Development of a Geospatial Agent-Based Simulation of Disaster Evacuations for Battery Electric Vehicle (BEV) Policy

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ABSTRACT

Several nations have signaled their intent to phase out petroleum-based engines for passenger vehicles and promote a transition to battery electric vehicles (BEVs). While researchers have established the long-term environmental benefits of BEVs, there are critical considerations for policymakers in areas prone to natural disasters. This research intends to develop a geospatial-based model to explore and simulate the evacuation of BEVs during a disaster. This work-in-progress (WiPe) paper examines the variables essential to creating an effective hurricane simulation. The final simulation model is intended to allow for the evaluation of BEV policy options under a variety of scenarios. We describe the considerations made during the development of this geospatial agent-based simulation under various hurricane parameters. Finally, we mention the expected benefits of our work and hint at possible policy directions.

Keywords

Battery Electric Vehicles, Government Policy, Hurricane Evacuation, Geospatial Agent-Based Simulation.

INTRODUCTION

Governments are increasingly moving toward phasing out sales or registration for new passenger vehicles with petroleum-based combustion engines. For example, Norway established a phaseout goal of 2025, while Iceland, Slovenia, Sweden, Ireland, Netherlands, and Slovenia plan to achieve their phaseout goals by 2030 (Wappelhorst, 2021). Other nations will likely implement similar phaseout goals. The transition to battery electric vehicles (BEVs) from passenger vehicles with petroleum-based engines is primarily prompted by established links between carbon dioxide emissions and climate change (Meyer et al., 2007; Nickischer, 2020). Simultaneously, the availability of a variety of affordable BEVs reduced consumer skepticism toward electric vehicles (Higueras-Castillo, 2021). While BEVs provide environmental benefits, they significantly alter the vehicle ownership experience. For instance, instead of fueling your car at a fuel pump (petrol station), many owners ‘fuel’ their BEVs by charging them overnight at home. Therefore, many vehicles may already be fully charged during an evacuation order. However, once on the road, some of these advantages may disappear. While traditional fuel could be pumped or simply poured into a vehicle’s fuel tank in a matter of minutes, fully charging an electric vehicle can take from over 30 minutes to several days (depending on the charging infrastructure). Carbon-based fuels (e.g., diesel and gasoline) can also be more easily stored and transported. Finally, carbon-fueled vehicles tend to cover longer distances between re-fueling compared to the distances covered by BEVs between recharges. These “benefits” of petroleum-based vehicles are advantageous when evacuating natural disasters such as hurricanes, flooding, and wildfires. However, such perceived benefits may erode once BEVs become ubiquitous.

Barrett (2000) described when Hurricane Andrew struck Florida's Dade County in 1992. Hurricane Andrew directly impacted about 350,000 people, however, it would have been far more catastrophic and impacted over 1.6 million people had it arrived just a few miles further north. While hurricane frequencies increase and decrease over decades, the United States can expect two catastrophic hurricanes (with significant damage and loss of life) every three years (Barrett, 2000). Municipalities may issue evacuation notices when meteorologists predict weather patterns that lead to loss of life or other significant infrastructure damage. Indeed, a hurricane's direct impact on highly-populated areas will have devastating results. Issuing a late hurricane warnings along with a mismanaged evacuation efforts may cause a substantial loss of life with vehicles exposed on gridlocked roadways (Barrett, 2000). Such evacuations result in a massive outflow of people from the affected areas that may already suffer from challenges related to roadway configurations and fuel infrastructure. However, little research has been done to guide policymakers in response to these events under increasing electric vehicle adoption. Therefore, we plan to distill the effects of the BEV transition on large-scale disaster evacuations. More specifically, we are guided by the following research question: What is the most effective approach to ensuring effective and efficient disaster evacuation using BEVs (RQ1)? In subsequent sections, we provide a brief evaluation of other simulations of BEV evacuations, define the geographical area being utilized in this study, and describe our research methodology. A description of essential simulation variables follows those sections. Finally, we discuss the potential implications of our findings. Our intent is to create a universal model that allows policymakers to examine the impact of policy decisions using past data to simulate future scenarios.

