Assessment of Intended Electric Vehicle Usage and Travel Behaviour during Wildfire Evacuations

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ABSTRACT

The rise in the adoption of electric vehicles (EVs) presents a unique challenge for disaster planning. Their reliance upon the grid for fuel requires capable and resilient electricity infrastructure to withstand the surge in demand during evacuation scenarios. This grid resilience is crucial for safe and resilient evacuations by those living in areas highly vulnerable to wildfires. On the other hand, EVs present a novel opportunity to act as power sources that fulfill the electricity needs of communities that would otherwise lose power. Underpinning both challenges and opportunities is how EV drivers will behave, especially related to charging. However, research on this behaviour in the context of disasters remains sparse.

To address the behavioural gap, this study developed a series of discrete choice models to understand the factors that impact EV charging behaviour in a future wildfire. Through a non-probability panel from the Canadian provinces of Alberta and British Columbia of people living in high/medium fire risk, we distributed a survey (n=1371) to collect intended choices for a nearby wildfire, assuming a 400 km range EV. Results indicate diverse EV charging patterns, both spatially and temporarily, which could limit some peaks in electricity demand and congestion. Across all models, we found that EV ownership, a preference to reduce risk to property and family, intended evacuation choices, and past hazard experience influenced charging behaviour. Results indicate that targeted improvements in grid capacity and charging stations may be sufficient to meet future demand from EV drivers in evacuations.

Keywords: Electric Vehicles; Discrete Choice Modeling; User Behavior; Wildfires; Evacuation

1. INTRODUCTION

The rapid rise in EV adoption has revealed many challenges faced by this new technology, including how EV drivers might react and behave in disaster scenarios. Hazards, some amplified in frequency and intensity due to climate change, continue to require large-scale evacuations. In the North American context, wildfires have become increasingly dangerous and disruptive. From 1980 to 2021, over 1,300 evacuation events have taken place in Canada, requiring the evacuation of 500,000 people (Christianson et al., 2024). This includes the 2016 Horse River wildfire, the largest wildfire evacuation in Canadian history, which displaced about 90,000 people in Fort McMurray, Alberta (Christianson et al., 2024). In the United States, wildfires have severely impacted multiple states and regions, especially in California where nearly 1.2 million people were ordered to evacuate from wildfires between 2017 and 2019 (Wong et al., 2020).

Together, these high-impact events highlight the critical need for research on the resilience of EVs and their use in disaster scenarios. While the use of electricity as fuel presents its own challenges, most disaster planning does not consider EV needs in extreme event evacuation procedures (Donaldson et al., 2020). Yet, EVs can also serve as invaluable sources of power during emergencies (Yang et al., 2020) by providing power back to the grid or key resources (e.g., electronics, medical devices). The challenges and benefits of these vehicles rely on their use by drivers and evacuees. As a new and emerging technology, not much is known about how users interact with these vehicles and what behaviours they may exhibit within an emergency context. While some research has assessed the grid impact of EVs in disasters (Donaldson et al., 2020, 2022), specific user behaviour was not collected. Other research on the use of EVs as supplementary power sources in post-disaster recovery methods has focused more on supply (Liu et al., 2023; Wu et al., 2022).

Consequently, this paper aims to close this research gap by answering the following research questions:

1) What are potential EV-enabled actions that users will engage in during a wildfire, using western Canada as a case study?
2) What factors influence the evacuation choices of current, future, and non-EV users in disaster scenarios?

To answer these questions, we distributed an online survey to residents living in high/medium fire-risk areas in Alberta and British Columbia. Using hypothetical scenarios where respondents would have access to a 400 km EV, we develop several discrete choice models focusing on EV charging. Scenarios included: 1) initial charging actions before evacuating (with and without sufficient range); 2) en-route charging actions during the evacuation; and 3) travel time to/from a charging station.

2. LITERATURE REVIEW

In this section, we will briefly discuss EVs in disasters and evacuations and recent modelling efforts to understand behaviour in wildfire evacuations.

2.1 EVs in Disasters and Evacuations

The adoption of EVs has been rising due to technological advancements, cost reductions, and a need to decarbonize transportation. From 2009 to 2019, the price of lithium-ion batteries dropped by more than 80% (Muratori et al., 2021). Forecasts estimate global demand for vehicles to increase by over 30% by 2030, and for EVs to account for 13.3% of the market (Jones et al., 2020). Despite a dip due to the COVID-19 pandemic, EV sales in many regions are returning to pre-pandemic forecasts (Wen et al., 2021). One consequence of this rise in EV adoption and sales is that EVs and their drivers will now interact more often with emergencies and hazards, such as through evacuations. In addition, disasters can lead to power outages, potentially preventing EV owners from evacuating hazardous areas or leaving them without transportation for extended periods after the outage. Currently, the shorter range of most EVs compared to gasoline vehicles combined with longer charging times amplifies the criticality of charging stations along evacuation routes. If the reliable supply of electricity is interrupted, the usability of EVs can be compromised (Adderly et al., 2018). Consequently, most research on EVs in disasters focuses on two main areas: the impact of EV evacuations on the electric grid, and the use of EVs as auxiliary power sources. Research on the grid impacts of EVs is more limited and focuses on the effects of these vehicles on the grid while exploring solutions through technological innovations (Hussain & Musilek, 2022), temporary or permanent infrastructure (MacDonald et al., 2021; Rahimi & Davoudi, 2018), and policy and planning (Johnson et al., 2022; Purba et al., 2022). In comparison, the use of EVs as supplementary power sources has received more attention. Research has studied EVs dispatched to or prepositioned at critical sites to restore power (Erenoglu et al., 2022; Q. Li et al., 2021; H. Liu et al., 2023), and the use of vehicle-to-grid (V2G) technology to return power to the grid (Hasan et al., 2021; Momen et al., 2020; Wu et al., 2022).

Several recent studies have researched EVs in evacuation with significant depth. For example, Purba et al. (2022) developed a framework for evacuation route planning tailored to alternative fuel vehicles (AFVs) under emergency conditions using minimum spanning trees and hop constraints. Applied to the Sioux Falls and South Florida transportation networks, the framework evaluated optimal evacuation routes under various driving ranges and refuelling station placements. Findings indicated that denser and strategically sited refuelling infrastructure significantly enhanced evacuation performance, highlighting the importance of AFV driving range in emergency planning.

Donaldson et al. (2020) investigated the impact of EV evacuation on the resilience of power systems during wildfires using the 2019 IEEE Reliability Test System Grid Modernization Laboratory Consortium (RTS-GMLC) model overlaid with realistic wildfire hazard zones obtained from the California Public Utilities Commission. Key findings indicated that when generation exceeded load, system resilience improved during a wildfire, even with EV evacuation considered. Conversely, when generation was less than load, resilience was notably worsened with additional EV charging demands. Results indicated that increased EV penetration can exponentially worsen resilience indices, with EV evacuation contributing up to an 11% increase in loss of load probability. With many researchers pressing for the inclusion of EVs in modern evacuation planning (Johnson et al., 2022; Purba et al., 2022), the value of understanding key differences between EV and non-EV user behaviour will be critical. Finally, in a systematic review of literature in the field, Babaei & Wong (2024) found that EV driver behaviour is highly understudied with a need for assessment in both stated and revealed circumstances.

2.2 Behavior in Wildfire Evacuations

Research on wildfire evacuation behaviour reveals complex decision-making processes and regional differences. Behavioural work during wildfires encompasses areas such as evacuation decisions, departure times, and choices about shelter, mode of transportation, route, and destination. Recent research has demonstrated that prompt evacuation decisions are significantly influenced by mandatory evacuation orders as seen in both hypothetical and actual wildfire evacuations (Lovreglio et al., 2014; McCaffrey et al., 2018; Wong et al., 2023). Other variables, such as heightened risk perceptions and a variety of demographic characteristics have been shown to impact decision-making for wildfire evacuations (Kuligowski, 2021; McLennan et al., 2019; Wong et al., 2023). Additionally, studies have found that some residents prefer to stay and defend their properties, introducing unique dynamics in behaviour during emergencies (Stasiewicz & Paveglio, 2021).

Beyond these results, studies show that individuals often delay evacuation by undertaking various actions before leaving, with priorities varying across cultures (Vaiciulyte et al., 2021). Latent class choice models have revealed varied responses to mandatory evacuation orders, with some people more reluctant to evacuate than others (Wong et al., 2023). Brachman et al. (2019) found that contrary to assumptions, only 31% of evacuees take the shortest route to the nearest exit, with factors such as downhill slope and exit elevation influencing route choices. Delayed evacuations are also sometimes common, often due to insufficient warning information or desires to protect property (McLennan et al., 2019). Most recently, Cova et al. (2024) used GPS data to analyze evacuee destinations, uncovering a surprising diversity of locations and differences among subgroups based on warning and departure contexts. Further reviews of evacuation behaviour in wildfires can be found in Kuligowski (2021), Elhami-Khorasani et al. (2023), and Ma & Lee (2024).

Currently, key gaps in understanding and analyzing behaviour remain prevalent, which can limit the effectiveness of evacuation planning, communication strategies, and infrastructure improvements for disasters. Importantly, the inclusion of EVs and choice-making surrounding charging actions inserts another choice dimension into the complex evacuation process. Studies have yet to explore this dimension separately or jointly with other transportation choices.

2.3 Research Gaps

While studies such as MacDonald et al. (2021) explore the capacity of EV charging networks during short-notice evacuations, the behavioural aspect of EV charging demand is rarely considered. Similarly, Purba et al. (2022) primarily focused on the mathematical and algorithmic aspects of evacuation planning, while incorporating behaviour in a limited capacity in the form of refuelling needs and routing feasibility. Beyond these studies, research has focused more attention on grid resilience related to EVs (Cao et al., 2023; Donaldson et al., 2020; Hussain & Musilek, 2022; Yamagata & Seya, 2013), rather than on user behaviour. Importantly, existing research on behaviour has been generally limited to incentivization programs (Hussain & Musilek, 2022; Rahimi & Davoudi, 2018). To close these gaps, our study focuses on key charging decisions of EV drivers before and during wildfire evacuations. Descriptive statistics and modelling results provide a first step in understanding the possible demand of electricity, charging needs, and evacuation timing with EVs, though more research will also be needed.

