Evaluation of Battery Electric Vehicle Performance in Mountainous Regions and Cold Climates

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Background

- This study aims to investigate the compounded impact that **climate**, **terrain**, and **road classification** have on the overall performance (range) of battery electric vehicles (BEVs).
  - Test vehicle is a 2024 Tesla Model Y Long Range.
- The real-world range of BEVs will directly impact the charging infrastructure required to provide energy for/to BEVs.

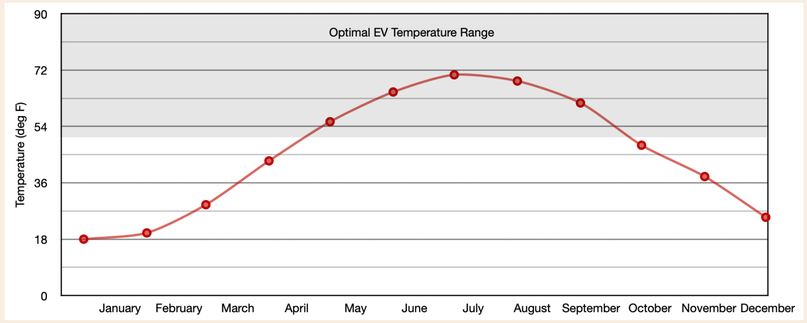

Figure 1. Average monthly temperatures for Montpelier, VT.[1]

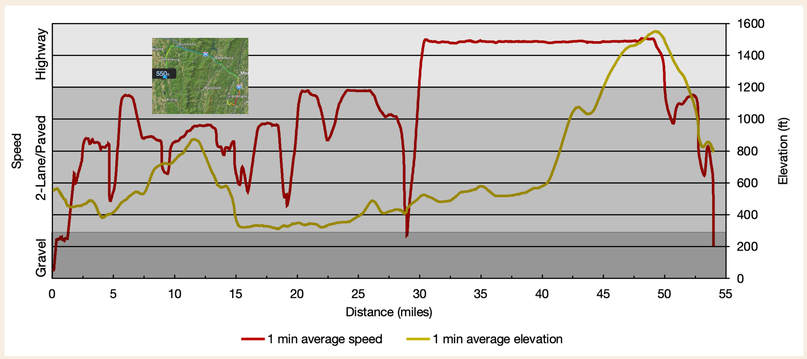

Figure 2. One-minute average speed and elevation profile for daily commute.

Range Impacts

- Temperature: Range decreases as temperatures vary outside of the optimal range of 50-90 ^{o}F.[2]
  - The average daily temperature in Montpelier, VT,[1] is below the optimal BEV operating range for 7 months of the year.
- Elevation: Range decreases as the terrain becomes more mountainous.
  - Commutes outside the Champlain and Upper Valleys encounter large elevation gains (up to 3400 ft in Figure 3).
- Speed: Range decreases at a rate of 4% for each 5 mph above 50 mph.[2]
  - Commutes in VT consist of varying road classifications, ranging from gravel roads with a 35 mph speed limit to 2-lane roads with a 50 mph speed limit to 4-lane highways with a 65 mph speed limit.

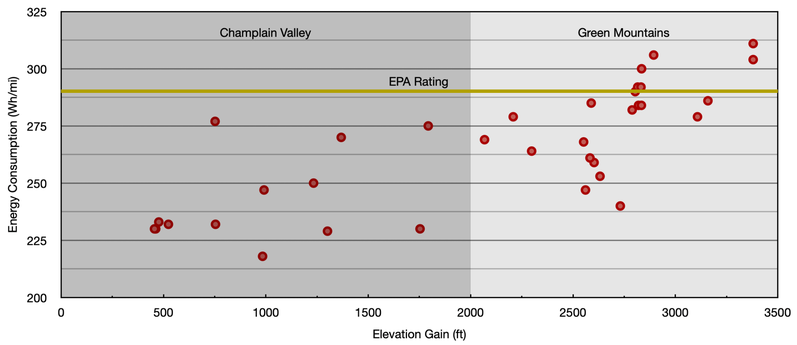

Figure 3. Energy consumption for Tesla Model Y Long Range BEV.

Future Work

- Vehicle energy consumption will be evaluated as a function of temperature, elevation gain, and average speed.
  - The compound effect of temperature, elevation, and speed will be quantified.
- The impact that varying driving conditions and road classification have on vehicle safety systems and self-driving performance may also be assessed.
- Vehicle range data will be used to explore the optimal spatial distribution of BEV charging stations throughout Vermont, emphasizing ensuring rural areas subject to environmental justice considerations.
  - Optimal distribution will be the product of GIS and AI evaluations, with the goal of eliminating barriers to electric vehicle uptake.

Acknowledgments

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References

[1] https://weatherspark.com/y/25716/Average-Weather-in-Montpelier-Vermont-United-States-Year-Round#google_vignette (accessed September 4, 2024)

[2] https://www.geotab.com/blog/ev-range-impact-of-speed-and-temperature/ (accessed September 4, 2024)