LITERATURE REVIEW

In reviewing the existing research on emergency evacuations, only three studies appear to consider the specific impact of BEVs and their requirements. Feng et al. (2020) investigated the evacuation of Florida, specifically during Hurricane Irma (2017), with a focus on the percentage of vehicles that could be BEVs before the electrical power system would fail. They concluded that the power system would still be functional with up to 45% of the evacuating vehicles as BEVs. A suggestion from that research is for the government to invest in grid capacity strategically. Alternatively, longer-lasting batteries would need to be developed to support a higher percentage of BEVs. McDonald et al. (2021) considered the effects of BEVs on the pre-departure stage of an evacuation. In their research, a short-notice evacuation was hypothetically required due to a forest fire in Prince George, British Columbia. McDonald et al. found an insufficient charging capacity to service all BEVs prior to departure, with additional charging stations, earlier evacuation notices, and fast-charging Level 3 chargers needed to provide a reliable solution. Adderley et al. (2018) provided the most comprehensive estimation of the effect of increased use of BEVs during a hurricane-triggered evacuation. Their case study focused on the effects of a hypothetical hurricane hitting Key West, Florida. Their analysis assumed 10% of the population evacuated with BEVs utilizing a standardized vehicle type to determine charging rate and number of chargers needed to support their evacuation. Based on their findings, they advocated for an increased number of chargers, the use of fast-charging Level 3 chargers, and the standardization of charging connectors across all BEVs. They also show concern about the ability of the grid to handle the increased demands during an evacuation, pointing out that most electric demand for BEVs in non-emergency situations is at night when demand is lower.

No study to date has done an evaluation that considers the spatial placement and utilization of BEVs or a geospatially-placed support network to allow them to withdraw effectively during an emergency evacuation. This study intends to create a more realistic rendition of an evacuation to evaluate policy levers needed create a more effective and efficient evacuation under the increasing adoption of BEVs.

AREA OF STUDY

Our study area is the Mobile-Daphne-Fairhope combined statistical area, representing a metropolitan region of coastal Alabama located in the southern United States. Our choice of this area was to find a reasonably complex location with multiple possible evacuation routes that contemplates or executes evacuations with reasonable regularity. This area is also inhabited by a cross-section of individuals with relevant and measurable characteristics, yet whose evacuation routes have a structure that provides some simplification. We believe that our choice of study area provides sufficient sophistication to foster a generalizable disaster model, at least with regards to hurricanes. Thus, our intent with this research is not to focus solely on the Mobile-Daphne-Fairhope combined statistic area, but to create a model that can be adjusted for various population characteristics and transportation networks, with the hope that the attributes of the location and scenario will allow extension to other disasters.

The Mobile-Daphne-Fairhope statistical area has a population of over 650,000 people spread over two counties. Due to this area's elevation and location directly on the Gulf of Mexico, the National Hurricane Center considers Mobile a very high hurricane risk zone. Not surprisingly, meteorologists have recorded over 60 hurricanes, subtropical cyclones, and subtropical storms in the Mobile area. Mobile and Baldwin[1], the counties in our study area, have dedicated hurricane evacuation routes and procedures. Specifically, Mobile has three distinct highway routes that Mobile County Emergency Management identifies. These routes emanate from Mobile city proper and lead north. There are also a small number of secondary routes that provide some relief to the congestion along the primary routes. Other major highways that emanate from Mobile lead directly to the east and west, and would be unlikely options for households looking to evacuate. To simulate a large-scale evacuation, our study design will collect public data, geospatial features, and past hurricane evacuation data. Furthermore, we focus on the primary evacuation routes identified and utilized in prior evacuations, with some vehicles traversing secondary routes. While some researchers have attempted to simulate large-scale evacuations (e.g., Edara et al., 2010), most focus on local perspectives.

METHODOLOGY

The simulation will be developed using Python. Moreover, we plan to utilize well-established packages designed for agent-based simulations. An agent-based simulation simulates the actions and interactions of autonomous objects that self-direct within an artificial environment. The agent level will be defined as a collective from an individual household. Our approach to building this complex simulation will be to create a model in stages consistent with models that have previously been built. Data from prior evacuations from the Mobile area has been obtained, including traffic patterns, and will be used to validate the model under existing conditions. Upon validation, additional factors will be brought in to be evaluated to ensure that results remain consistent with historical evacuations and models. Ultimately, upon completion and validation, our final model will be used to create and evaluate the effect of various parameter settings and policy decisions on the efficiency and effectiveness of an evacuation of BEVs and other vehicles due to a hurricane.

