Transport electrification and fast-charging expansion: A case study in Alaska*

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Abstract. Research on the use of electric vehicles (EVs) typically focuses on urban areas only with a lack of case studies in areas that are not highly populated. This paper presents an agent-based model of EV users in Alaska, USA, combining a city with more remote areas and characteristics which lack representation in the literature. The developed agent-based model, supported by interviews and questionnaires, produces specific, relevant recommendations for local regulators and policymakers, showing that adding fast-charging stations in remote areas can support leisure use, and workplace charging can reduce peak demand. The methodology proposed in this work can serve as a baseline for other communities looking to make impactful policy and regulatory decisions regarding their EV transition.

1 Introduction

With the push to decarbonise energy generation, transport has become the highest-emitting sector globally, now accounting for almost a quarter of carbon dioxide emissions and contributing significantly to air pollution [2]. As a result, more focus is now being placed on the decarbonisation of the transport sector, and hence the electric vehicle (EV) market has grown substantially in the last decade [3]. However, there are still many barriers to widespread electric vehicle adoption [7, 4]; even in the presence of available charging infrastructure, it has been shown that EV uptake was lower than expected from a lack of consumer willingness to accept disruptions in their daily routines for charging purposes [1].

Fast-charging, while a ubiquitous solution to improve usability of EVs, has a limited business case arising from high capital and operational costs. Additionally, uncertainty regarding negative grid impacts have stifled widespread expansion of such infrastructure. An important issue for many communities attempting to transition to electric mobility is the lack of case studies focused on areas that are not highly-populated and urbanised. Such a limited scope is reasonable when considering the priority to decarbonise high-density communities producing significant carbon emissions; nevertheless, an understanding of the

* Supported by Imperial College London and the Alaska Center for Energy and Power

impacts of unique lifestyles in atypical environments and climates is crucial to promoting an equitable transition to electrification.

In response, this study aims to understand the systemic challenges with transport electrification and expansion of public fast-charging infrastructure as perceived by the stakeholders within a unique EV system. Furthermore, it offers specific, relevant guidelines and recommendations through the implementation of an agent-based model that focuses on individual driving and charging behaviours of residents for a variety of activity types. The model focuses on a case study of the Municipality of Anchorage (MoA) in Alaska. Anchorage is Alaska's largest city with a population of nearly 300k and it is currently rapidly gaining interest in transport electrification, but has many barriers to overcome for EVs to become mainstream. The remote setting as well as the local climate make this an interesting case study.

2 Methodology

To understand the barriers to charging infrastructure expansion in Alaska, a three-pronged approach was chosen which seeks to understand the problem from multiple perspectives and viewpoints. The methodology consists of stakeholder interviews, a survey of drivers in MoA, and an agent-based model to evaluate different interventions.

Firstly, stakeholder interviews were conducted to identify commonalities and differences in opinion between the major players in the Alaskan EV infrastructure landscape regarding public charging infrastructure and the promotion of electric mobility. Interviews were procured with a private charging station installer, a utility representative, a state energy agency representative, an elected state representative, and three local researchers. The viewpoints presented in the interviews influenced scenarios modelled.

Secondly, a survey of MoA drivers, in the form of an online questionnaire, was developed (based on [6]) with the main goals of understanding driving behaviour and charging preferences, to potentially use as input into the agent-based model and as a reference for future policy-making decisions.

Finally, an agent-based model (Fig. 1) of the Municipality of Anchorage and its drivers (based on the driver survey) was developed in NetLogo building on a previous application in Swindon, UK [5] adding fast charging, impact of external temperatures, and behaviour linked to EV use in remote locations. The goal of the model is to determine the EV load of drivers in the MoA and the utilisation of the public charging network based on the travel behaviour of electric vehicle drivers for a typical weekday and weekend using the current and potential future EV fleet, following the scenarios from the stakeholder interviews.

3 Results and Discussion

The model was ran for the year 2021 and 2025. The results of the model indicate that weekday travel needs in the MoA are met primarily without the aid of public

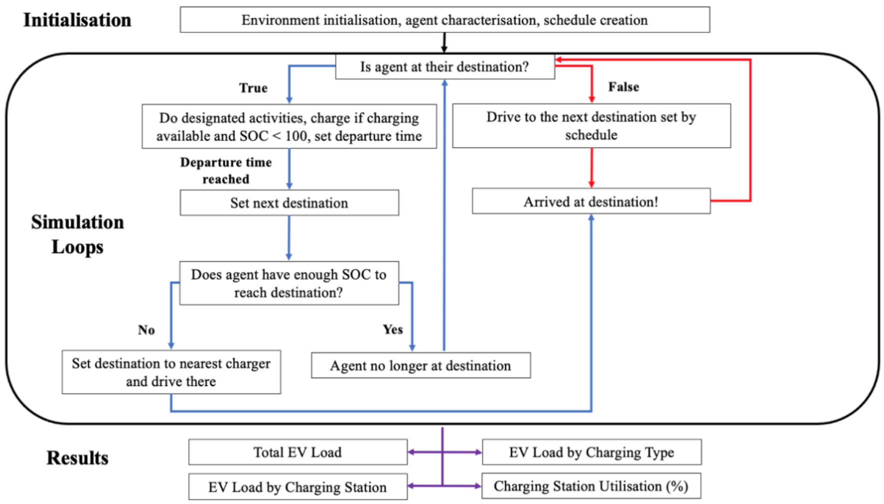

Fig. 1. Overview of the agent-based model of EV drivers.

