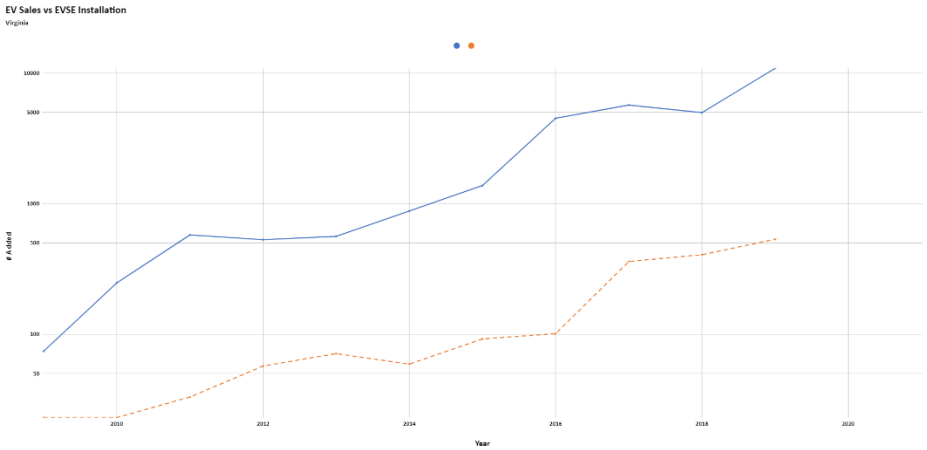

Figure 3-A

EV Sales: California

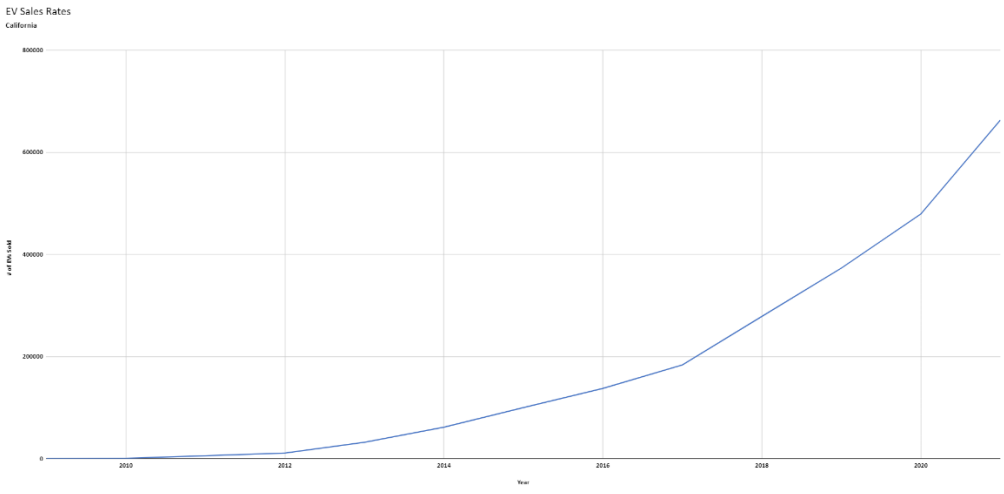

Figure 3-B

EVSE Installations: California

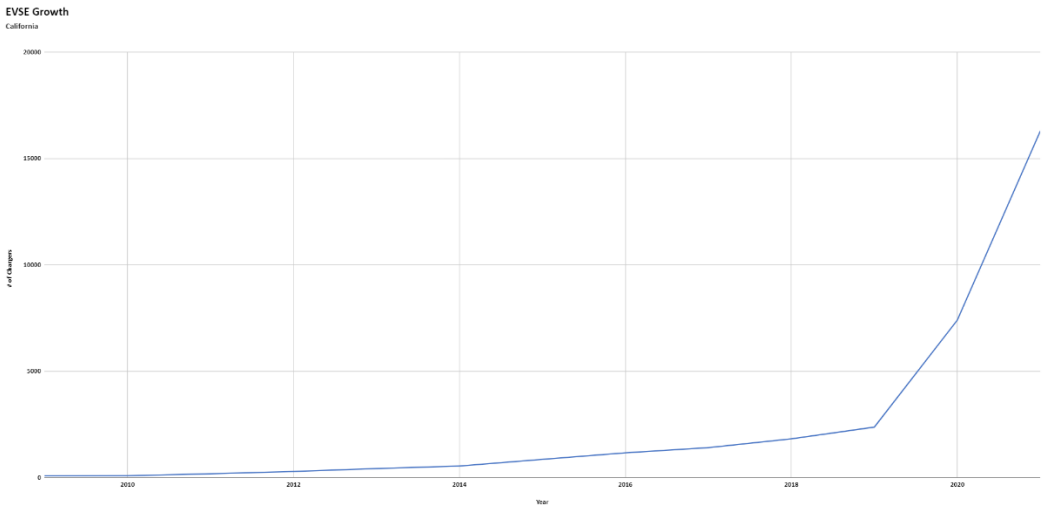

Figure 4

Federal and State Party Affiliation

	California		Virginia		Federal				State Governor		State Senate		State House		State Env Head	
Year	Number of Chargers	Rates of Change	Number of Charger	Rates of Change	President Party	Fed House Party	Fed Senate Party	Head of EPA	CA	VA	CA	VA	CA	VA	CA	VA
1995	1	--			dem	rep	rep	dem	rep		dem		dem		rep	
1996	2	+100%			dem	rep	rep	dem	rep		dem		rep		rep	
1997	8	+75%			dem	rep	rep	dem	rep		dem		dem		rep	
1998	22	+64%			dem	rep	rep	dem	rep		dem		dem		rep	
1999	23	+4%			dem	rep	rep	dem	dem		dem		dem		dem	
2000	26	+12%			dem	rep	rep	dem	dem		dem		dem		dem	
2001	26	+0%			rep	rep	rep	rep	dem		dem		dem		dem	
2002	43	+40%			rep	rep	dem	rep	dem		dem		dem		dem	
2003	43	+0%			rep	rep	dem	rep	dem		dem		dem		--	
2004	54	+20%			rep	rep	rep	rep	rep		dem		dem		--	
2005	56	+4%			rep	rep	rep	rep	rep		dem		dem		--	
2006	58	+3%			rep	rep	rep	rep	rep		dem		dem		--	
2007	58	+0%			rep	rep	rep	rep	rep		dem		dem		--	
2008	72	+19%			rep	dem	dem	rep	rep		dem		dem		--	
2009	74	+3%			dem	dem	dem	dem	rep		dem		dem		--	
2010	78	+5%	23	--	dem	dem	dem	dem	rep	dem	dem	dem	dem	rep	--	rep
2011	174	+55%	46	+100%	dem	dem	dem	dem	dem	rep	dem	dem	dem	rep	dem	rep
2012	279	+38%	69	+50%	dem	rep	dem	dem	dem	rep	dem	rep	dem	rep	dem	rep
2013	417	+33%	96	+33%	dem	rep	dem	dem	dem	rep	dem	rep	dem	rep	dem	rep
