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Zero Emission Electric Vehicle Evacuation Readiness Indicators

# Is Your Community Ready to Evacuate with Zero-Emission Vehicles?

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## Acknowledgement

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# Contents

# Glossary

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| **ZEV (Zero-Emission Vehicle)** | A vehicle that emits no exhaust gas or other pollutants from the onboard source of power. This includes battery electric vehicles (BEVs) and hydrogen fuel cell electric vehicles (FCEVs). |
| **EV (Electric Vehicle)** | A vehicle powered by electricity, either fully electric (BEV) or partially through hybrid systems (PHEV). |
| **State of Charge (SoC)** | The current battery level of an EV, expressed as a percentage of its full capacity. |
| **Backup Power** | A power source (e.g., battery storage, generator, hydrogen unit) that can operate independently from the electric grid to supply energy in case of power outages. |
| **Mobile Charging Unit** | A transportable system (e.g., battery trailer, generator) capable of charging EVs temporarily, often used during emergencies or in remote areas. |
| **V2X (Vehicle-to-Everything)** | Technology allowing an EV to supply power back to buildings, grids, or other vehicles (includes V2G, V2H, and V2L applications). |
| **MOU (Memorandum of Understanding)** | A formal agreement between two or more parties outlining collaboration terms, often used between public agencies and private entities. |
| **PSPS (Public Safety Power Shutoff)** | A planned power outage to prevent wildfire ignition during extreme weather events, especially in high-risk zones. |
| **Contraflow** | A traffic management practice where traffic is temporarily directed in the opposite direction on designated roads to increase evacuation capacity. |
| **Spinning Reserves** | Extra electricity generation capacity kept online by grid operators to rapidly respond to sudden increases in demand or system failures. |
| **EVI-X Toolbox** | A modeling tool developed by the U.S. Department of Energy to estimate EV infrastructure needs based on travel behavior and regional characteristics. |
| **Critical Infrastructure** | Essential facilities or systems (e.g., shelters, hospitals, fire stations) that must remain functional during emergencies and require reliable access to energy. |
| **High Fire-Threat District (HFTD)** | A geographic designation for areas in California and other states prone to wildfires, often used for infrastructure planning and risk mitigation. |

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| **P3s (Public-Private Partnerships)** | Collaborative agreements between public agencies (such as governments or municipalities) and private sector companies to jointly develop and manage infrastructure projects or services. In the context of EV infrastructure, P3s can accelerate deployment by leveraging private investment and expertise while sharing risks. |
| **SOPs (Standard Operating Procedures)** | Detailed, standardized instructions describing how specific tasks or processes must be carried out consistently and safely. For emergency EV charging operations, SOPs guide activities such as charger deployment, EV fire management, and hazardous material handling. |
| **US DoE (United States Department of Energy)** | A federal agency responsible for advancing energy policy, research, and development, including initiatives related to clean energy technologies, energy resilience, electric vehicles, and infrastructure planning. The US DoE provides funding, technical guidance, and strategic frameworks for improving energy systems across the country. |

# Executive Summary

This document presents a set of Readiness Markers / Indicators designed to help communities evaluate and strengthen their preparedness for evacuating using Zero-Emission Vehicles (ZEVs) during emergencies such as wildfires, floods, or power outages. With the growing adoption of ZEVs, it is critical for local governments and emergency planners to ensure that charging infrastructure, communication strategies, and backup systems are in place to support safe, equitable, and efficient evacuations.