SIMULATION VARIABLES

We plan to work with a number of variables to develop a realistic simulation, defining our simulation variables into five primary variable themes: vehicles, infrastructure, hurricane attributes, demographics, and policy. Our simulation will focus on those variables that provide an effect of magnitude on the simulation rather than those that are simply statistically significant. In their meta-analysis, Tanim et al. (2022) identify 25 viable predictors of evacuation decisions. Based on the findings of the studies cited by Tanim et al., we intend to incorporate spatial analysis to create a model that accounts for increased usage of BEVs in the future and their need for location-based support. We will elucidate these variables in greater detail next.

Unit Base for Simulation

The unit on which our study will be based is a collective from an individual household. This does not imply that all members of a household will evacuate together, nor does it necessitate that they evacuate separately. It is entirely plausible that multiple vehicles will be used in the evacuation of one household (mainly to preserve property). These vehicles may consist of some combination of BEVs and petroleum-powered vehicles. Although multiple vehicles will likely travel together in such a case, the individual vehicles must be accounted for when simulating the effect of different policies and parameters on evacuation performance.

Vehicle Variables

BEV State-of-Charge

Many BEV owners charge their vehicles overnight using a Level 2 charger. Therefore, assuming no power disruptions and morning evacuation orders, most BEVs would be fully charged. However, this would not be the case for BEV owners who reside in multi-family buildings that may not have any chargers. It is also possible that evacuation orders occur after power loss and that some vehicles would have diminished charges. This may suggest pre-evacuation orders for BEV owners to maintain fully charged vehicles.

[1] Baldwin County Evacuation Zones: https://baldwincountyal.gov/departments/emergency-management-agency/ema-evacuation/evacuation-zones; Mobile Country Evacuation Zones: https://www.mcema.net/evacuation/evacuation-zones

BEV Battery Capacity

As battery density improves and manufacturing costs are reduced, it is expected that overall battery capacity will increase. The battery capacity ranges in the ten most popular electric vehicles in 2021 (U.S. Market) ranged from 38.3 kWh to 95 kWh. The Mini Cooper SE battery capacity is only 28.9 kWh, while some upcoming BEVs claim 200 kWh (Stafford, 2022). Battery capacity is essential for determining the power demand of each vehicle. It is important to note that the capacity is reduced as batteries age.

BEV Driving Range

While batteries influence the driving range, other factors are also at play, including the efficiency of the vehicle determined by the weight, aerodynamics, and power output of the engine(s). Most BEVs travel between 100 to 300 miles on a charge. However, such ranges do not consider vehicle load. In evacuation scenarios, such loads are likely to be above what the vehicle manufacturers considered in their range determinations.

Table 1. Sample BEV Data (U.S. Market)

BEV	Battery Capacity	Range	Charge Times	
2022 Tesla Model Y	75 kWh	303-330 mi	110V 33h 220V 7h	DCFC 20min
2022 Tesla Model 3	50-82 kWh	272-358 mi	110V 33h 220V 7h	DCFC 30min
2022 Chevrolet Bolt	65 kWh	102 mi	110V 55h 220V 7.5h	DCFC 1h
2022 Ford Mustang Mach-E	91 kWh	305 mi	110V 95h 220V 15h	DCFC 45m
2021 Volkswagen ID.4	82 kWh	240-260 mi	110V 36h 220V 8h	DCFC 30m
2022 Nissan Leaf	62 kWh	239 mi	110V 27h 220V 10h	DCFC 30m
2022 Audi e-tron	95 kWh	249 mi	110V 42h 220V 9h	DCFC 30m
2021 Hyundai Kona	39-64 kWh	258 mi	110V 9h 220V 1.5h	DCFC 40m
2021 Porsche Taycan	79.2 kWh	254 mi	110V 35h 220V 7h	DCFC 20m
2022 Hyundai Ioniq	38.3 kWh	193 mi	110V 17h 220V 6h	DCFC 30m

Note(s):
1) DCFC = DC Fast Charge capable of 150kW, all times approximate
2) 220V assumes 22kW, all times approximate
3) Range reported using WLTP cycle.
4) All data per PodPoint & ChargedFuture.