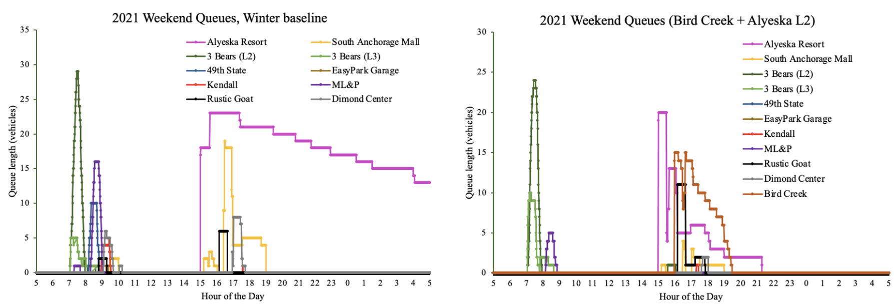

Fig. 2. Improvements to charging network lead to queue reduction.

charging infrastructure, with 86% of charging occurring at home during the weekday in 2021. On the other hand, the existing public infrastructure is limited in its capacity to handle weekend recreational travel, with clear limitations on the charging options available to drivers. The limited infrastructure located south of the MoA produced long queues for charging, which left some agents who travelled away from the city unable to make it home by the end of the simulation (Fig. 2).

Improvements in this area of the network were proposed through an additional fast-charging station and a supplementary charging port at the most congested station (Alyeska Resort, 40 miles out of Anchorage), which significantly reduced queuing and improved the feasibility of recreational EV use. These improvements even had success with higher penetration of EVs, seeing less queuing with the 2025 EV fleet than what was observed with the unimproved 2021 baseline infrastructure. Additionally, it was shown that the addition of workplace

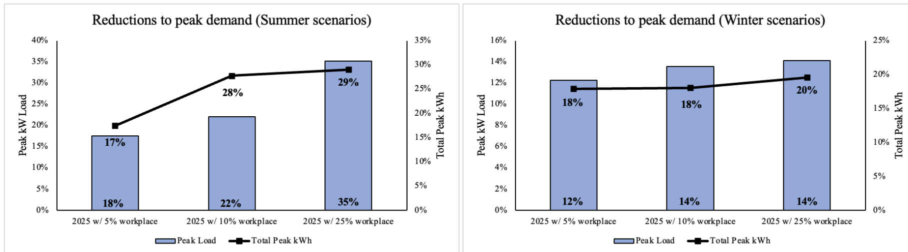

Fig. 3. Reduction in peak load and peak kWh consumed.

charging infrastructure has the potential to reduce negative grid impacts of increased EV penetration in 2025 (Fig. 3). With a 25% penetration of workplace charging, summertime peak demand and peak energy consumption were reduced by 35% and 29% compared to the baseline, respectively. On the other hand, increasing workplace charging past 5% did not produce consistent improvements in the winter, with reductions to peak demand and total peak energy consumption stagnating at approximately 14% and 20% from the baseline, respectively.

4 Conclusion

From the results of the case study we can conclude that existing infrastructure does not support weekend recreational travel, but simple improvements to the public charging network can significantly improve its feasibility within MoA. Moreover, environmental conditions are an important consideration for driver behaviour and charging network utilisation. Simple mitigation strategies for EV grid impacts are less effective in the winter and alternative methods must be considered to reduce peak demand with higher EV penetration.

The methodology proposed in this study can be applied broadly to case studies concerning EV impacts and utilisation of public charging infrastructure. Through the three-phase approach, the analysis produced can serve as a baseline to make specific, impactful policy and regulatory change through an understanding of local stakeholder needs and a foundation of end user requirements and preferences. The use of qualitative results from stakeholder interviews and the model initialisation based on driver surveys meant that the model could be used to explore relevant scenarios and provide input in the decision-making process, while also gaining trust in the model output from their involvement.

Future work on this agent-based model can more accurately assess EV impacts on the grid system by integrating network data into the model, such as feeder limits and substation capacity. Moreover, A simulation which considers all major travel destinations will have a better view of the limitations of the planned charging network, with important implications for charger roll-out. Finally, the model can be applied to other geographies to compare recommendations for less-densely populated areas in cold climates.

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