3. METHODOLOGY

3.1 Survey Design

A stated preference survey was designed and distributed among high/medium fire-risk residents of Alberta and British Columbia using a panel via Qualtrics. A non-probability sampling technique was used to ensure that residents met basic study criteria, though general population quotas were considered by Qualtrics during the data collection process. Fire risk was self-reported by the respondent. Distributed between May to July 2023, the online survey contained 85 questions divided into 13 sections that collected responses on risk perception, future evacuation choices, hazard experience, resource sharing, resilience hubs and EV actions, trust and compassion, and demographic information. The survey was part of a broader study and only EV actions and their relevant independent variables were considered for this study. Figure 1 presents an example of one of the EV-based questions, and the exact phrasing of the other EV-based questions is provided in the results section. Data cleaning accounted for unfinished surveys, ineligible participants (based on geography), and unreasonably fast responses (completed within 3 minutes). 1371 responses were retained for further use for descriptive statistics and modelling.

In the EV section of the survey, participants were presented with a series of scenarios to assess their charging behaviors and decision-making during a simulated wildfire evacuation. The scenarios provided specific contexts and multiple-choice options to capture their preferences and priorities in emergency conditions. In Scenario 1 (S1), participants were asked to assume the following context:

"Consider a situation where a wildfire is burning a few kilometers from your residence. The current temperature is high, with strong winds, and low humidity. You have access to an electric vehicle with 400 kilometers of battery range. Assuming your vehicle currently has enough charge to reach your potential evacuation destination, what is your initial charging action prior to evacuating?"

The response options were:

1. Charge your vehicle at home to full battery
2. Travel to the closest charging station to charge your vehicle
3. Travel to a charging station that you expect will take the least amount of time to charge your vehicle
4. Not charge at all
5. Other (please specify)

In Scenario 2 (S2), participants were asked to consider the same context but with a crucial variation of charge sufficiency:
"Assuming your 400 km vehicle currently does not have enough charge to reach your potential evacuation destination, what is your initial charging action prior to evacuating?"

The response options were:

1. Charge your vehicle at home to full battery
2. Charge your vehicle at home to sufficient battery for the evacuation trip
3. Travel to the closest charging station to charge your vehicle
4. Travel to a charging station that you expect will take the least amount of time to charge your vehicle
5. Not charge at all
6. Other (please specify)

In Scenario 3 (S3), participants were asked about their willingness to invest time in traveling to and charging at a local charging station within the context of a wildfire:
"In this wildfire situation, how much time are you willing to spend traveling to/from and charging your 400 km vehicle at a local charging station?"

The response options were:

1. Less than 15 minutes
2. 16–30 minutes
3. 31–45 minutes
4. 45–60 minutes
5. More than 1 hour
6. I would only charge at home
7. I would not charge at all

In Scenario 4 (S4), participants were asked about their charging strategies while evacuating to their destination (along the route):
"Which of the following actions are you most likely to conduct while evacuating from a wildfire with a 400 km electric vehicle (en route to your destination)?"

The response options were:

1. Charge at the first possible location
2. Charge en route somewhere else along the way
3. Arrive at the evacuation destination as soon as possible without charging
4. Charge en route more than once

The division of alternatives in the first two scenarios (S1 and S2) provide valuable insight into charging behaviors based on the sufficiency of charge. Options were the same between the scenario with the exception that respondents could charge to a sufficient level for S2. The alternatives of the third scenario (S3) offer the advantage of more precise time brackets, particularly within the first hour, allowing for detailed insights into user behaviors in 15-minute intervals. This is useful for understanding short-term decision-making under time constraints. However, a limitation is that participants, especially those who do not currently own EVs, may find it difficult to accurately estimate how much time they would be willing to spend traveling to a charging station during an emergency. Last, the options in the final scenario (S4) provide insights on enroute charging, which can help identify potential congestion and queuing near and beyond the evacuation zone. However, the question does not specify where charging would occur for those who choose alternatives to the first charging station, limiting the ability to predict specific charging demand for stations beyond the initial location.

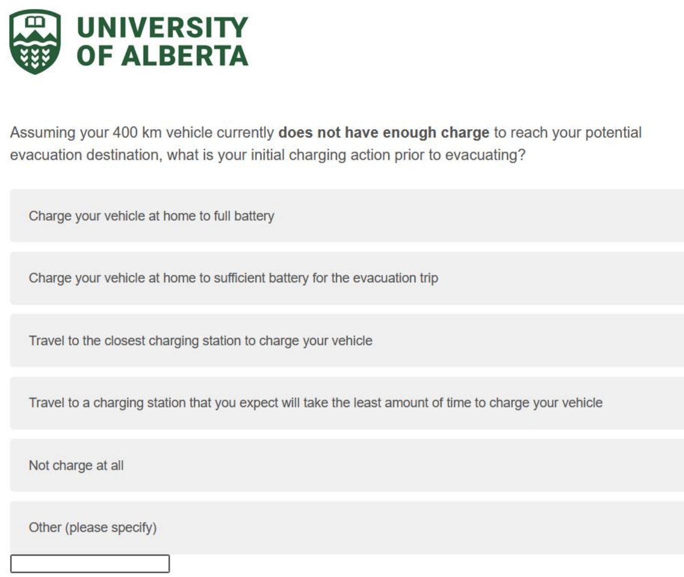

Figure 1. Screenshot of Survey Design for Stated Charging Action in an Evacuation Scenario

3.2 Discrete Choice Modeling

Discrete choice models were developed using the Python programming language and the Biogeme package (Bierlaire, 2020). Initially, simple multinomial logit models were chosen given the construction of the questions and the complexity of the scenarios. The models were based a random utility function, which has been outlined below.

$$U_i = \sum_{j=1}^{n} \beta_j \cdot x_j$$

Where:

U_i = Utility function for alternative i
β_j = Coefficient corresponding to attribute j
x_j = Attribute (independent variable)

For each question, at least one category was excluded from the modeling process to ensure a correct specification, though multiple alternatives were sometimes excluded based on statistical significance.

Independent variables were checked for correlation, and variables were removed intuitively to ensure no pair had a correlation coefficient higher than 0.3. Since ten usable variables were related to hazard experience, a latent variable was constructed via confirmatory factor analysis. This variable attempted to summarize and conceptualize hazard experience as a single variable, and it was checked for better explanatory power and fit. A latent variable was hypothesized since an individual's hazards experiences are likely to form a holistic perception and worldview. Conceptually, this construction would be intuitive for evacuation behaviours and would better determine the weights of different experiences.

The model results were checked to ensure the independent variables were statistically significant. The threshold for this significance was set at 95% as is the standard for statistical significance in transportation modeling. With more than 1,000 responses in the dataset (n=1371), the tests required a minimum t-statistic value of 1.96 and a maximum p-value of 0.05. Furthermore, the results were assessed for intuitive validity. This included checking to ensure the directionality of the coefficients aligned with intuitive expectations and the directionality revealed through a cross-tabulation analysis. Non-relevant attributes were iteratively removed based on significance and relevance until all resulting variables met the significance criteria.

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

Demographically (n=1371), 54.3% of survey takers were 18-35 years of age. 51.4% identified as woman while 47.3% identified as man. 46.2% of respondents lived in Alberta and 52.8% lived in British Columbia. 71.7% of the sample population identified as white. Within households, 95.6% had less than five people, 55.7% had children, and 23.4% had at least one person with a disability. Furthermore, 29.1% of respondents had a four-year degree and 68.3% were employed full-time. More than one third of respondents stated that they owned or leased an EV (37.3%). This aligns with the oversampling of high-income individuals in this survey, where 63.7% of survey takers disclosed $70,000 CAD or more in annual income. Table A1 in the Appendix provides a breakdown of the demographic characteristics, along with a comparison to the Canadian Census. Despite some instances of under and oversampling — due to non-probability sampling and the geographic location of people living high/medium fire risk places — characteristics are generally representative of Alberta and British Columbia.

Table 1 displays the EV-based questions from the survey and associated descriptive statistics. Four of these scenarios were used as dependent variables within the model, labelled in this paper as: S1, S2, S3, and S4. In all scenarios, respondents who answered "Other" were removed from the dataset for modelling purposes, as their responses could not be determined. These tended to make up a very small proportion of responses.

4.1.1 Charging Action Prior to Evacuation

Scenario 1 asked participants for their initial charging actions prior to evacuation in a scenario where they had sufficient charge to reach their evacuation destination (see Table 1). A plurality of respondents (41.0%) chose to charge their vehicle at home to full charge. S2 presented an identical scenario except that charge would not be sufficient to reach their evacuation destination. The percentage of participants choosing to charge at home rose to 58.3% (31.3% to full capacity and 27.0% sufficiently to perform the evacuation). The share of those choosing to travel to the closest charging station was generally consistent (25.2% in S1 and 24.2% in S2). Fewer respondents chose to travel to the least time-consuming station (17.8% in S1 and 12.0% in S2). Not charging one's vehicle fell from 14.7% of responses in S1 to 4.5% in S2. The high percentage of those charging at home in both scenarios indicates a strong preference (and expectation) for charging that can be completed quickly and conveniently. In addition, from S1 to S2, charging at home became more popular while all other alternatives saw a decrease in response share. Grid managers should expect significant demand in residential areas. Concurrently, a higher number of evacuees would go to a charging station, which could produce significant congestion on roadways. Wait times might also be long due to this demand.

4.1.2 Time Spent Traveling to Charge

S3 asked participants about the amount of time they would be willing to travel to and from a charging station (Table 1). The options of not charging and charging at home were also provided to respondents. The results of S3 revealed that 17.2% of respondents would not be willing to spend more than 15 minutes travelling to and from charging stations in a wildfire situation, while almost half of respondents (49.2%) would not be willing to spend more than 30 minutes for the same purpose. About 12% would only charge at home, and 3.8% would not charge at all. These results highlight the need for planning and policy that address the evacuation concerns of EV users while minimizing required travel time to no more than 30 minutes. Coupled with wait times, long travel times could significantly increase evacuation time estimates.

4.1.3 Charging While Evacuating

S4 asked respondents about their intended actions while evacuating (i.e., en route to their destination). Each option also branched to identify a possible reason *why* they made that decision (Table 1). The responses to S4 reveal that during the evacuation, most participants would prefer to charge their vehicle once, with just about 10% opting to charge multiple times. These evacuees might have far intended destinations. 41.6% of respondents would prefer charging at the first possible location, while 34.6% would prefer to charge at a station somewhere else along the route. Just 13.7% of respondents would try to get to their destination without charging. The results indicate the likelihood of significant demand for charging at all stations along an evacuation route.

