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The Insight of Electric Vehicle Population in Washington

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Abstract: With the declination of the traditional vehicles that need fuel to combust engine, the number of electric vehicle population has been booming in recent years, which is effective and environmental-friendly. With electric consumption increasing, this study takes American electric vehicle population in Washington for example, analyzing the current situation of EVs by numbers of EV manufacture, geographic distribution, top brands, top models, and electric charge types by a given data set. These market phenomenon provides some clues about the progress of zero carbon emission in a global vision. The study will compare the similarities and differences about battery electric vehicles and plug-in hybrid electric vehicles, and also mention some the possible future tendency about electric vehicles. Moreover, based on the analysis, this paper presents some market opportunities and threatens of the development of electric vehicles. The achievement about low carbon and clean energy consumption not only rely on consumers' purchasing choice, but also need macro regulation on power structure and balance in supply and demand of electricity.

Keywords: electric vehicles (EVs); electric model, electric charge type, battery electric vehicles (BEVs), plug-in electric vehicles (PHEVs)

1. Introduction

Electricity is one of the most essential energy we can use to support our basic daily life activities, including transportation, industrial production, residential usage, and so on. The significant sources of electricity, according to U.S. Energy Information Administration (IEA) in 2022, include 39.8% natural gas, 19.5% coal, 18.2% nuclear, 0.9% petroleum, and 21.5% renewables [1]. The traditional vehicles usually use petrol combustion engines, which require gasoline and diesel. Thus, the combustion causes a large amount of carbon dioxide, which leads to global warming. IEA also claimed that electric vehicles are the key technology to decarbonize road transport, a sector that accounts for around one-sixth of global emissions. In recent years, extensive research has been done on alternative automotive technologies to address the world's most pressing carbon reduction concerns [2]. Electric vehicles, which are regarded as having "zero tailpipe emissions," might be a solution for greenhouse gas [3], and they are considered to be the more environmentally friendly ones because each uses one or more electric motors [4], which can be powered autonomously by a battery. The battery was charged by electricity, which originated from not only natural gas but also renewables such as wind, hydro, solar, biomass, and geothermal power. The renewable sources of electricity generate much less or even zero carbon dioxide, so using electric vehicles is a sustainable way to

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attain the goal of lesser carbon emissions. Besides the sustainable benefits, electric vehicles are more straightforward, more reliable, more efficient, more cost-effective, and have more driving range [5].

Although electric vehicles contain so many merits, they are not yet a global phenomenon. 95% of all EV sales in 2021 were made in China, Europe, and the United States, with the remaining 5% going to emerging nations like Indonesia, India, and Brazil. Clearly [6]. The IEA reveals that despite huge growth in China, some European countries, and some U.S. states, sales in the majority of underdeveloped nations have been slow due to higher purchase costs and a lack of charging infrastructure [7]. Therefore, those developing countries still have a long way to go if they are to successfully implement the EVs [8]. Furthermore, America is one of the pacemakers who initiated calls for a clean energy transition, so the study of electric vehicles in America may help us see the process of the global path of zero carbon. Additionally, a study found that high-income nations have the largest national average carbon footprints, with Luxembourg having the highest average carbon footprint, over 30t CO2 and followed by the United States, which had 14.5t CO2 [9].

The study chose Washington in America mainly because it was listed forth in electric registrations at the end of 2022 in the U.S. [10], information derived by the National Renewable Energy Laboratory with data from Experian Information Solutions. Moreover, a data set found on Kaggle.com with a total number of 138,779 electric vehicle population size is available, originating from the Washington State Department of Licensing (DOL) through the data.gov website [11]. The data collection contains details on battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) that are currently registered with the Washington State Department of Licensing. Battery electric vehicles refer to pure electric vehicles that derive all power from the battery pack, without any secondary source of propulsion such as an internal combustion engine, and thus use no direct fuel. Similar to BEVs, plug-in hybrid electric vehicles have both battery packs, but they also contain internal combustion engines that may cause more carbons than BEVs.