2014	537	+22%	153	+37%	dem	rep	dem	dem	dem	dem	dem	dem	dem	rep	dem	dem
2015	850	+37%	224	+32%	dem	rep	dem	dem	dem	dem	dem	rep	dem	rep	dem	dem
2016	1156	+26%	283	+21%	dem	rep	rep	dem	dem	dem	dem	rep	dem	rep	dem	dem
2017	1403	+18%	375	+25%	rep	rep	rep	rep	dem	dem	dem	rep	dem	rep	dem	dem
2018	1817	+23%	476	+21%	rep	rep	rep	rep	dem	dem	dem	rep	dem	rep	dem	dem
2019	2365	+23%	836	+43%	rep	rep	rep	rep	dem	dem	dem	rep	dem	rep	np	dem
2020	7399	+68%	1442	+28%	rep	dem	rep	rep	dem	dem	dem	dem	dem	dem	np	dem
2021	16291	+55%	1975	+27%	dem	dem	dem	dem	dem	dem	dem	dem	dem	dem	np	dem
2022	--	--			dem	rep	dem	dem	dem	rep	dem	dem	dem	rep	np	rep

Figure 5

Industry Events Timeline

	California		Virginia		Major Event
Year	Number of Chargers	Rates of Change	Number of Chargers	Rates of Change	
1995	1	--			
1996	2	+100%			GM EV1 (not for sale)
1997	8	+75%			Toyota Prius Hybrid JPN
1998	22	+64%			
1999	23	+4%			Honda Insight US
2000	26	+12%			Toyota Prius Hybrid US
2001	26	+0%			
2002	43	+40%			tZero + others being researched
2003	43	+0%			Tesla Founded
2004	54	+20%			
2005	56	+4%			
2006	58	+3%			T. Roadster Announced
2007	58	+0%			
2008	72	+19%			T. Roadster Released
2009	74	+3%			
2010	78	+5%	23	--	Tesla got $465M loan, Chevy Volt,
2011	174	+55%	46	+100%	T. Model S
2012	279	+38%	69	+50%	T. Superchargers
2013	417	+33%	96	+33%	Nissan Leaf US
2014	537	+22%	153	+37%	
2015	850	+37%	224	+32%	
2016	1156	+26%	283	+21%	T. Model 3, VW Lawsiut
2017	1403	+18%	375	+25%	
2018	1817	+23%	476	+21%	
2019	2365	+23%	836	+43%	
2020	7399	+68%	1442	+28%	T. Cybertrucks, Covid-19
2021	16291	+55%	1975	+27%	