Infrastructure Variables

Charger Type/Charging Speeds

As shown in Table 1, fully charging an electric vehicle can take from 20 minutes to several days based on the vehicle and the charging infrastructure. In the United States, three predominant charging levels exist. These include AC Level 1, AC Level 2, and DC Fast Charge. AC Level 1 uses standard household 120V single-phase outlets. The charge loads range from 1.4 kW to 1.9 kW. Some households and many public chargers are AC Level 2 chargers. These provide 2.5 to 19.2 kW. Both AC Level 1 and AC Level 2 charge at a continuous rate (Pleško & Sullivan, 2021). Finally, DC Fast Charge equipment can provide up to 350 kW charging, with 50 kW being typical. DC Fast Charge equipment does not charge at a continuous rate but at a variable rate that decreases charge rate as the battery reaches capacity. A complicating issue with charger types is the inability of some legacy BEVs to accept connections to specific chargers.

Charger Availability/Location

It is essential to clarify the differences between DC Fast Charge chargers, stations, and networks. The difference between chargers and stations is akin to the pumps and stations of the gasoline era. Unfortunately, many publications confound these two concepts.

While DC Fast Charge chargers may be nearly identical, most operate on incompatible charging networks. In some cases, the physical plugs are incompatible. Even in public stations, most require some form of membership and app-based payment. Some vehicles have plug-and-pay capability that does not require human interaction other than physically plugging in the car. Other networks require a combination of app-based and charger-based interactions to facilitate payment. While the ideal positioning of chargers and stations along the evacuation route is a primary focus of this study, it does not preclude locating stations at primary entrance points to the evacuation route. It is plausible that pre-charging low-charge BEVs prior to joining a primary evacuation route may benefit the overall evacuation.

Charger Wait Times/Station Queueing

Much like passenger cars with internal combustion engines may form queues and wait for fuel pumps, drivers of BEVs will encounter similar situations. However, as the charging speeds vary drastically between vehicles and the charging infrastructure, wait times will be considerably longer and less predictable. It is essential to recognize that older vehicles may take considerably longer to charge than newer vehicles, even on modern equipment; therefore, a single vehicle with a shorter range could prevent several other vehicles from charging.

Policies to address congestion at charging stations include the design and implementation of queueing systems that optimize the overall flow at a charging station while considering the charging characteristics of individual vehicles. Given the type and number of chargers at a charging station, policies could be implemented on the optimal disconnect level for charged batteries. Some BEVs allow may for this to be automated, while some legacy BEVs would require compliance by the individual.

Of course, a preliminary determination of charger wait times and station queueing is the number of chargers placed at each station. This can vary by station, along with the types of chargers. This variance may even affect the choice and number of queueing systems at stations.

Grid Stability

The stability of the electrical grid is examined in previous research involving the effect of BEVs during an evacuation (Feng et al., 2020). McDonald et al. (2021) highlight the necessity of a functioning grid to support the need for additional chargers to support BEVs in an evacuation. Adderley et al. (2018) mention their concern for grid overload as BEVs may overburden an electrical grid during an evacuation. A common thread among concerns for the grid is the tendency to build it to support peak use during normal times. In the case of a hurricane, not only will demand be heightened during the pre-landfall evacuation as an increased number of BEVs are utilized to withdraw from the region, but the grid will also be affected post-landfall due to hurricane damage. This latter point suggests policymakers consider the difficulties posed by a returning population traveling in BEVs. Regardless of grid demands, there will likely be the need to extend the grid to support chargers along evacuation routes. This requirement may become particularly acute as more Level 3 fast-chargers are utilized. A critical understanding from our simulation will be the total electrical demand under a simulated hurricane evacuation during the increasing adoption of BEVs.

Hurricane Attribute Variables

Hurricane Path/Intensity/Timing

The main driver of all evacuations is the actual destructive event. In the case of hurricanes, extensive research and history have provided scientists with good predictive ability on the expected storm severity, size, speed, and location (Alley et al., 2019). That has led to a more advanced understanding of areas that are likely to be impacted and the timing of the impact. The dissemination of this information to the public has also led to more self-diagnosis of whether an evacuation is warranted. The distribution of historical evacuation timing may be altered as collective groups make these decisions more independent of governmental authorities. Besides the impact on public decisions to evacuate, the actual values for hurricane wind speed, storm size, and storm surge can affect decisions by authorities to evacuate. The speed of the storm and direction of the storm relative to the location can also change evacuation orders. Parameters taking these factors into account all affect the support needed to evacuate BEVs from the affected zones.