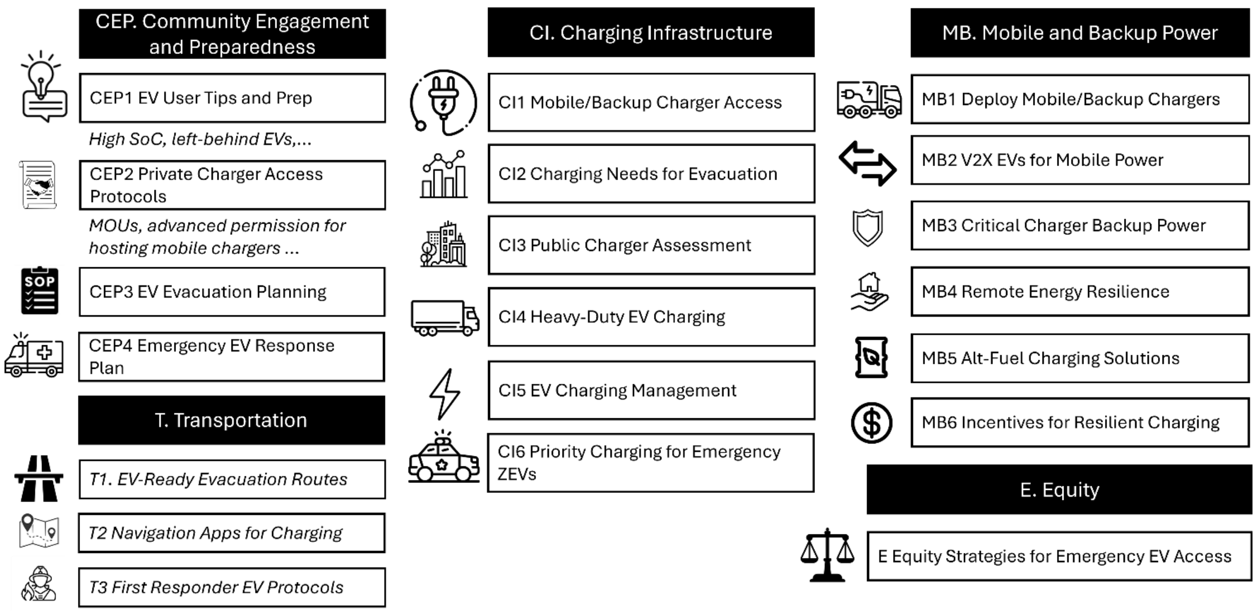



Fig. 1. Overview of Indicators

Each indicator targets a specific niche of preparedness and is classified according to its relation to broader emergency strategies or policy questions.

In particular, some indicators were directly developed to address key policy questions from the EV evacuation planning proposal (e.g., required levels of backup power, equity of access, prioritization for emergency vehicles). Others are tied to specific strategies such as:

- Mobile charger deployment along evacuation routes.
- Free or open access to chargers during disaster declarations.
- Staggered departure planning to avoid congestion.
- Minimum charge reserve protocols for EV users.

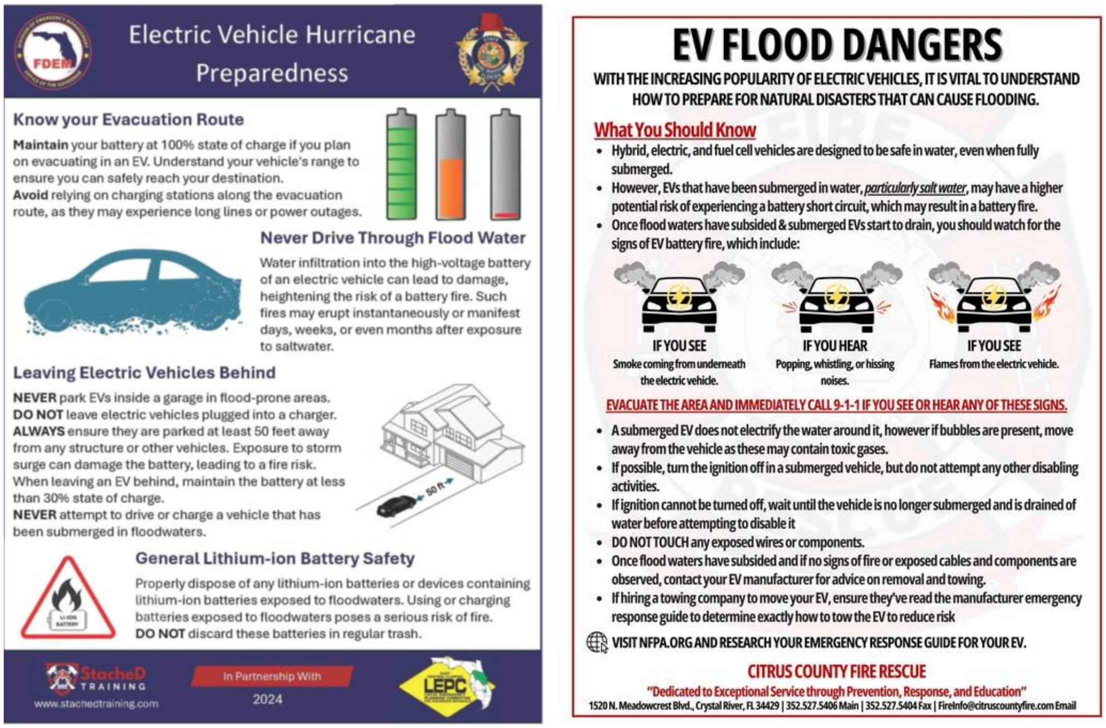
This framework ultimately serves as a practical tool for local agencies, enabling them to identify gaps, prioritize improvements, and develop concrete, actionable emergency preparedness plans tailored to their EV landscape.