S4.1 through S4.4 correspond to each of the choices in S4 respectively. Participants were presented with one of these four questions based on their response to S4 to clarify their reasoning (select all that apply). The results of the first three charging scenarios revealed that insufficient range to reach one's destination was a common reason for their actions, ranging from 44% for charging at the first station to 35% for charging once en route to 27% for charging multiple times. Range anxiety was also a commonly chosen reason (28%-32%) along with wanting to rest or get other services (31%-41% depending on the scenario). 31-52% of participants wanted to avoid reaching their destination with little charge, perhaps because their destination might not have charging capabilities. For the last scenario of not charging at all during the evacuation, 62% said they would have enough charge and 78% said they wanted to escape immediate danger as soon as possible. It is not immediately clear why just 62% said they had enough charge, though some respondents may have chosen the options to impact their decision the most.

Table 1. *Descriptive Statistics of EV-Based Questions*

Q11.7 Which of the following best describes you? *(n=1371)*	**%**
I am interested in owning/leasing an electric vehicle within the next 3 years	37.3%
I own/lease an electric vehicle	32.5%
I am not interested in owning/leasing an electric vehicle in the foreseeable future	30.2%
Consider a situation where a wildfire is burning a few kilometers from your residence. The current temperature is high, with strong winds, and low humidity. You have access to an electric vehicle with 400 kilometers of battery range	

S1 Assuming your vehicle currently has enough charge to reach your potential evacuation destination, what is your initial charging action prior to evacuating? *(n=1371)*	**%**
Charge your vehicle at home to full battery	41.0%
Travel to the closest charging station to charge your vehicle	25.2%
Travel to a charging station that you expect will take the least amount of time to charge your vehicle	17.8%
Not charge at all	14.7%
Other (please specify)	1.4%

S2 Assuming your 400 km vehicle currently does not have enough charge to reach your potential evacuation destination, what is your initial charging action prior to evacuating? *(n=1371)*	**%**
Charge your vehicle at home to full battery	31.3%
Charge your vehicle at home to sufficient battery for the evacuation trip	27.0%
Travel to the closest charging station to charge your vehicle	24.2%
Travel to a charging station that you expect will take the least amount of time to charge your vehicle	12.0%
Not charge at all	4.3%
Other (please specify)	1.2%

S3 In this wildfire situation, how much time are you willing to spend traveling to/from and charging your 400 km vehicle at a local charging station? *(n=1371)*	**%**
Less than 15 minutes	17.2%
16-30 minutes	32.0%
31-45 minutes	17.7%
45-60 minutes	9.7%
More than 1 hour	8.0%
I would only charge at home	11.6%
I would not charge at all	3.8%

S4 Which of the following actions are you most likely to conduct while evacuating from a wildfire with a 400 km electric vehicle (en route to your destination)? *(n=1371)*	**%**
Charge at the first possible location	41.6%
Charge en route somewhere else along the way	34.6%
Arrive at the evacuation destination as soon as possible without charging	13.7%
Charge en route more than once	10.1%

↳ **S4.1 Why would you charge at the first possible location? (select all that apply)** *(n=570)*	**%**
Insufficient charge to reach my destination (assuming 400km of max range on vehicle)	44.2%
Avoid arriving at my evacuation destination with little charge	39.3%
Rest or get other services (e.g., food/water/restrooms)	30.7%
Anxious about range	30.4%
Avoid busy or out-of-service charging stations further along	18.8%
Other (please specify)	0.2%

↳ **S4.2 Why would you charge once en route to your destination? (select all that apply)** *(n=474)*	**%**
Insufficient charge to reach my destination (assuming 400km of max range on vehicle)	35.2%

Avoid arriving at my evacuation destination with little charge	52.3%
Rest or get other services (e.g., food/water/restrooms)	40.7%
Anxious about range	27.8%
Avoid busy or out-of-service charging stations further along	19.2%
Other (please specify)	0.2%
↳ **S4.3 Why would you charge more than once en route to your destination? (select all that apply)** *(n=188)*	**%**
Insufficient charge to reach my destination (assuming 400km of max range on vehicle)	26.6%
Avoid arriving at my evacuation destination with little charge	30.9%
Rest or get other services (e.g., food/water/restrooms)	32.4%
Anxious about range	32.4%
Reach my evacuation destination with the most possible charge	22.3%
Other (please specify)	2.1%
↳ **S4.4 Why would you arrive at your destination as soon as possible without charging? (select all that apply)** *(n=139)*	**%**
Will have enough charge	61.9%
Escape immediate danger as soon as possible	78.4%
Avoid waiting at charging stations	28.1%
Urgent need to get to a destination	48.2%
Other (please specify)	2.2%

4.2 Confirmatory Factor Analysis

Two latent variables were chosen for testing based on the relative impact of the experiences: "Major Hazard Experience" and "Minor Hazard Experience." The former included being personally affected by wildfires, experiencing wildfire-related injury, property damage caused by wildfires, evacuation due to wildfires, job disruptions attributed to wildfires, and employment in wildfire-related fields. The latter included experience with discomfort from wildfire smoke, observing wildfire flames, attending public meetings about wildfires, and engaging in learning activities related to wildfires. This bifurcation helped group hazard experiences that were more similar. The resulting weights for each variable are displayed in Table 2.

The KMO (Kaiser-Meyer-Olkin) test was performed on both groupings. The major hazard experience grouping returned a score of 0.644 while the minor hazard grouping yielded a score of 0.532. According to the KMO guidelines (Kaiser and Rice, 1974), these values fall within the range of "mediocre" and "miserable" respectively. These results reveal that factor analysis was not able to adequately capture the variance of minor experiences. As a result, only major hazard experience was included in the modelling. It should be noted due to the lower fit of the latent variable, results and related discussion focus on the simpler model without the latent variable.

Table 2. *Resulting weights and KMO scores of variables combined using confirmatory factor analysis*

Variable	Weight
Major Hazard Experience	**KMO=0.644**
Previously Affected by Wildfires	0.363
Has Experienced Injury from Wildfires	0.363
Has Experienced Property Damage from Wildfires	0.566

Previous Evacuee	0.380
Has Had Job Affected by Wildfire	0.237
Wildfire-Related Job	0.276
Minor Hazard Experience	**KMO = 0.532**
Has Experienced Discomfort from Wildfire Smoke	0.504
Has Seen Wildfire Flames	0.484
Has Attended a Public Meeting on Wildfires	0.128
Has Learned About Wildfires	0.164

4.3 Factors for Initial Charging Action with Sufficient EV Charge

For initial charging actions prior to a wildfire evacuation, the results in Table 3 show that EV ownership increases the likelihood of all charging actions, which may be based on past charging experience. Those seeking to reduce risk to personal property are more likely to charge at home or at the closest station, as they may perceive charging close to home as safer and more controllable during emergencies. Regularly checking maps during evacuations is positive and significant in the choice to charge at home and at the least time-consuming station. We find indications that having learned about wildfires negatively impacts the likelihood of charging vehicles at a charging station, while the experience of wildfires affecting a person's job or occupation positively influences those same choices.

Beyond these results, we find that those with no wildfire experience and those with a willingness to evacuate after witnessing neighbors evacuate are less likely to charge their vehicles at home. Other experiences (e.g., property damage and smoke) had mixed effects on charging at the closest station. Those who would evacuate after defending or receiving a mandatory evacuation order are less likely to charge at the closest station. These individuals likely prioritize completing the full evacuation with their existing charge. Low-income individuals and those who believe staying home greatly reduces the odds of losing their homes are less likely to travel to the least time-consuming charging stations. Conversely, those seeking to reduce risk to their families and who would evacuate after a reduction in exiting traffic congestion are more likely to do so.

Results from grouping the hazard experience variables returned the same significant variables with some minor additions. Those with major hazard experience were more likely to perform any form of charging. Also, those seeking to reduce risk to their families were less likely to charge at the closest charging station. The rho-square value of this model (0.13) was slightly lower than that of the original model (0.12).

Table 3. Modelling Results (Multinomial Logit) for Charging with Sufficient Range

Question: A wildfire is burning a few kilometers from your residence. You have access to an EV w/ 400 KM of range. Assuming your vehicle currently has enough charge to reach your potential evacuation destination, what is your initial charging action prior to evacuating?

Choice 1: Charge At Home
Choice 2: Charge At Closest Charging Station
Choice 3: Charge At Least Time-Consuming Charging Station
Choice 4: Not Charge - **Base**

	Model I: Distinct Hazard Experience Variables									**Model II: Major Hazard Experience as a Latent Variable**								
	Charge At Home			**Charge At Closest Charging Station**			**Charge At Least Time-Consuming Charging Station**			**Charge At Home**			**Charge At Closest Charging Station**			**Charge At Least Time-Consuming Charging Station**		
Variable	*Coeff.*	*p-value*		*Coeff.*	*p-value*		*Coeff.*	*p-value*		*Coeff.*	*p-value*		*Coeff.*	*p-value*		*Coeff.*	*p-value*	
Constant	0.15	0.520		0.21	0.404		-0.51	0.087		0.26	0.256		0.74	0.006	**	0.11	0.464	
<u>Latent Variables</u>																		
Hazard Experience	---	---		---	---		---	---		0.46	0.002	**	0.74	<0.001	**	0.57	0.001	**
<u>Electric Vehicles</u>																		
Own or Lease an EV	2.16	<0.001	**	1.78	<0.001	**	1.26	<0.001	**	1.96	<0.001	**	1.66	<0.001	**	1.15	0.001	**
<u>Hazard Experience</u>																		
Has Learned About Wildfires	---	---		-0.45	0.006	**	-0.76	<0.001	**	---	---		---	---		---	---	
Has Had Job Affected by Wildfires	---	---		0.51	0.002	**	0.50	0.007	**	---	---		---	---		---	---	
Not Previously Affected by Wildfires	-0.31	0.038	*	---	---		---	---		---	---		---	---		---	---	
Has Experienced Discomfort from Wildfire Smoke	---	---		-0.41	0.006	**	---	---		---	---		---	---		---	---	
Has Experienced Property Damage from Wildfires	---	---		0.45	0.006	**	---	---		---	---		---	---		---	---	