Temperatures

Two types of temperature impact charging speed. Cold batteries will reduce charge speeds until they have warmed sufficiently. Furthermore, charging speed is impacted by ambient temperature[2]. While we do not expect hurricane conditions to occur in frigid temperatures, other disaster scenarios (e.g., flooding) may occur in conditions that impact battery efficiency and charging speeds.

Demographic Variables

BEV Market Saturation

The transition to BEVs will occur at different rates depending on consumer perceptions, supply constraints, incentives, and other policy decisions. Even if the sale or registration of passenger vehicles with internal combustion engines is eliminated, such vehicles may continue to dominate roads for several years. Autotrader (a used car retailer in the United States) estimates that automobiles remain on the road for up to 12 years. However, knowing that a government has adopted a phaseout may inspire individuals to rapidly move toward BEVs. For instance, in Norway (where the sale of combustion vehicles is expected to end in 2025) the new registration for BEVs had already reached 70.1% by October 2021.

Another consideration is the decision on whether to utilize a BEV during an evacuation. While market saturation may limit options going forward, most collectives will primarily choose the vehicle that is the most reliable and provides the greatest potential to complete an evacuation, the vehicle that is the newest or most valuable, or the vehicle with the highest capacity to move possessions. It is also likely that the effectiveness of the decisions and policies on the number and placement of BEV chargers and stations may directly affect the likelihood to utilize a BEV during an evacuation. In the shorter term, a determination will need to be made on how collectives will choose their evacuation vehicle or vehicles in the situation where more than one vehicle is available.

Residence Effects/Hurricane-resistance

Several residence-related factors need to be evaluated regarding their effect on evacuation behavior. From a location standpoint, the propensity of an area to flood due to rain or storm surges will no doubt propel households to move out. This propensity may be modeled based on proximity to the coast, flood zones, and elevation. While some locations may also be more prone to wind damage, the relative random effect of wind may make this effect difficult to model.

A structure's storm resistance is known to play a role in whether a household evacuates. For example, households in structures that have been strengthened to resist hurricanes (usually at substantial cost) are more likely to remain in place. In contrast, dwellers in mobile houses are more likely to evacuate. Interestingly, the nature of the household structure is confounded with and supersedes income-level in determining evacuation behavior (Whitehead, et al., 2001). In the form of sandbags, plywood over windows, and generators, some temporary storm resistance may also encourage households to remain in place rather than evacuate. Finally, the ownership of a residence may play a role as ownership may encourage the desire to remain and protect property.

Psychological/Demographic Factors of Evacuation Behavior

Studies have shown the connection of demographic factors with evacuation behavior, including an effect of gender, specific age groups, race, and marital status (Bateman & Edwards, 2002; Horney et al. 2012). It has additionally been postulated that the education, household mobility, and presence of children, disabled, or elderly may affect the evacuation decision. Pet ownership can also lead collectives to limit their evacuations due to the inability to house pets in an emergency or temporary shelters (Whitehead et al., 2000).

Previous experience, and the closely related factor of the longevity of residence in an area affected by hurricanes, are likely to alter the evacuation decision. Households with longer and likely more robust connections to a location

[2] See https://www.chargepoint.com/blog/how-dc-fast-charging-really-works-and-intro-charging-curves

will also be more likely to have friends or family that are regional but outside the evacuation zone. This would affect the evacuation decision and timing and may affect a household's provisional or permanent destination. While prior experience provides a perspective on whether an evacuation is executed, it is likely that a household's risk orientation plays a role in the decision. So called "shadow evacuees" are individuals that are risk-averse and will evacuate despite not living in an evacuation zone.

Policy Variables

Governmental Response and Timing/Evacuation Zones

The role of government and related authorities in the triggering, degree, and scope of an evacuation is paramount. In terms of simulation parameters, their role is focused on the timing of the evacuation announcement, the determination of whether the evacuation is mandatory or voluntary, and the geographic regions to which the evacuation applies. The timing of the evacuation is mainly a determinant of the window that is provided before the hurricane makes landfall. However, it has been shown that the time of day at which the evacuation order is given also has an effect (Pham, et al., 2020). The impact on BEV owners can be more substantial as evacuation orders that start at the beginning of the day will likely provide BEV drivers with the maximum charge in their vehicle.