# CEP. Community Engagement and Preparedness

## CEP1. EV User Communication and Readiness during Emergencies

| CEP1 | EV User Communication and Readiness during Emergencies |
|---|---|
| **Objective and Description**<br>Effective communication with EV owners before and during emergency evacuations is essential to ensure community safety and mobility. Residents should be encouraged to maintain a high State of Charge (SoC) in their vehicles prior to anticipated natural disasters, in order to avoid being stranded due to power outages, charging congestion, or deteriorating road conditions.<br>Preparedness guidance should include practical charging tips, such as carrying Level 1 and Level 2 charging attachments to enable access to basic outlets when needed. Future planning may also consider implementing a “locked reserve release” protocol, where a minimum battery reserve is preserved and made accessible during evacuation declarations.<br>Communities must also provide instructions for safely managing EVs left behind during evacuations. This includes unplugging vehicles from chargers, parking them on elevated ground to avoid flood zones, reducing their SoC to minimize thermal risks, and avoiding indoor parking for damaged vehicles with lithium-ion batteries. | |
| **Recommended Verification**<br>✓ Any evidence of communication outreach to (social media, website, outdoor billboards, radio announcements, e.g.) | |
| **Examples**<br>i. Electric Vehicle Hurricane Preparedness **\| Town of Belleair Shore**<br>The webpage from the Town of Belleair Shore provides EV owners with hurricane preparedness guidelines, including maintaining a full charge before evacuation, avoiding driving through floodwaters, and proper procedures for parking EVs to mitigate fire risks associated with battery exposure to saltwater.<br>ii. EV Flood dangers **\| Citrus County Fire Rescue**<br>Crucial safety tip sheet regarding EV and flooding. | |

Fig. 2. Tips to be prepared for an evacuation with EV: (a) Adapted from Town of Belleair Shore, “Electric Vehicle Hurricane Preparedness” [11]. (b) Adapted from Citrus County Fire Rescue, “EV Flood Dangers” [12].




**Resources**

- Submerged Vehicle Guidance **| Tesla**
- Hurricane- and Flood-Damaged Vehicles **| National Highway Traffic Safety Administration**
- Staying Safe with Electric Vehicles**| Hillsborough County, Florida**
- Hurricane Ian Is Not a Friend of Electric Vehicles **| Institute for Energy Research**

## CEP2. Emergency EV Charging Access Agreements and Public-Private Coordination

| **CEP2** | **Emergency EV Charging Access Agreements and Public-Private Coordination** |
|---|---|

**Objective and Description**

During emergency evacuations, access to EV charging infrastructure must be rapidly expanded and stabilized. Communities should establish Memorandums of Understanding (MOUs) with private EV charging operators—especially those managing high-capacity locations like malls, stadiums, and parking structures—to make charging resources publicly accessible and operational under emergency declarations.

These agreements should define:

- Priority access for emergency responders and critical services.
- Real-time data sharing with emergency management platforms.

- Temporarily free or unlocked charging, in case of payment system failures.
- Activation protocols outlining who triggers access and under what conditions.

In parallel, coordination with utilities and the deployment of mobile charging solutions must be anticipated to relieve congestion and cover gaps in fixed infrastructure. These efforts require clear communication protocols and joint planning mechanisms.

By formalizing these actions through public-private partnerships (P3s), communities can accelerate infrastructure readiness, reduce risks for public agencies, and ensure that EV users—especially in high-risk or underserved zones—maintain mobility during evacuations.

**Recommended Verification**

- ✓ Signed MOUs or agreements with private EV charging operators specifying emergency protocols, including access, prioritization, and fee waivers.
- ✓ Operational procedures defining how private charging infrastructure will be activated and managed during declared emergencies.
- ✓ Evidence of integration with emergency management systems, such as real-time charger status sharing or communication protocols.

  Documentation of coordination efforts, such as planning meetings, simulation exercises, or joint emergency response drills with utilities and private charging partners.

**Examples**

i. [Michigan State Plan for EV Infrastructure Deployment](#) **| State of Michigan**

Michigan's State Plan for EV Infrastructure Deployment: Michigan's plan emphasizes collaboration with both governmental agencies and private entities to construct EV charging stations, ensuring infrastructure resilience during emergencies.


Fig. 3. Collaboration in the State of Michigan

**MEMORANDUM OF UNDERSTANDING**
**BETWEEN**
**THE MAYOR AND CITY COUNCIL OF BALTIMORE**
**AND**
**BALTIMORE GAS AND ELECTRIC COMPANY**
**FOR INSTALLATION OF ELECTRIC VEHICLE CHARGING STATIONS**

**THIS MEMORANDUM OF UNDERSTANDING** (the "MOU"), is entered into this 26th day of May, 2020, by and between the Mayor and City Council of Baltimore, a municipal corporation of the state of Maryland, acting by and through its Department of Transportation (collectively, the "City") and Baltimore Gas and Electric Company ("BGE"), a public utility duly organized and existing under the laws of Maryland.