Evacuation Choices																		
Regularly Checks Maps for Navigation	0.43	0.001	**	---	---		0.42	0.010	*	0.44	<0.001	**	---	---		0.41	0.009	**
Will Evacuate After Neighbors Evacuate	-0.44	<0.001	**	---	---		---	---		-0.40	0.001	**	---	---		---	---	
Will Evacuate After Can't Do More to Defend Home	---	---		-0.48	0.002	*	---	---		---	---		-0.59	<0.001	**	---	---	
Will Evacuate After Receiving a Mandatory Order	---	---		-0.32	0.024	**	---	---		---	---		-0.38	0.006	**	---	---	
Will Evacuate After Witnessing Traffic Congestion Reduce	---	---		---	---		0.45	0.017	*	---	---		---	---		0.41	0.021	*
Risk Perception																		
Seek to Reduce Risk to Property	0.59	0.008	**	0.57	0.015	**	---	---		0.50	0.022	*	0.60	0.013	*	---	---	
Seek to Reduce Risk to Family (Very/Somewhat)	---	---		---	---		0.69	0.014	*	---	---		-0.55	0.005	**	---	---	
Staying Greatly Reduces Odds of Losing Home	---	---		---	---		-0.64	0.003	**	---	---		---	---		-0.68	0.002	**
Demographics																		
Low Income (<$50k)	---	---		---	---		-0.54	0.011	*	---	---		-0.03	0.876		-0.56	0.008	**
Income Prefer Not to Answer	---	---		-1.13	0.019	*	-0.15	0.656		---	---		-1.26	0.010	*	-0.24	0.491	
Number of Observations	1352									1352								
Rho-Square	0.13									0.12								
Adjusted Rho-Square	0.12									0.11								
Final Log-Likelihood	-1631.72									-1647.69								

* 95% Significance

** 99% Significance

4.4 Factors for Initial Charging Action Without Sufficient EV Charge

The results in Table 4 show initial charging actions for a scenario with insufficient charge. Similar to the previous scenario, EV ownership once again appears across all charging choices, indicating EV owners are more likely to charge than not. This, again, is likely due to familiarity with the charging process. People without direct wildfire experience are less likely to charge in any form. Those with prior experience of discomfort from wildfire smoke are more likely to charge at home fully or charge at a station. Participants who are confident in their ability to protect themselves are more likely to charge at home fully or charge at the closest charging station. These individuals may be more willing to accept higher proximity to an advancing fire in exchange for more certain charge.

Residents of single-family homes, those seeking to reduce risk to their property, and those believing that remaining at home reduces their risk of losing their home are more likely to charge at home to full capacity. These individuals might view charging at home as a safer and more secure option, especially if they prefer to defend their property. In contrast, those aged 18-35, those with more than five people in their household, and those willing to evacuate after witnessing neighbours evacuate are less likely to charge fully at home. These individuals may place a higher value on moving further away from the wildfire. Younger individuals and larger households may prioritize quick evacuations or are willing to take extra trips to go charge. Participants that believed staying increased their odds of harm and those willing to evacuate after receiving a mandatory order are both less likely to charge at the closest charging station as opposed to other options. Across other experiential categories, the results produced different effects, and clear patterns did not emerge.

The latent variable model had a similar fit as the original model, and a marginally improved log-likelihood. However, major hazard experience was not shown to be a significant variable in respondents' decision to charge. Furthermore, as seen in Table 4, variables such as evacuating after receiving a mandatory order, extreme high risk of wildfire damage to residence this season, and more than five people in a household were not significant in the second model, while new variables such as ages 18-35, older adults in household, worry about finding shelter, worry about damage to or theft of belongings, and mainly using highways to evacuate appeared significant. Since fit did not substantially improve, the simpler multinomial model was retained. However, it should be noted that the comparison shows how different model types and assumptions can lead to different significant variables.

Table 4. Modelling Results (Multinomial Logit) for Charging without Sufficient Range

Question: A wildfire is burning a few kilometers from your residence. You have access to an EV w/ 400 KM of range. Assuming your vehicle currently *does not have* enough charge to reach your potential evacuation destination, what is your initial charging action prior to evacuating?

Choice 1: Charge At Home Fully
Choice 2: Charge At Home Sufficiently
Choice 3: Charge At Closest Charging Station
Choice 4: Charge At Least Time Consuming Charging Station
Choice 5: Not Charge - **Base**

	Model I: Distinct Hazard Experience Variables								**Model II: Major Hazard Experience as a Latent Variable**							
	Charge At Home Fully		**Charge At Home Sufficiently**		**Charge At Closest Charging Station**		**Charge At Least Time-Consuming Charging Station**		**Charge At Home Fully**		**Charge At Home Sufficiently**		**Charge At Closest Charging Station**		**Charge At Least Time-Consuming Charging Station**	
Variable	*Coeff.*	*p-value*	*Coeff.*	*p-value*	*Coeff.*	*p-value*	*Coeff.*	*p-value*	*Coeff.*	*p-value*	*Coeff.*	*p-value*	*Coeff.*	*p-value*	*Coeff.*	*p-value*
Constant	1.29	<0.001	1.64	<0.001	2.04	<0.001	1.23	<0.001	1.42	<0.001	1.71	<0.001	1.94	<0.001	0.73	0.017
<u>Latent Variables</u>																
Hazard Experience	---	---	---	---	---	---	---	---	0.42	0.160	0.68	0.023	0.39	0.192	0.28	0.375
<u>Electric Vehicles</u>																
Own or Lease an EV	2.11	0.001	2.26	<0.001	2.11	0.001	1.94	0.002	2.02	0.001	2.01	0.001	1.79	0.004	1.75	0.006
<u>Hazard Experience</u>																
Has Had Job Affected by Wildfires	---	---	0.52	0.015	---	---	---	---	---	---	---	---	---	---	---	---
Affected by Zero Wildfires	-0.80	0.007	-1.02	0.001	-0.80	0.008	-0.81	0.016	---	---	---	---	---	---	---	---
Has Experienced Discomfort from Wildfire Smoke	0.52	0.001	---	---	0.41	0.015	0.58	0.004	---	---	---	---	---	---	---	---
Has Attended a Public Meeting on Wildfires	---	---	---	---	---	---	0.66	0.007	---	---	---	---	---	---	---	---

Has Experienced Injury from Wildfire	---	---	---	---	-0.87	0.001	-0.77	0.047	---	---	---	---	---	---	---	---
Evacuation Choices																
Regularly Checks Maps for Navigation	---	---	---	---	---	---	---	---	0.33	0.008	---	---	---	---	---	---
Mainly Evacuating Using Highways	---	---	---	---	---	---	---	---	0.37	0.008	---	---	---	---	0.47	0.010
Will Evacuate After Neighbors Evacuate	-0.400	0.001	---	---	---	---	---	---	-0.41	0.001	---	---	---	---	---	---
Will Evacuate After Can't Do More to Defend Home	---	---	---	---	-0.31	0.039	---	---	---	---	---	---	-0.40	0.007	---	---
Will Evacuate After Receiving a Mandatory Order	---	---	---	---	-0.35	0.013	---	---	---	---	---	---	---	---	---	---
Risk Perception																
Extreme High Risk of Wildfire Damaging Residence This Season	---	---	---	---	---	---	-0.43	0.021	---	---	---	---	---	---	---	---
Worried About Injury or Death	---	---	---	---	---	---	0.39	0.024	---	---	---	---	---	---	0.39	0.027
Worried Belongings will be Damaged or Stolen	---	---	---	---	---	---	---	---	---	---	-0.39	0.012	-0.31	0.041	-0.62	0.002
Worried About Self/Loved Ones Finding Shelter	---	---	---	---	---	---	---	---	-0.29	0.025	---	---	---	---	---	---
Seek to Reduce Risk to Property (Very/Somewhat)	0.45	0.044	---	---	---	---	---	---	0.57	0.010	---	---	---	---	---	---
Seek to Reduce Risk to Family (Very/Somewhat)	---	---	---	---	---	---	-0.66	0.006	---	---	---	---	---	---	-0.83	0.001
Staying Greatly Reduces Odds of Losing Home	0.48	0.010	0.38	0.037	---	---	---	---	0.50	0.001	---	---	---	---	---	---

Confident in Ability to Protect Self (Very/Somewhat)	0.71	0.003	---	---	0.60	0.023	---	---	0.72	0.003	---	---	0.59	0.023	---	---
Staying Increases Odds of Harm	---	---	---	---	-0.30	0.031	---	---	---	---	---	---	---	---	---	---
Demographics																
Age 18-35	-0.31	0.010	---	---	---	---	---	---	-0.39	0.002	---	---	---	---	---	---
Has Disability	---	---	---	---	---	---	---	---	0.34	0.030	---	---	---	---	0.44	0.030
More Than 5 People in Household	-0.94	0.013	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Older Adults in Household	---	---	---	---	---	---	---	---	-0.46	0.007	---	---	-0.51	0.004	---	---
Live in Single-Family Home	0.36	0.004	---	---	---	---	---	---	0.50	<0.001	---	---	---	---	---	---
Number of Observations	1355								1355							
Rho-Square	0.14								0.14							
Adjusted Rho-Square	0.12								0.13							
Final Log-Likelihood	-1876.62								-1865.86							

4.5 Factors for Time Spent Traveling for Charging

EV ownership appears across the results of all modelled choices in Table 5, and EV owners are more likely to perform any form of charging than not. Those who have visually seen fire are less likely to charge than travel or charge at home. At the same time, those who have not been affected by a wildfire directly are less likely to charge their EV. In both cases, participants may prefer faster evacuations due to their higher risk perceptions. People who would evacuate after receiving a mandatory order are more likely to charge at home or spend less than 30 minutes charging, likely due to a sense of urgency from the order. Low-income individuals (with an annual income below $50,000 CAD) and those who would evacuate after defending their homes are both less likely to spend any amount of time charging away from home. They instead prefer to charge at home or not charge. Conversely, those who would wait for reduced traffic congestion are more likely to charge away from home, no matter the charging time.

Results from the latent variable model show those with major hazard experience are more likely to charge, regardless of location or travel time. Those evacuating promptly during an evacuation, very or somewhat willing to take risks, and worried about finding shelter were less likely to charge at home. Women were less likely to travel more than 30 minutes for charging. This model had similar Rho-square values and log-likelihood compared with the initial model where hazard experience was disaggregated.

Table 5. Modelling Results (Multinomial Logit) for Travel Time to Charging

Question: How much time are you willing to spend traveling to/from charging in the event of a wildfire?