2. Analysis and results

2.1. The rising trend of the numbers of electric vehicles

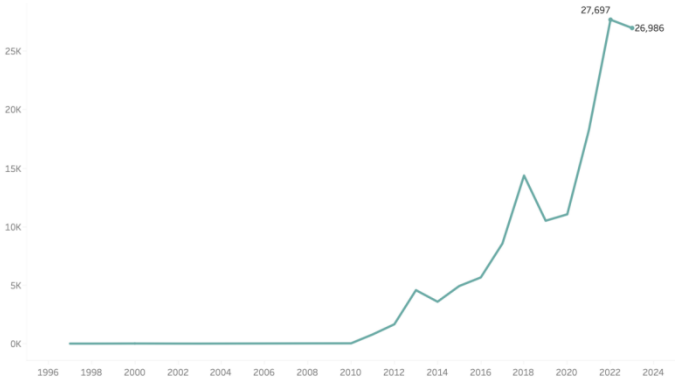

Figure 1: The trend of the number of EVs for the year from 1996 to 2023 in which they are manufactured.

The number of EVs produced generally was in a rising trend in the last decade. From 1996 to 2023, electric vehicles stared to be manufactured in a large-scale production since 2010 in Washington. The number of EV production began to rise sharply from 2020. By 2022, the number of production had reached 27,697, and by 2023, the known electric vehicles that manufactured in the year have already reached 26,986. So the market of electric vehicles in Washington is expanding and prosperous. Based

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on the booming tendency of using electric vehicles, we can find that the decarbonisation is in process and accelerate its speed in Washington.

2.2. The county king, Snohomish, Pierce, and Clark have the largest number of electric vehicles

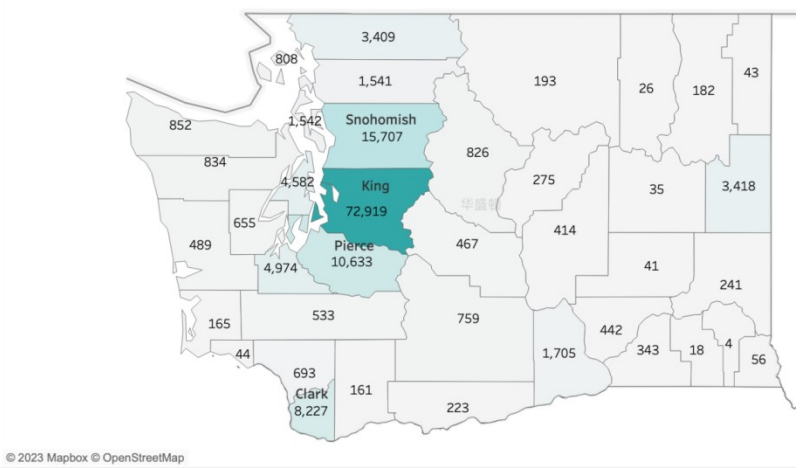

Figure 2: The electric vehicle distribution in Washington by county, including all the electric vehicles manufactured since 1996. The Colour from light to dark shows the sum of electric vehicles in a county.

As figure 2 shows, the county King (72,919), Snohomish (15,707), Pierce (10,633), and Clark (8,227) have the most significant number of EVs, and their population of electric vehicles are far more than other counties. The prime reason for this phenomenon is that these counties also have the largest population of residents [12], according to the demographic data revealed by Washington Demographics.

2.3. Battery electric vehicles are more popular than Plug-in Electric Vehicles in 2023

In 2023, battery electric vehicles, which comprise 83.05% of Washington's population, are much more popular than plug-in hybrid electric vehicles, which comprise 16.95% EV population. The tendency of preference for BEVs indicates Washington has taken a comprehensive step down a low-carbon path. As we mentioned before, although BEVs and PHEVs are both environmentally friendly vehicles compared to the traditional vehicle types, theoretically when used for transportation, BEVs emit zero carbon, whereas PHEVs emit some carbon [13]. Because battery electric vehicles rely upon no gasoline fuels and thus need less carbon resources to produce electricity than Plug-in electric vehicles do.

There is another term to measure which type of vehicles are more environmentally——clean alternative fuel vehicles eligible. The differences between BEVs and PHEVs exist in their battery range and eligibility for clean alternative fuel vehicles. Battery range refers to the range of the vehicle on a full electric charge. The term “clean alternative fuel” means any fuel or power source (including electricity) used in a clean-fuel vehicle that complies with the standards and requirements applicable to such vehicle. In the case of any flexible fuel vehicle or dual fuel vehicle, the term “clean alternative fuel” means only a fuel with respect to which such vehicle was certified as a clean-fuel vehicle meeting the standards applicable to clean-fuel vehicles under section 7583(d)(2) of this title when operating on clean alternative fuel (or any CARB standards which replaces such standards pursuant to section 7583(e) of this title) [14]. So the term clean alternative fuel vehicle (CAFV) eligibility in

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the chart below basically means whether the vehicles use the fuel or power that meets clean alternative fuel standards under some items.