Figure 6-A

Federal Legislation Timeline

	California		Virginia		Federal Legislation
Year	Number of Chargers	Rates of Change	Number of Chargers	Rates of Change	
1995	1	--			
1996	2	+100%			
1997	8	+75%			
1998	22	+64%			
1999	23	+4%			
2000	26	+12%			
2001	26	+0%			
2002	43	+40%			
2003	43	+0%			
2004	54	+20%			
2005	56	+4%			
2006	58	+3%			
2007	58	+0%			Energy Independence and Security Act of 07
2008	72	+19%			
2009	74	+3%			ARRA (built chargers)
2010	78	+5%	23	--	
2011	174	+55%	46	+100%	
2012	279	+38%	69	+50%	
2013	417	+33%	96	+33%	
2014	537	+22%	153	+37%	
2015	850	+37%	224	+32%	
2016	1156	+26%	283	+21%	
2017	1403	+18%	375	+25%	
2018	1817	+23%	476	+21%	
2019	2365	+23%	836	+43%	
2020	7399	+68%	1442	+28%	
2021	16291	+55%	1975	+27%	INVEST in America Act
2022	--	--			

Figure 6-B

Virginia Legislation Timeline

	Number of Chargers	Rate of Change	Important State Legislation
Virginia			
2010	23	--	
2011	46	+100%	
2012	69	+50%	
2013	96	+33%	
2014	153	+37%	
2015	224	+32%	first mention of EVSE in budget
2016	283	+21%	
2017	375	+25%	CoV 22.1-131(schools can use EVSE for profit)
2018	476	+21%	CoV 15.2-967.2(localities can use EVSE for profit)
2019	836	+43%	
2020	1442	+28%	Right to Charge Laws
2021	1975	+27%	HB 1919, HB 1965, EV Rebate Advisory Council, CoV 67-1905(EV Rebate Fund), Commonwealth Clean Energy Policy, Virginia Energy Plan, HB2118 (EV rebates) Commonwealth Clean Energy Policy, Virginia Energy Plan, HB 2118 (EV rebates)
2022	--	--	

Figure 6-C

California Legislation Timeline

	Number of Chargers	Rates of Change	Important Legislation
California			
1995	1	--	CARB Expenditure Requirements
1996	2	+100%	
1997	8	+75%	
1998	22	+64%	
1999	23	+4%	
2000	26	+12%	
2001	26	+0%	
2002	43	+40%	CCR tit.13sec.1962.2 (ZEV production 05-08)
2003	43	+0%	
2004	54	+20%	
2005	56	+4%	
2006	58	+3%	
2007	58	+0%	
2008	72	+19%	
2009	74	+3%	CCR tit.13chap.8.1 (CLean Trans. Program(setup of incentives))
2010	78	+5%	
2011	174	+55%	
2012	279	+38%	
2013	417	+33%	Greenhouse Gas Reduction Fund
2014	537	+22%	Charge Ahead California Initiative, CHSC 44268.2 (open access EVSE)
2015	850	+37%	
2016	1156	+26%	Electrify America (VW) investment plan
2017	1403	+18%	
2018	1817	+23%	CEC EVSE Programs, CVC 5205.5+21655.9 (HOV exempt)
2019	2365	+23%	CPUC sec.740.13 (EVSE grants), GGRF EV grants (CHSC o44274+44258), CPRC 25722.9 (parking incentives), Right to Charge Laws (CCC 4745+6713)
2020	7399	+68%	E.O. N79-20, A.B.841, California State Transportation Plan, Cal. Clean Fuel Reward
2021	16291	+55%	CCR. tit.13sec.1963 (medium+heavy trucks), CCR tit.4sec.4002 (charging rates), CPUC sec.740.13 (EVSE grants), ZEVs for companies, EVSE training+cert., *local EVSE revates begin*
2022	--		