Choice 1: Charge At Home
Choice 2: Less Than 30 Minutes
Choice 3: More Than 30 Minutes
Choice 4: Not Charge - **Base**

	Model I: Distinct Hazard Experience Variables									**Model II: Major Hazard Experience as a Latent Variable**								
	Charge At Home			**Less Than 30 Minutes**			**More Than 30 Minutes**			**Charge At Home**			**Less Than 30 Minutes**			**More Than 30 Minutes**		
Variable	*Coeff.*	*p-value*		*Coeff.*	*p-value*		*Coeff.*	*p-value*		*Coeff.*	*p-value*		*Coeff.*	*p-value*		*Coeff.*	*p-value*	
Constant	1.20	0.001		2.68	<0.001		2.99	<0.001		1.39	<0.001	**	2.36	<0.001	**	2.56	<0.001	**
<u>Latent Variables</u>																		
Hazard Experience	---	---		---	---		---	---		0.70	0.049	*	0.69	0.040	*	0.74	0.028	*
<u>Electric Vehicles</u>																		
Own or Lease an EV	2.08	0.006	**	2.04	0.006	**	2.10	0.004	**	1.99	0.013	*	2.09	0.007	**	2.06	0.007	**
<u>Hazard Experience</u>																		
Affected by Zero Wildfires	-1.04	0.004	**	-0.74	0.017	*	-1.18	<0.001	**	---	---		---	---		---	---	
Has Seen Wildfire Flames	-0.69	0.040	*	-0.88	0.004	*	-0.93	0.003	**	---	---		---	---		---	---	
<u>Evacuation Choices</u>																		
Will Evacuate Promptly	---	---		---	---		---	---		-0.65	0.009	**	---	---		---	---	

Will Evacuate After Can't Do More to Defend Home	---	---		-0.41	0.020	*	-0.54	0.004	**	---	---		---	---				
Will Evacuate After Receiving a Mandatory Order	0.61	0.005	**	0.71	<0.001	**	---	---		0.65	0.003	**	0.67	<0.001	**	---	---	
Willing to Take Risks	-0.39	0.030	*	---	---		---	---		---	---		---	---		---	---	
Will Evacuate After Witnessing Traffic Congestion Reduce	---	---		0.81	0.002	**	1.02	<0.001	**	---	---		---	---		0.34	0.025	*
Risk Perception																		
Willing to Take Risks (Very/Somewhat)	---	---		---	---		---	---		-0.36	0.046	*	---	---		---	---	
Extreme High Risk of Wildfire Damaging Residence This Season	---	---		0.25	0.039	*	---	---		---	---		---	---		---	---	
Seek to Reduce Risk to Property (Very/Somewhat)	---	---		0.46	0.024	*	---	---		---	---		0.48	0.018	*	---	---	
Seek to Reduce Risk to Family (Very/Somewhat)	---	---		-0.65	0.001	**	---	---		---	---		-0.62	0.002	**	---	---	
Staying Greatly Reduces Odds of Losing Home	0.66	0.001	**	---	---		---	---		0.64	0.002	**	---	---		---	---	
Worried About Lack of First Responders During Evacuation	---	---		0.33	0.004	**	---	---		---	---		0.34	0.003	**	---	---	
Worried About Self/Loved Ones Finding Shelter	---	---		---	---		---	---		-0.41	0.023	*	---	---		---	---	
Demographics																		
Woman	---	---		---	---		---	---		---	---		---	---		-0.27	0.027	*
Own One Car	---	---		0.26	0.025	*	---	---		---	---		0.24	0.036	*	---	---	

Older Adults in Household	---	---		-0.43	0.003	**	---	---		---	---		-0.46	0.001	**	---	---	
Low Income (<$50k)	---	---		-0.77	0.015	*	-0.81	0.021	*	---	---		-0.58	0.003	**	-0.64	0.002	**
Income Prefer Not to Answer	---	---		-0.58	0.004	**	-0.63	0.003	**	---	---		-0.77	0.016	*	-0.77	0.030	*
Number of Observations	1371									1371								
Rho-Square	0.26									0.26								
Adjusted Rho-Square	0.25									0.25						* 95% Significance		
Final Log-Likelihood	-1402.00									-1405.45						** 99% Significance		

4.6 Factors for Charging While Evacuating

EV ownership increases the likelihood to charge at the first location or somewhere along the route. In this sense, EV owners would prefer to charge but only once. Those who have resided in their homes for more than ten years and those with an evacuation distance longer than 200 kilometres are both less likely to charge their vehicles once, irrespective of the charging station location. Those facing long evacuation distances may prioritize reaching their destination quickly *or* feel more comfortable charging multiple times. Alternatively, those with an evacuation distance shorter than 20 kilometres are more likely to not charge or charge at the first location, which follows prior expectations.

Those with high confidence in their ability to protect themselves, willingness to reduce risk to property, require less than 30 minutes to prepare for evacuation, and worry about needing to work during a wildfire are all more likely to charge at the first location. The shorter distance of these evacuees or the desire to stay nearby would likely prompt this choice. Previous evacuees and people with prior discomfort from wildfire smoke are less likely to charge at the first location.

Concern about the presence of first responders on an evacuation path, experience having a wildfire-related occupation, or experience with wildfires affecting one's job all increase the likelihood of charging somewhere other than the first station. This is the inverse of those who regularly check maps for navigation during evacuations and those who will evacuate once given a mandatory order. The results also found that sheltering with family, promptly evacuating one's residence in a wildfire, and belief that remaining increases the chances of saving one's home are all less likely to charge more than once. Overall, the results generally suggest some similarities between single charging options (anywhere on the route) and the importance of evacuation choices and risk perceptions.

The results of the latent variable model in Table 6. The fit and log-likelihood of this model was marginally lower than its non-aggregated counterpart. Major hazard experience was not found to be significant in influencing charging behavior during evacuations. Those evacuating after observing a reduction in traffic congestion were less likely to charge at the first location. Alternatively, those with residences at extreme or very high risk of damage from wildfires this season were more likely to charge at the first location. Those not making any trips before their evacuation were less likely to charge somewhere along the route or charge multiple times.

Table 6. Modelling Results (Multinomial Logit) for Charging While Evacuating

Question: Which of the following actions are you most likely to conduct while evacuating from a wildfire with a 400 km electric vehicle (en route to your destination)?

Choice 1: Charge At First Location
Choice 2: Charge Somewhere Else Along Route
Choice 3: Charge More Than Once
Choice 4: Not Charge - Base

	Model I: Distinct Hazard Experience Variables									**Model II: Major Hazard Experience as a Latent Variable**								
	Charge At First Location			**Charge Somewhere Else Along Route**			**Charge More Than Once**			**Charge At First Location**			**Charge Somewhere Else Along Route**			**Charge More Than Once**		
Variable	*Coeff.*	*p-value*		*Coeff.*	*p-value*		*Coeff.*	*p-value*		*Coeff.*	*p-value*		*Coeff.*	*p-value*		*Coeff.*	*p-value*	
Constant	1.52	<0.001	**	1.02	<0.001	**	2.04	<0.001	**	1.19	<0.001	**	0.81	0.003	**	2.28	<0.001	**
<u>Latent Variables</u>																		
Hazard Experience	---	---		---	---		---	---		0.03	0.858		0.26	0.068		-0.12	0.503	
<u>Electric Vehicles</u>																		
Own or Lease an EV	0.53	0.004	**	0.57	0.003	**	---	---		0.57	0.005	**	0.63	0.002	**	---	---	
<u>Hazard Experience</u>																		
Wildfire-Related Job	---	---		0.46	0.039	*	---	---		---	---		---	---		---	---	
Job Affected by Wildfires	---	---		0.32	0.027	*	---	---		---	---		---	---		---	---	
Previous Evacuee	-0.32	0.019	*	---	---		---	---		---	---		---	---		---	---	
Experienced Discomfort from Wildfire Smoke	-0.43	0.001	**	---	---		-0.44	0.028	*	---	---		---	---		---	---	
<u>Evacuation Choices</u>																		

Evacuation Distance Greater Than 200 Kilometers	-0.37	0.028	*	-0.46	0.009	**	---	---		-0.44	0.010	*	-0.49	0.006	**	---	---	
Evacuation Distance Less Than 20 Kilometers	---	---		-0.39	0.029	*	-0.58	0.05	*	---	---		-0.43	0.015	*	-0.61	0.037	*
Will Not Make Any Trips Before Evacuating	---	---		---	---		---	---		---	---		-0.77	0.042	*	-2.10	0.044	*
Will Need Less Than 30 Mins to Prepare for Evacuation	0.40	0.001	**	---	---		---	---		0.41	0.001	**	---	---		---	---	
Regularly Checks Maps for Navigation	---	---		-0.30	0.015	*	---	---		---	---		-0.30	0.016	*	---	---	
Will Promptly Evacuate Residence During Wildfire	---	---		---	---		-0.89	0.001	**	---	---		---	---		-0.88	0.001	**
Will Evacuate After a Mandatory Order	---	---		-0.59	<0.001	**	---	---		-0.39	0.022	*	-0.65	<0.001	**	---	---	
Will Evacuate After Can't Do More to Defend Home	---	---		-0.39	0.005	**	---	---		---	---		-0.42	0.002	**	---	---	
Will Evacuate After Witnessing Traffic Congestion Reduce	---	---		---	---		---	---		-0.37	0.025	*	---	---		---	---	
Will Shelter with Family	---	---		---	---		-0.52	0.009	**	---	---		---	---		-0.50	0.013	*
<u>Risk Perception</u>																		
High/Extremely High Risk of Wildfire Damage to Residence This Season	---	---		---	---		---	---		0.25	0.049	*	---	---		---	---	
Very/Somewhat Confident in Ability to Protect Self	1.04	<0.001	**	---	---		---	---		1.00	<0.001	**	---	---		---	---	
Seek to Reduce Risk to Property (Very/Somewhat)	0.78	<0.001	**	---	---		---	---		0.71	<0.001	**	---	---		---	---	