On the contrary, evacuation orders in the middle or end of the day mean that many BEV drivers have utilized part of their battery charge without the chance to refresh it using their home charger. An early evacuation order can also provide a longer evacuation window. A longer window allows a household to prepare their BEV and achieve maximum charge prior to departure.

Authorities also determine which geographic regions are to be evacuated. This ability can be utilized to create staged evacuations to alleviate congestion and competition for electric and petroleum energy. Additionally, the decision to not declare certain areas for evacuation allows evacuated inhabitants to choose to remain local. This can reduce the demand for energy if these evacuations hold but can also cause subsequent evacuations to be more demanding if the zones are expanded. It is also possible that these non-evacuated regions will subsequently lose power and contribute to evacuation demand for BEV charging.

Evacuation Routes/Destination

The route selected is highly dependent on the destination chosen by the evacuee. Some percentage of the population will travel to local destinations, perhaps even in the evacuation area, deemed to be of lower risk. Barrett et al. (2000) identify other options for evacuees as the nearest safe destination, the safe destination that incurs the least travel time, and the safe destination that requires the least cost. Authorities can also direct evacuees to a defined evacuation point, considering the likelihood of encountering damage or route restrictions along the way.

Other sources of evacuation direction could include external guidance sources like Google Maps, Waze, and Apple Maps. Ironically, congestion along evacuation routes may cause in-vehicle navigation systems to direct traffic to non-evacuation routes. Complicating things, Edelman et al. (1980) found that individuals in other situations often resort to familiar routes when faced with an evacuation. Additionally, some navigation systems built into BEVs will suggest routes with pre-established chargers and stations known by their manufacturer.

Furthermore, households may choose evacuation routes based on their preference of destination, which may be based on perceived housing availability and costs, and with the availability of emergency services at the destination. Perhaps the easiest determiner of an evacuation route is simply the proximity of the route to the residence or starting point of the evacuation for that household. Given the inability to estimate some of the effects of the other factors, it provides a solid basis for initial simulations.

Regardless of the route chosen, the macro effect will be additional vehicles on the roads, leading to increased congestion. This congestion can affect the rate at which BEVs discharge their battery resulting in a confounding effect in a simulation. To develop our model, we collected traffic data during past hurricanes[3]. We are modeling flood maps, demographic data, and vehicle ownership to create a baseline.

POTENTIAL POLICY RECOMMENDATIONS

Our investigation will simulate various policy recommendations to determine the optimal policy mix. We

[3] For instance, real-time traffic data can be sourced from: https://aldotgis.dot.state.al.us/TDMPublic/

highlight three potential policy areas.

Charging Infrastructure

Due to the benefits of overnight charging, we expect our simulation to reveal a benefit to coastal communities that implement mandatory charging infrastructure for all new single and multi-family construction projects. Similarly, we expect that eliminating proprietary connectors will improve evacuation rates. Such policy recommendations are consistent with the work of Adderly et al. (2018).

Mobile Charging

The Interim Report for the Florida Electric Vehicle Roadmap (2020) suggests that mobile chargers may be an available solution to support evacuations. Agencies could deploy such chargers along evacuation routes. Therefore, we will simulate various deployment options, such as in large parking lots or directly on the evacuation route. Additionally, we plan to investigate the optimal mobile charging infrastructure mix. For example, we may find that there are a variety of optimizations available to policymakers.

Vehicle Specifications

There are currently a wide variety of BEVs on the road today. Some feature two-way charging, some feature proprietary connectors, some have substantial battery capacity, and others have efficient charging curves. Policies for vehicle specifications in coastal areas could help ensure that most vehicles in hurricane evacuation zones support optimal evacuation.

CONCLUSION

As societies transition away from fossil fuels and embrace electric mobility, it is important to reevaluate and plan for disaster implications related to their presence. Our WiPe study intends to develop a sophisticated geospatial agent-based simulation of hurricane evacuations in an era of electric mobility. We highlight numerous variables that must be considered and are not traditionally part of disaster evacuation simulation models. Our next steps are to complete the model development and validate our model with ground data collected during past (and future) disasters (e.g., traffic sensors, social media reports, charger wait times). We hope that our final model will allow policymakers to develop creative solutions and avoid common one-size-fits-all solutions to complex problems that impact human lives.

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