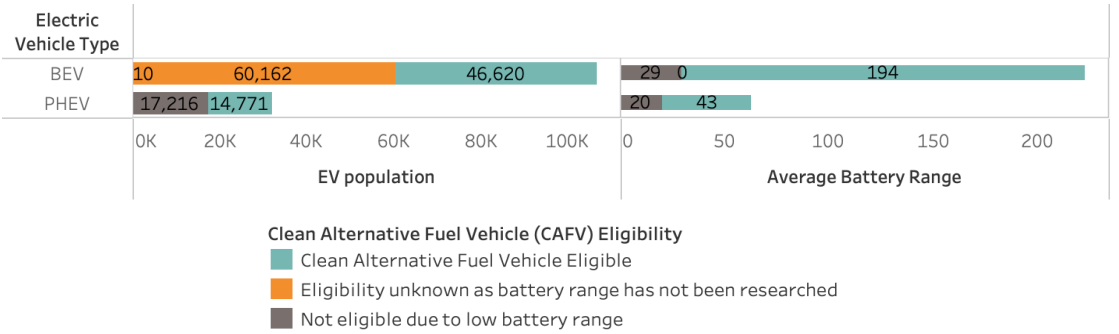

Figure 3: The EV population and average battery range of each electric vehicle type, filtered by CAFV eligibility since 1996 in Washington.

From the same electric vehicle type, we can find the lower the battery range, the less possibility of the electric vehicle being CAFV eligible. The 10 BEVs that are not eligible for CAFV have a 29 average battery range; Similarly, the 17,216 PHEVs that are not CAFV eligible have a 20 average battery range. Both battery ranges are very low compared to vehicles that are CAFV-eligible. We can notice that 14,771 PHEVs that are CAFV eligible have 43 average battery range, and 46,620 BEVs that are eligible for CAFV have an average battery range of 194, which is four times higher than that of PHEVs. Battery range is one of the significant concerns of consumers because it determines how far they can go and what the frequency to charge the vehicles. Besides, battery range determines the eligibility of CAFV. Because BEVs generally have a higher battery range than PHEVs, far more BEVs are CAFV-eligible than PHEVs. Maybe that is why BEVs are more popular than PHEVs—— more comprehensive battery range when it is fully charged and more eligible to be CAFV.

2.4. First Section Top five EV brands in 2023 Compared to 2022 in Washington.

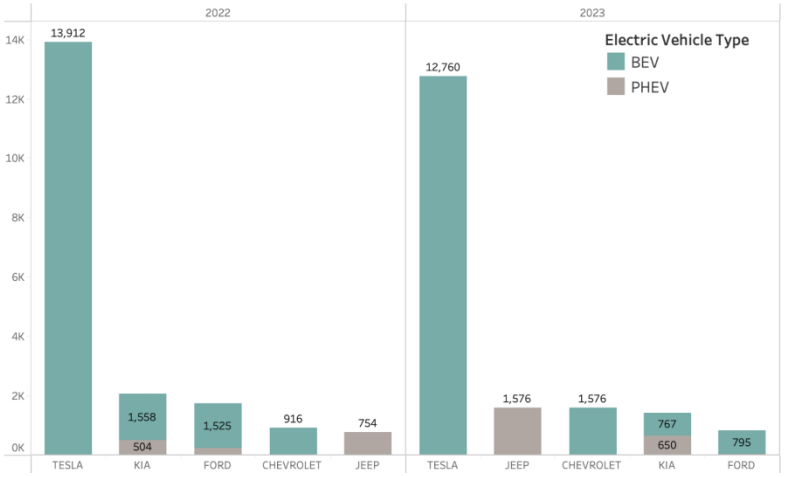

Figure 4: Ranks of the five most prevalent electric vehicle brands of the total 36 brands in 2022 and 2023 in Washington, filled by EV types.

The top five brands are same in both 2022 and 2023. The best-selling electric vehicle brands in 2022 are ranked by Tesla, KIA, Ford, Chevrolet, and Jeep. And the five most popular electric vehicle brands in 2023 are currently ranked by Tesla, Jeep, Chevrolet, KIA, and Ford. The chart also presents the population of Tesla far exceeds other brands, which is 13,912 in 2022 and 12,760 in 2023.