Worried About Lack of First Responders During Evacuation	---	---		0.34	0.008	**	---	---		---	---		0.36	0.004	**	---	---	
Worried Will Be Required to Work During Wildfire	0.41	0.002	**	---	---		0.49	0.015	*	0.41	0.002	**	---	---		0.51	0.011	*
Staying Greatly Reduces Odds of Losing Home	-0.47	0.004	**	---	---		-1.02	<0.001	**	-0.49	0.002	**	---	---		-1.07	<0.001	**
Staying Greatly Increases Odds of Harm	-0.40	0.002	**	---	---		---	---		-0.47	<0.001	**	---	---		---	---	
Worried About Self/Loved Ones Finding Shelter	0.27	0.030	*	---	---		---	---		0.29	0.017	*	---	---		---	---	
Demographics																		
Age 18-35	---	---		0.32	0.010	**	---	---		---	---		0.35	0.005	**	---	---	
Woman	---	---		-0.28	0.024	*	---	---		---	---		-0.32	0.008	**	---	---	
More Than 5 People in Household	---	---		0.68	0.028	*	---	---		---	---		0.68	0.029	*	---	---	
Lived in Current Residence More than 10 Years	-0.61	<0.001	**	-0.48	0.006	**	---	---		-0.61	<0.001	**	-0.46	0.009	**	---	---	
Number of Observations	1371									1371								
Rho-Square	0.20									0.19								
Adjusted Rho-Square	0.19									0.17						* 95% Significance		
Final Log-Likelihood	-1515.76									-1535.07						** 99% Significance		

5. DISCUSSION AND POLICY RECOMMENDATIONS

5.1 Modeling Discussion

Focusing first on the modelling methodology, the latent variable for major hazard experience was not always significant. In addition, the fit and likelihood of the latent variable models were very similar or marginally lower when compared to the models with distinct hazard experience variables. While latent variables may be useful to identify hazard experience broadly, we did not find a compelling reason to retain these models given the results. Regardless, risk perceptions were a key component in understanding intended EV driver behavior in emergencies and evacuations. Despite the lack of improvement of model fit with the inclusion of a latent variable, we continue to recommend a multi-modeling approach to test different model forms.

Second, EV ownership appears across all scenario models and in almost all choices. The results indicate that EV owners are generally more proactive about charging their vehicles before and during evacuations. Policies that help emphasize the importance of proactive charging and maintaining charge levels could inform future EV owners of preparedness practices in emergencies (Souto et al., 2024). Incentivizing the installation of systems such as at-home fast chargers and backup batteries would also help reduce congestion at charging stations (De Simone & Piegari, 2019; Gjelaj et al., 2019; Marty & Pietrowicz, 2018).

Third, seeking to reduce risk to personal property appears in all models as well, and seeking to reduce risk to family is a concern in three of the four models in this paper. The appearance of these factors highlights that a significant factor driving charging behaviour is the desire to minimize risks to their homes and families. Individuals who prioritize protecting their property are more likely to take measures to ensure their vehicle is ready for evacuation. Similarly, individuals concerned with the safety of their families are likely to make decisions based on their perception of the safest option. Individuals who believe staying at home increases their chances of saving their property tend to lean toward home charging. This aligns with intuitive expectations as this group prefers to defend or monitor the situation before evacuating. In addition, the repetition of risk reduction behaviours (seeking to reduce risk to property and staying to reduce odds of losing home) across different models suggests a consistent pattern that underscores the importance of perceived safety and property protection in individual decision-making processes during emergencies. Placing sufficient charging stations along evacuation routes, coupled with other amenities such as rest areas with shelter, food, and water, would help accommodate all evacuees and produce a safe option for EV drivers (Xu et al., 2020; ZareAfifi et al., 2024).

Demographic variables tended to be weaker and mixed, while intended evacuation actions indicated some influence. The effect of evacuation actions may pre-determine future actions or be considered jointly with charging behaviour. Overall, the results indicate that a wide range of variables influence charging behavior and additional studies will be needed to isolate the most critical variables across different geographies and disaster types. Given this range and the hypothetical nature of the research question, immediate policy suggestions based on demographic results are not readily apparent. However, the scenarios indicate that demand for charging is relatively spread out over time and space. The results suggest that emergency managers and grid managers will have to contend with a multi-pronged surge in demand, though perhaps with lower peaks than if preferences indicated strong temporal or spatial concentration.

5.2 Descriptive Statistic Discussion

Beyond the modelling exercise, descriptive statistics suggest several practical insights for emergency planning. In S1, 41.0% of respondents preferred to charge at home and 14.7% preferred to not charge. In S2, these percentages changed to 58.3% and 4.3% respectively. These percentages show a general preference for users to charge at home as well as a significant decrease in non-charging users between the two scenarios. This reemphasizes the importance of incentives for at-home chargers and optimal evacuation awareness campaigns for EV users, while also signifying the importance of emergency response measures such as temporary chargers and vehicle-to-vehicle (V2V) technologies (Chauhan & Gupta, 2018; Derickson, 2022; Mosayebi et al., 2022). Importantly, most people will charge, even when they may be able to get to their destination. The implication is that the demand for concurrent power may strain the grid. Spatially, the varied charging choices may help spread out demand.

In addition, a significant proportion of respondents in S3 were willing to charge for less than 30 minutes or only at home, indicating the necessity for fast-charging infrastructure and sufficient home charging incentives. Subsidizing home charging equipment (e.g., Level 2 chargers) and educating EV owners on maintaining adequate home charging levels during wildfire season can enhance preparedness and reduce reliance on public charging infrastructure during emergencies (ZareAfifi et al., 2024). Increasing the number of charging stations near evacuation routes, with strategic placement to prioritize locations that are both "closest" and "least time-consuming," can alleviate bottlenecks and help drivers identify the best option (Derickson, 2022; Zhang et al., 2019). Upgrading charging stations with fast chargers and ensuring regular maintenance can accommodate increased demand while addressing range anxiety and the willingness of 49.2% of respondents to spend 30 minutes or less on charging (Khalid et al., 2021).

Furthermore, traffic management strategies and real-time updates on charging station availability can help prevent congestion near the first possible charging locations, a preference expressed by 41.6% of respondents in S4 (Benetti et al., 2015; Y. Li et al., 2018). Demand distribution methods, such as dynamic routing systems (Purba et al., 2022) or mobile charging units (see for example Afshar et al., 2021), can help manage the sudden surge of demand resulting from evacuations. These combined strategies emphasize the importance of tailoring infrastructure and communication to user preferences and behaviors during emergency evacuations.

6. LIMITATIONS

While this study provides an overview of EV user behaviour during emergencies, a number of limitations should be considered. First, the survey may have been biased by oversampling specific groups. For the purposes of this paper, oversampling of EV owners may have led to a bias in overall responses. Second, the stated preference nature of this survey combined with the hypothetical scenarios involving EV ownership and charging behaviour for non-EV owners may reduce the response reliability compared to actual events. Participants may struggle with conceptualizing the scenarios, especially those without an EV. Third, the online survey would have excluded individuals without internet access, while the overall survey length yielded some rushed responses. While the data was checked for response patterns, random selection of responses could be possible. Fourth, the study lacks strong external validity for all locations in North America, though results could be extrapolated for other fire-prone areas in Canada and the U.S. with similar populations. Fifth, from a modeling perspective, our results did not find significant value of latent variables, especially minor risk variables. Further work using other risk perception, experiential, and psychometric questions will be needed to verify this non-result. Finally, the models produced are relatively simple in nature due to the complexity of the scenarios. The testing of different types of models would be a key next research step, though the results in this work alone are sufficient as inputs for evacuation models.

7. CONCLUSION

This study examined the factors influencing intended EV charging behaviour during a hypothetical wildfire emergency. We developed multinomial logit models using data from a survey of wildfire-prone individuals in the Canadian provinces of Alberta and British Columbia. Hazard experience variables were combined into a latent variable using confirmatory analysis in separate models, but these models did not result in better fit. The models identified several key attributes that consistently impact charging decisions. EV ownership was noted as a significant factor across all scenarios, highlighting the proactive nature of EV owners in maintaining a sufficient charge for evacuation readiness. In addition, risk perception variables, past disaster experience, and intended wildfire evacuation choices regularly influenced charging behaviour, though often with a mixture of positive and negative effects. Demographic variables were generally weak, indicating that the context of the evacuation, charging options, and risk considerations were more relevant. Moreover, the descriptive statistics suggest that decision-makers should expect demand spikes across the disaster phases and in different spatial locations, but with lower peaks. This early result indicates that selective grid improvements, thoughtful charging station locations along routes, and wait-time reduction measures at stations may be sufficient to handle EV charging in wildfires. Additional research using revealed preference data and other stated preference data across different populations and disasters will be needed to clarify the most critical variables and considerations for EV charging behaviour in evacuations.

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9. CONTRIBUTIONS

The authors confirm contributions to the paper as follows: study conception and design: M. Babaei, S. Wong; data collection: all authors; analysis and interpretation of results: all authors; draft manuscript preparation: all authors. All authors reviewed the results and approved the final version of the manuscript.

APPENDIX

Table A1: Household and individual respondent demographics across the provinces of Alberta and British Columbia in Canada

Survey Categories	Alberta Sample *(n=634)*	British Columbia Sample *(n=737)*	Combined (Sample) *(n=1371)*	Census Categories	Combined (Census)
Gender				***Gender***	
Woman	48.4%	53.0%	50.9%	Women+*	50.5%
Man	48.9%	44.9%	46.8%	Men+*	49.5%
Non-binary	1.2%	1.1%	1.2%	---	---
Two spirit	0.2%	0.1%	0.1%	---	---
Transgender	1.1%	0.5%	0.8%	---	---
I prefer not to answer	0.2%	0.4%	0.3%	---	---
Age				***Age***	
18 to 35	60.0%	49.9%	54.6%	20 to 34	19.8%
36 to 50	29.1%	32.2%	30.8%	35 to 49	20.6%
51 to 64	8.5%	11.7%	10.3%	50 to 64	19.9%
>64	2.4%	6.1%	4.4%	65 or Older	17.8%
Race or Ethnicity				***Race or Ethnicity***	
Arab	1.3%	0.6%	1.0%	Arab	1.1%

