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The Economic Obstacles to Electric Vehicle Adoption in Montana

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The electric vehicle (EV) market has been becoming more popular through the last couple of years, starting around 2008 with the production of the first all-electric car from Tesla. However, there are certain obstacles that society must address before EV's can become a credible substitute, especially in rural areas like Montana. This paper will walk through those potential issues.

Driving Distance

The distance limitations of EVs has been a problem since their conception, however, it is more important when considering EV adoption in rural areas. The average distance between towns in Montana is approximately 285 miles.[1] The average car sold in the US has a 12-gallon tank and travels 25 miles per gallon (resulting in a range of 300 miles), while the average range of a single charge for 2022 EVs is only 277 miles.[2,3] While the range of EVs has improved over the years, even the newest models don't meet the requirement to travel in Montana. Though there are EVs available that are capable of traveling farther than the average 277 miles, there is a trend that as range increase, so does the base price, meaning consumers in Montana and other rural areas would need to pay a higher price just to achieve their "normal" driving standards (see Figure 1 below).

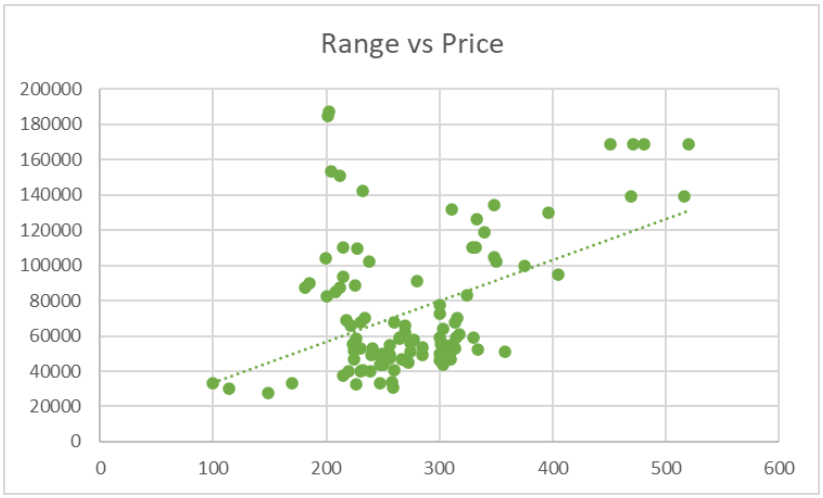

Figure 1: EV Range vs Price

Availability of Charging Stations

When most people think of purchasing an electric vehicle, consumers often comment on how charging the vehicle is more convenient than going to a gas station (and also cheaper). And while it may be true that home and work charging stations are both cost efficient and convenient to EV owners, the availability of charging stations outside of city limits (i.e., highways and interstates) can be significantly limited and therefore inconvenient for most states. To decide how many charging stations Montana should implement, three implementation levels should be considered. Montana currently has 167 stations (for over 147,164 square miles) and is ranked 46th in terms of public charging availability.[4] The United States is estimated to have 111,000 gas stations, with 327 of those being in Montana. If EV charging stations were similar to gas station availability,

Montana would need to double the public charging stations in the state, focusing mainly on more rural areas such as along highways and interstates.[5] This should be considered the lowest possible implementation level for a successful public charging system. Each charging station can be expected to cost about $9,500 when accounting for the electricity and fixed costs, however, as the number of charges/day increases, the cost of electricity would also increase.[6] If Montana were to consider a moderately aggressive implementation standard, they would be expected to follow an example set by the state of Vermont. While it may be shocking, Vermont is ranked first in availability of charging stations (768 stations for 9,623 square miles) and provides evidence that rural adoption and implementation of charging stations can be successful. Using the moderate level, one charging station would be required every 12.5 square miles, resulting in 11,745 charging stations throughout the state. However, due to the size difference of these two states, a third implementation level can also be considered. California is just slightly larger than Montana (163,696 square miles) yet has almost 32,000 public EV charging stations.[4] Following a highly aggressive adoption method, Montana would need 28,768 charging stations. The number of stations and cost analysis of each implementation level is summarized below in Table 1.

	Low	**Moderate**	**High**
Charging stations required for Montana	334	11,745	28,768
Current charging stations	167	167	167
Difference	167	11,578	28,601
Cost of implementation	$1,586,500	$109,991,000	$271,709,500

Table 1: Cost Analysis of Charging Station Implementation Methods

Charging Time

Even if an EV has an acceptable range and fair accessibility to travel through the rural areas of Montana, the time the vehicle takes to recharge is another issue that must be addressed. The time it takes to charge an EV can be anywhere between 40 minutes to almost 21 hours depending on the size of the battery and the speed of the charging point.[7] However, this data is representative on the charging length from an empty-to-full battery. Owners of EVs will typically not run their battery to empty and should instead focus on the top-off method of charging. Home chargers usually have a power rating of 3.7 kW or 7 kW.[7] These are the lowest power chargers and, thus, require the most time to charge, especially if the batter capacity is greater than 14 kW. Rapid chargers (anywhere between 43 and 150 kW) are the best solution when considering which types of chargers should be at public charging stations in rural areas like Montana. Rapid chargers can provide between 60-200 miles of range within 20-30 minutes of charging, depending on the vehicle.[7] One of the benefits of employing the highest power rapid chargers (150 kW) is that it is compatible with all battery sizes. Even if the EV battery cannot accept the maximum charge rate with the highest power rapid charger, it will accept energy at the maximum rate it can (meaning only the battery type in the EV is affecting the charging rate).[7] While this charging time is significantly lower than the empty-to-full charging time, it still requires EV owners and passengers to spend up to half an hour sitting at a charging station while traveling. Depending on the number of times one needs to stop on the way to their destination, this could increase travel

time significantly. For example, the journey from Missoula to Billings, Montana, is 350 miles. If someone had the average EV, they would be able to travel 277 miles on one full battery. This trip would require the driver to stop at least once, increasing travel time from approximately 5 hours to at least 5.5 hours. The first half of the drive would use up around 63% of the battery, meaning that the charging time when stopped halfway between the two places would likely be greater than 30 minutes to charge back up enough to finish the drive. If stopping each time the battery reaches 50% capacity, one would have to stop approximately 2.5 times, increasing the travel time to at least 6.5 hours. Additional research has also been conducted into other methods of charging, specifically, charging highways. This method would allow electric vehicles to continuously charge while driving on the highway, mitigating the need to stop and charge for longer periods of time. However, there are obstacles for the implementation of such an expansive project, including the charging devices themselves, how they will be built into the road, financial requirements, and bridging the gap between wireless charging in different vehicles, as well as the collaboration of highway infrastructure, the electricity grid, and the automobile industry.[7] Research is continuing to be conducted on how to best progress with this method of charging and is expected to be tested on a small section of road in Indiana, funded by Purdue University, before widely considered in other rural areas.

Conclusions

Overall, Montana and other rural areas face three main obstacles to the adoption of electric vehicles. The driving range of EVs, availability of public charging stations, and charging time are all external infrastructure that must be addressed in order for consumers to readily consider implementation in their day to day lives. Driving distance must be addressed by automobile companies as a continued benefit for consumers, however, most Montanans may not even consider purchasing an EV until driving ranges improve without an additional increase in price. Public charging stations must be implemented by companies and governments and a strategy devised to choose the best level of implementation. And finally, both governments and automobile companies must collaborate on the best ways to reduce charging time for consumers in Montana to be able to use an EV as they use their vehicle now.

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