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From the chart, we can also find that BEVs dominated the Washington electric vehicle market. Except for Jeep, the other top brands manufactured far more BVEs than PHVEs. The brands are inclined to BEVs, indicating that the market of vehicles tends to believe in the performance and efficiency of full-battery vehicles and to reduce the reliance on fuels. The inclination is on the way to a more sustainable and clean-energy future. BVEs are the trend of the electric vehicle market, which can be seen from not only the percentage of BEVs in production in top brands but also the manufacturer's model choice.

2.5. Top five EV models in 2023 Compared to 2022 in Washington.

The study also ranks the five most prevalent electric vehicle models of the total 127 models in 2022 and 2023 in terms of registered numbers of them. The top five models are identical in both 2022 and 2023. The most popular five electric vehicle models in 2022 are Model Y (7,455), Model 3 (4,893), Leaf (941), Bolt EV (916), and Model X (858). In 2023, they are Model Y (8,621), Model 3 (3,313), Model X (636), Bolt EV (614), and Leaf (538). We can find the number of Model Y and Model 3 is much higher than other brands in both 2022 and 2023. Different brands apply different models. Tesla provides Model X, Model Y, Model 3, and Model S. Chevrolet uses a Bolt EV. Nissan provides the model Leaf. Additionally, all the top 5 models are used in battery-type vehicles, which infers the same thing that the Washington businesses of cars lean to a less energy use and resource depletion way to enter the market.

The proliferation of electric vehicles casts us a question——Can BEVs fully replace PHEVs, which sometimes need fuel to propel engines in the future? Although it is ideal that everyone converts fuel vehicles or PHEVs to BEVs, the choice depends on consumers. They have a trade-off in their mind, including short-turn or long-turn saving, short or long-distance commutes, and environmental concerns. Generally, BEVs cost more to buy than PHEVs do in America [15], but PHEVs are more expensive in the long-term because they may consume much more expensive gasoline in the future application, which causes relatively more discharge of carbons. Moreover, PHEVs run less distance than BEVs, but long-distance daily commute for BEVs means one should ensure there are public charging infrastructure along the way [16], as a study claims that the electric vehicle miles travelled of PHEVs and BEVs could rise if public charging infrastructure is developed [17]. However, some scholars illustrated that some BEV owners have anxiety and frustration to get public charging station since they always concern about detouring to reach a charging station, availability of an open charging slot, and charge-up time in a long distance driving [18]. Therefore, the opportunity for the future development of the BEV market includes lowering the cost to produce batteries and lowering the retail price for consumers, which can attract more consumers to convert from PHEVs. Other measures include adding public and home charging stations to ensure that drivers can easily charge their vehicles. The wireless charging is also a great solution when the public space of charging is limited [19].

The threat of electric vehicle usage in a country regards the energy structure and extreme electricity demand [20]. If a country depends merely on fossil fuels and almost no other measures to generate electricity, then the so-called environmental effect of BEVs is totally a lie. For example, in the U.S., about 60% of the utility-scale electricity generation was produced from fossil fuels, 18% from nuclear, and 22% from renewables in 2022 [21]. So, in the U.S., the development of electric cars is meaningful. But in some other countries, the outcome may not necessarily be positive. Furthermore, since more and more people choose electricity cars, the demand for electricity is dramatically increasing; how can a country get consistent electricity support without using more carbon resources and controlling the electricity price still deserves further consideration? Governments should pay more attention to improving the energy supply structure and balance between the demand and supply of electricity.

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Other potential obstacles to the widespread use of such cutting-edge battery technologies have been identified as cycling stability of high-capacity electrodes, safety concerns, and fast charging [22].

3. Conclusion

The study takes Washington, for example, and introduces current market conditions of electric vehicles. The electric vehicle market in Washington is booming and flourishing. More than 80% of consumers prefer battery electric vehicles to plug-in hybrid electric vehicles. BEVs are more popular than PHEVs because BEVs offer a more extended battery range when fully charged, and thus, they are more eligible for clean alternative fuel vehicles. Snohomish, Pierce, and Clark counties have the most electric vehicles. Tesla, KIA, Ford, Chevrolet, and Jeep are the top five electric vehicle brands. Model Y, Model 3, Bolt EV, Model X, and Leaf are the top five electric car models, and they are all battery types. BEV dominance is an environmental trend in the future electric vehicle market. While reducing the manufacturing cost of BEVs will bring opportunities to embrace a sustaining future, limitations such as poor energy structure and electricity price fluctuation should also be considered and overcome.

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