Black	2.8%	2.3%	2.5%	Black	2.6%
Chinese	4.0%	4.3%	4.1%	Chinese	7.9%
Filipino	2.5%	2.6%	2.5%	Filipino	4.3%
First Nations (within Canada)	7.6%	6.5%	7.0%	First Nations	2.0%
Indigenous / Aboriginal from North America but outside of Canada	0.7%	0.6%	0.7%	---	---
Indigenous / Aboriginal from outside of North America	0.4%	0.5%	0.5%	---	---
Inuk (Inuit) (within Canada)	0.1%	0.3%	0.2%	Inuit	0.1%
Japanese	1.0%	0.6%	0.8%	Japanese	0.6%
Korean	0.9%	0.4%	0.6%	Korean	1.1%
Latin American	1.6%	1.5%	1.6%	Latin American	1.5%
Métis (within Canada)	1.9%	2.1%	2.0%	Métis	2.2%
South Asian (e.g., Indian, Pakistani, Sri Lankan, etc.)	2.9%	2.8%	2.9%	South Asian	8.5%
Southeast Asian (e.g., Vietnamese, Cambodian, Laotian, Thai, etc.)	1.6%	1.2%	1.4%	Southeast Asian	1.4%
West Asian (e.g., Iranian, Afghan, etc.)	0.1%	0.4%	0.3%	West Asian	1.0%
White	67.6%	70.8%	69.3%	Not a visible minority	68.7%
I prefer not to answer	1.5%	1.2%	1.3%	---	---
Other	1.3%	1.3%	1.3%	---	---
Household characteristics					
Presence of children	62.0%	50.4%	55.8%	Married or common law families with children	49.9%
Presence of elderly	17.0%	22.0%	19.7%	---	---
Presence of disabled	19.4%	26.9%	23.4%	---	---
Annual Household income				***Annual Household income***	
Under $10,000	1.6%	1.9%	1.8%	Under $10,000	1.9%
$10,000 to 19,999	2.7%	4.8%	3.8%	$10,000 to 19,999	2.5%
$20,000 to 29,999	4.7%	6.1%	5.5%	$20,000 to 29,999	6.7%
$30,000 to 39,999	4.1%	4.6%	4.4%	$30,000 to 39,999	6.2%
$40,000 to $49,999	2.4%	5.3%	3.9%	$40,000 to $49,999	6.8%
$50,000 to $59,999	7.4%	7.9%	7.7%	$50,000 to $59,999	13.5%
$60,000 to $69,999	7.3%	7.6%	7.4%	$60,000 to $69,999	13.1%
$70,000 to $79,999	12.6%	9.1%	10.7%	$70,000 to $79,999	6.4%
$80,000 to $89,999	11.5%	11.0%	11.2%	$80,000 to $89,999	6.0%
$90,000 to $99,999	14.2%	12.2%	13.1%	$90,000 to $99,999	5.6%
$100,000 and over	27.3%	24.5%	25.8%	$100,000 and over	44.3%
I prefer not to answer	4.3%	5.0%	4.7%	---	---
Education level				***Education level***	
Less than high school	3.2%	2.7%	2.9%	No certificate, diploma or degree	14.4%
High school graduate (or equivalent)	17.2%	18.2%	17.7%	High (secondary) school diploma or equivalency certificate	29.2%
Some college, no degree	12.5%	16.6%	14.7%	University certificate or diploma below bachelor level	3.5%
College/diploma	21.6%	22.1%	21.9%	College, CEGEP or other non-university certificate or diploma	17.5%
4 year degree (bachelor's)	30.3%	28.0%	29.1%	Bachelor’s degree	18.2%
Graduate or professional degree	12.8%	10.3%	11.5%	Master’s degree	5.7%
Doctorate	2.1%	1.1%	1.5%	Doctorate	0.9%
I prefer not to answer	0.5%	1.0%	0.7%	---	---
Employment status				***Employment status***	
Employed full time	72.4%	64.8%	68.3%	Employed full time	32.0%

Employed part time	8.5%	11.7%	10.2%	Employed part time	28.9%
Unemployed looking for work	5.0%	4.8%	4.9%	Unemployed, in the labour force	7.8%
Unemployed not looking for work	2.8%	2.6%	2.7%	Not in labour force	32.0%
Retired	4.1%	6.3%	5.3%	---	---
Student	4.9%	4.3%	4.6%	---	---
Disabled	1.4%	4.2%	2.9%	---	---
I prefer not to answer	0.8%	1.4%	1.1%	---	---
Marital status				***Marital status***	
Never married	25.9%	28.4%	27.2%	Never married	28.1%
Married	59.6%	51.1%	55.0%	Married	48.3%
Living common law	8.0%	11.1%	9.7%	Living common law	9.8%
Separated	1.9%	3.1%	2.6%	Separated	2.5%
Divorced	3.2%	3.4%	3.3%	Divorced	6.4%
Widowed	0.6%	1.1%	0.9%	Widowed	4.8%
I prefer not to answer	0.8%	1.8%	1.3%	---	---
Type of residence				***Type of residence***	
Single-family home	51.7%	56.5%	54.3%	Single-detached or semi-detached home	55.0%
Townhome	23.5%	17.3%	20.1%	Row house	8.1%
Condominium	9.3%	5.8%	7.4%	---	---
Apartment (1-10 units)	4.6%	3.8%	4.2%	Apartment or flat in a duplex	8.0%
Apartment (11-50 units)	3.8%	6.0%	5.0%	Apartment fewer than five storeys	18.1%
Apartment (more than 50 units)	2.7%	2.9%	2.8%	Apartment with five or more storeys	8.1%
Mobile home	2.7%	3.9%	3.4%	Mobile dwelling	2.6%
I prefer not to answer	0.9%	1.1%	1.0%	---	---
Other (please specify)	0.8%	2.7%	1.8%	Other single-attached house	0.1%
Residence ownership				***Residence ownership***	
Yes	71.0%	68.0%	69.4%	Yes	68.6%
No	29.0%	32.0%	30.6%	No	31.4%
Length of stay in current residence					
Less than 1 year	10.6%	10.1%	10.3%		
1 to 5.99 years	35.3%	36.8%	36.1%		
6 to 10 years	28.7%	24.5%	26.4%		
More than 10 years	24.1%	27.6%	26.0%		
I prefer not to answer	1.3%	1.1%	1.2%		

*In order to protect the confidentiality of non-binary individuals in certain scenarios, the Canada census distributes these individuals into the categories of Men and Women, and denotes these categories with a "+" symbol.

REFERENCES

Adderly, S. A., Manukian, D., Sullivan, T. D., & Son, M. (2018). Electric vehicles and natural disaster policy implications. *Energy Policy*, *112*, 437–448. https://doi.org/10.1016/j.enpol.2017.09.030

Afshar, S., Macedo, P., Mohamed, F., & Disfani, V. (2021). Mobile charging stations for electric vehicles—A review. *Renewable and Sustainable Energy Reviews*, *152*, 111654. https://doi.org/10.1016/j.rser.2021.111654

Babaei, M. H., & Wong, S. D. (2024). Electric vehicles in emergencies and evacuations: A review of resilience and future research directions. *Transportation Letters*, 1–13. https://doi.org/10.1080/19427867.2024.2415753

Benetti, G., Delfanti, M., Facchinetti, T., Falabretti, D., & Merlo, M. (2015). Real-Time Modeling and Control of Electric Vehicles Charging Processes. *IEEE Transactions on Smart Grid*, *6*(3), 1375–1385. https://doi.org/10.1109/TSG.2014.2376573

Bierlaire, M. (2020). *A short introduction to PandasBiogeme* [Computer software]. Technical report TRANSP-OR 200605.

Brachman, M. L., Church, R., Adams, B., & Bassett, D. (2019). Wayfinding during a wildfire evacuation. *Disaster Prevention and Management: An International Journal*, *29*(3), 249–265. https://doi.org/10.1108/DPM-07-2019-0216

Cao, X., Cao, T., Xu, Z., Zeng, B., Gao, F., & Guan, X. (2023). Resilience Constrained Scheduling of Mobile Emergency Resources in Electricity-Hydrogen Distribution Network. *IEEE Transactions on Sustainable Energy*, *14*(2), 1269–1284. https://doi.org/10.1109/TSTE.2022.3217514

Chauhan, V., & Gupta, A. (2018). Scheduling Mobile Charging Stations for Electric Vehicle Charging. *2018 14th International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob)*, 131–136. https://doi.org/10.1109/WiMOB.2018.8589146

Christianson, A. C., Johnston, L. M., Oliver, J. A., Watson, D., Young, D., MacDonald, H., Little, J., Macnab, B., & Gonzalez Bautista, N. (2024). Wildland fire evacuations in Canada from 1980 to 2021. *International Journal of Wildland Fire*, *33*(7). https://doi.org/10.1071/WF23097

Cova, T. J., Sun, Y., Zhao, X., Liu, Y., Kuligowski, E. D., Janfeshanaraghi, N., & Lovreglio, R. (2024). Destination unknown: Examining wildfire evacuee trips using GPS data. *Journal of Transport Geography*, *117*, 103863. https://doi.org/10.1016/j.jtrangeo.2024.103863

De Simone, D., & Piegari, L. (2019). Integration of Stationary Batteries for Fast Charge EV Charging Stations. *Energies*, *12*(24), 4638. https://doi.org/10.3390/en12244638

Derickson, G. (2022). *Simulating Electric Vehicle Short-Notice Wildfire Evacuation in California Rural Communities* [California Polytechnic State Universiry]. https://www.proquest.com/dissertations-theses/simulating-electric-vehicle-short-notice-wildfire/docview/2838439121/se-2?accountid=14474

Donaldson, D. L., Alvarez-Alvarado, M. S., & Jayaweera, D. (2020). Power System Resiliency During Wildfires Under Increasing Penetration of Electric Vehicles. *2020 International Conference on Probabilistic Methods Applied to Power Systems (PMAPS)*, 1–6. https://doi.org/10.1109/PMAPS47429.2020.9183683

Donaldson, D. L., Alvarez-Alvarado, M. S., & Jayaweera, D. (2022). Integration of Electric Vehicle Evacuation in Power System Resilience Assessment. *IEEE Transactions on Power Systems*, 1–12. https://doi.org/10.1109/TPWRS.2022.3206900

Elhami-Khorasani, N., Kinateder, M., Lemiale, V., Manzello, S. L., Marom, I., Marquez, L., Suzuki, S., Theodori, M., Wang, Y., & Wong, S. D. (2023). Review of Research on Human Behavior in Large Outdoor Fires. *Fire Technology*, *59*(4), 1341–1377. https://doi.org/10.1007/s10694-023-01388-6

Erenoglu, A. K., Sancar, S., Terzi, I. S., Erdinc, O., Shafie-Khah, M., & Catalao, J. P. S. (2022). Resiliency-Driven Multi-Step Critical Load Restoration Strategy Integrating On-Call Electric Vehicle Fleet Management Services. *IEEE Transactions on Smart Grid*, *13*(4), 3118–3132. https://doi.org/10.1109/TSG.2022.3155438

Gjelaj, M., Arias, N. B., Traeholt, C., & Hashemi, S. (2019). Multifunctional applications of batteries within fast-charging stations based on EV demand-prediction of the users' behaviour. *The Journal of Engineering*, *2019*(18), 4869–4873. https://doi.org/10.1049/joe.2018.9280

Hasan, A. S. M. J., Enriquez-Contreras, L. F., Yusuf, J., Barth, M. J., & Ula, S. (2021). Demonstration of Microgrid Resiliency with V2G Operation. *2021 IEEE Transportation Electrification Conference & Expo (ITEC)*, 243–248. https://doi.org/10.1109/ITEC51675.2021.9490165

Hussain, A., & Musilek, P. (2022). Resilience Enhancement Strategies For and Through Electric Vehicles. *Sustainable Cities and Society*, *80*, 103788. https://doi.org/10.1016/j.scs.2022.103788

Johnson, C., Cappellucci, J., Luhring, L. S., St Louis-Sanchez, M., Yang, F., Brown, A., Sipiora, A., Kolpakov, A., Li, X., Li, Q., White, S., Gonzales, J., Nobler, E., & Wood, E. (2022, December). *Florida Alternative Transportation Fuel Resilience Plan*. National Renewable Energy Laboratory. 2022-12

Jones, B., Elliott, R. J. R., & Nguyen-Tien, V. (2020). The EV revolution: The road ahead for critical raw materials demand. *Applied Energy*, *280*, 115072. https://doi.org/10.1016/j.apenergy.2020.115072

Kaiser, H. F., & Rice, J. (1974). Little Jiffy, Mark Iv. *Educational and Psychological Measurement*, *34*(1), 111–117. https://doi.org/10.1177/001316447403400115

Khalid, M., Ahmad, F., & Panigrahi, B. K. (2021). Design, simulation and analysis of a fast charging station for electric vehicles. *Energy Storage*, *3*(6), e263. https://doi.org/10.1002/est2.263

Kuligowski, E. (2021). Evacuation decision-making and behavior in wildfires: Past research, current challenges and a future research agenda. *Fire Safety Journal*, *120*, 103129. https://doi.org/10.1016/j.firesaf.2020.103129

Li, Q., Huang, Q., Qin, W., Xing, Y., Zhao, H., Song, X., Hu, E., & Shen, Z. (2021). Resilience Lifting Method of Active Distribution Network Considering Charging and Discharging Scheduling of Electric Vehicles. *2021 IEEE 5th Conference on Energy Internet and Energy System Integration (EI2)*, 1973–1977. https://doi.org/10.1109/EI252483.2021.9713196

Li, Y., Liu, X., Wen, F., Zhang, X., Wang, L., & Xue, Y. (2018). Dynamic Charging Scheduling for Electric Vehicles Considering Real-Time Traffic Flow. *2018 IEEE Power & Energy Society General Meeting (PESGM)*, 1–5. https://doi.org/10.1109/PESGM.2018.8586460

Liu, H., Wang, C., Ju, P., Xu, Z., & Lei, S. (2023). A bi-level coordinated dispatch strategy for enhancing resilience of electricity-gas system considering virtual power plants. *International Journal of Electrical Power & Energy Systems*, *147*, 108787. https://doi.org/10.1016/j.ijepes.2022.108787

Liu, W., Liu, Y., Yang, Y., Xu, Q., & Dong, F. (2023). Power restoration model for distribution networks after extreme rainstorm disasters based on electric vehicle travel characteristics. *Energy Reports*, *9*, 372–380. https://doi.org/10.1016/j.egyr.2022.10.387

Lovreglio, R., Borri, D., dell’Olio, L., & Ibeas, A. (2014). A discrete choice model based on random utilities for exit choice in emergency evacuations. *Safety Science*, *62*, 418–426. https://doi.org/10.1016/j.ssci.2013.10.004

Ma, F., & Lee, J. Y. (2024). Understanding Evacuation Behavior During Wildfires: Exploring Key Factors Affecting Evacuee Behaviors and Developing Predictive Models for Decision-Making. *Fire Technology*. https://doi.org/10.1007/s10694-024-01683-w

MacDonald, C. D., Kattan, L., & Layzell, D. (2021). Modelling electric vehicle charging network capacity and performance during short-notice evacuations. *International Journal of Disaster Risk Reduction*, *56*, 102093. https://doi.org/10.1016/j.ijdrr.2021.102093

Marty, J., & Pietrowicz, S. (2018). Economic incentives for reducing peak power utilization in electric vehicle charging stations. *2018 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT)*, 1–5. https://doi.org/10.1109/ISGT.2018.8403377

McCaffrey, S., Wilson, R., & Konar, A. (2018). Should I Stay or Should I Go Now? Or Should I Wait and See? Influences on Wildfire Evacuation Decisions. *Risk Analysis*, *38*(7), 1390–1404. https://doi.org/10.1111/risa.12944

McLennan, J., Ryan, B., Bearman, C., & Toh, K. (2019). Should We Leave Now? Behavioral Factors in Evacuation Under Wildfire Threat. *Fire Technology*, *55*(2), 487–516. https://doi.org/10.1007/s10694-018-0753-8

Momen, H., Abessi, A., & Jadid, S. (2020). Using EVs as distributed energy resources for critical load restoration in resilient power distribution systems. *IET Generation, Transmission & Distribution*, *14*(18), 3750–3761. https://doi.org/10.1049/iet-gtd.2019.1561

Mosayebi, M., Fathollahi, A., Gheisarnejad, M., Farsizadeh, H., & Khooban, M. H. (2022). Smart Emergency EV-to-EV Portable Battery Charger. *Inventions*, *7*(2), 45. https://doi.org/10.3390/inventions7020045

Muratori, M., Alexander, M., Arent, D., Bazilian, M., Cazzola, P., Dede, E. M., Farrell, J., Gearhart, C., Greene, D., Jenn, A., Keyser, M., Lipman, T., Narumanchi, S., Pesaran, A., Sioshansi, R., Suomalainen, E., Tal, G., Walkowicz, K., & Ward, J. (2021). The rise of electric vehicles—2020 status and future expectations. *Progress in Energy*, *3*(2), 022002. https://doi.org/10.1088/2516-1083/abe0ad

Purba, D. S. D., Kontou, E., & Vogiatzis, C. (2022). Evacuation route planning for alternative fuel vehicles. *Transportation Research Part C: Emerging Technologies*, *143*, 103837. https://doi.org/10.1016/j.trc.2022.103837

Rahimi, K., & Davoudi, M. (2018). Electric vehicles for improving resilience of distribution systems. *Sustainable Cities and Society*, *36*, 246–256. https://doi.org/10.1016/j.scs.2017.10.006

Souto, L., Taylor, P. C., & Damree, S. (2024). Preemptive Electric Vehicle Charging Strategy in Active Power Distribution Networks. *2024 IEEE Power & Energy Society General Meeting (PESGM)*, 1–5. https://doi.org/10.1109/PESGM51994.2024.10689235

Stasiewicz, A. M., & Paveglio, T. B. (2021). Preparing for wildfire evacuation and alternatives: Exploring influences on residents' intended evacuation behaviors and mitigations. *International Journal of Disaster Risk Reduction*, *58*, 102177. https://doi.org/10.1016/j.ijdrr.2021.102177

Vaiciulyte, S., Hulse, L. M., Veeraswamy, A., & Galea, E. R. (2021). Cross-cultural comparison of behavioural itinerary actions and times in wildfire evacuations. *Safety Science*, *135*, 105122. https://doi.org/10.1016/j.ssci.2020.105122

Wen, W., Yang, S., Zhou, P., & Gao, S. Z. (2021). Impacts of COVID-19 on the electric vehicle industry: Evidence from China. *Renewable and Sustainable Energy Reviews*, *144*, 111024. https://doi.org/10.1016/j.rser.2021.111024

Wong, S. D., Broader, J. C., & Shaheen, S. (2020). *Review of California Wildfire Evacuations from 2017 to 2019*. https://doi.org/10.7922/G29G5K2R

Wong, S. D., Broader, J. C., Walker, J. L., & Shaheen, S. A. (2023). Understanding California wildfire evacuee behavior and joint choice making. *Transportation*, *50*(4), 1165–1211. https://doi.org/10.1007/s11116-022-10275-y

Wu, Y., Yang, Q., Su, J., Xiang, Y., Zhang, G., Li, Y., & Ji, C. (2022). A Rapid Recovery Strategy for Post-Earthquake Power Grids with the Auxiliary Support of V2G. *2022 IEEE/IAS Industrial and Commercial Power System Asia (I&CPS Asia)*, 1680–1685. https://doi.org/10.1109/ICPSAsia55496.2022.9949967

Xu, M., Yang, H., & Wang, S. (2020). Mitigate the range anxiety: Siting battery charging stations for electric vehicle drivers. *Transportation Research Part C: Emerging Technologies*, *114*, 164–188. https://doi.org/10.1016/j.trc.2020.02.001

Yamagata, Y., & Seya, H. (2013). *Community-based resilient electricity sharing: Optimal spatial clustering*. 43rd Annual IEEE/IFIP Conference on Dependable Systems and Networks Workshop. https://doi.org/10.1109/DSNW.2013.6615539

Yang, Z., Nazemi, M., Dehghanian, P., & Barati, M. (2020). Toward Resilient Solar-Integrated Distribution Grids: Harnessing the Mobility of Power Sources. *2020 IEEE/PES Transmission and Distribution Conference and Exposition (T&D)*, 1–5. https://doi.org/10.1109/TD39804.2020.9299986

ZareAfifi, F., De Castro, R., & Kurtz, S. (2024). Planning for electric-vehicle evacuations: Energy, infrastructure, and storage needs. *2024 IEEE Vehicle Power and Propulsion Conference (VPPC)*, 1–6. https://doi.org/10.1109/VPPC63154.2024.10755447

Zhang, Y., Chen, J., Cai, L., & Pan, J. (2019). Expanding EV Charging Networks Considering Transportation Pattern and Power Supply Limit. *IEEE Transactions on Smart Grid*, *10*(6), 6332–6342. https://doi.org/10.1109/TSG.2019.2902370