**WHEREAS**, the City desires to promote the use of electric vehicles in the City and to improve the City's electric vehicle charging infrastructure through installation of publicly-available electric vehicle charging stations and related equipment (collectively, "EV Stations") at various locations on City owned property and right of way; and

**WHEREAS**, BGE has implemented the EVsmart program to encourage the usage of electric vehicles in the City and elsewhere throughout BGE's electric distribution service territory; and

**WHEREAS**, BGE owns EV Stations and wishes to install them in City-approved locations throughout the City in accordance with the terms of this MOU and the directives of the Maryland Public Service Commission; and

**WHEREAS**, the City is willing to permit the installation, maintenance and operation of EV Stations by BGE on City property pursuant to this MOU, and in the event of installations on City right of way and Recreation and Parks' property provided BGE obtain a franchise as required by the City Charter, the cost of which, if any, is to be determined by the City Board of Estimates; and

**WHEREAS**, the City and BGE desire to enter into this MOU to set forth the terms and conditions by which BGE may install, maintain and operate its EV Stations in the City

**NOW, THEREFORE,** for and in consideration of these premises and the mutual covenants herein contained, it is agreed by and between the parties hereto as follows:

**I. Purpose of MOU**

The purpose of this MOU is to establish a framework for BGE to provide EV Stations at agreed locations in the City on a no-cost, turnkey basis for the City (the "Project"). The Project includes installation, supplying electric power, technical and labor support as well as data analytics and monthly reporting, and maintenance and repair of the EV Stations. The EV Stations must be made available to the public on a first come, first served basis 24 hours per day, seven days a week for a period of five (5) years unless the Project is terminated sooner in accordance with this MOU or by the Maryland Public Service Commission.

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Fig. 4. Memorandum of Understanding (MOU) for Installation of Electric Vehicle Charging Stations, adapted from City of Baltimore and BGE [13].

**ii. MOU between The Mayor and City Council of Baltimore and Baltimore Gas and Electric Company for Installation of Electric Vehicle Charging Stations | City of Baltimore**

The City of Baltimore and BGE signed an MOU to install, operate, and maintain public EV charging stations on city property, with a focus on equitable access.
This agreement can serve as a model for developing future MOUs in California to support EV-based evacuations.

**Resources**

- A toolkit for planning and funding rural electric mobility infrastructure | **Department of transportation**
- Public Private Partnerships| **Transportation.gov**
- An EV future: Navigating the transition | **U.S. Department of Energy Advanced Grid Research & Development Division by Arara Blue Energy Group**

## CEP3. Community Planning for ZEV-Based Emergency Evacuations

| **CEP3** | **Community Planning for ZEV-Based Emergency Evacuations** |
|---|---|

**Objective and Description**

This indicator assesses whether a community has established dedicated plans and strategies for conducting emergency evacuations involving ZEVs. As EV adoption grows, it is essential to address EV-specific challenges such as charging infrastructure availability, route optimization, and roadside assistance.

A well-developed EV evacuation plan should ensure community preparedness through:

- Maintaining an up-to-date registry of EV owners to support targeted communication.
- Promoting awareness about best practices, such as keeping battery levels above 80% and knowing the designated evacuation routes.
- Offering online resources, including detailed EV evacuation plans with charging locations, usage tips, and navigation tools.
- Mapping evacuation routes with mobile and fixed charging infrastructure in place.
- Including traffic management strategies, such as staggered evacuation times by neighborhood or zone, to reduce road congestion and pressure on charging infrastructure.
- Ensuring public transport options (e.g., buses, trains) are available for those unable to evacuate with their EVs.

Collaboration with emergency services, utilities, and local agencies is essential to make these plans actionable and resilient.

*See CEP1 for more information on communication.*

**Recommended Verification**

✓ Existence of an official EV evacuation plan published by the community (e.g., available on the local government's website).

✓ Identification and mapping of EV-friendly evacuation routes with charging stations and mobile charging options.

✓ Evidence of community awareness campaigns (e.g., public meetings, social media, educational materials) to inform EV owners about evacuation procedures.

✓ Collaboration with emergency management agencies and utility providers to ensure a coordinated response for EV-based evacuations.

✓ Implementation of real-time communication systems to inform EV users about charging station availability and evacuation route status.

✓ Planning for worst-case scenarios, including alternative transportation solutions (buses, trains) for EV users unable to evacuate with their vehicles.

**Examples**

- Emergency Evacuation of Florida **| Central Florida Clean Cities Coalition**

This report highlights significant challenges in evacuating EVs during emergencies due to limited fast-charging infrastructure, especially along key evacuation routes like I-75 and I-10. With over 60,000 registered EVs in Florida and a growing adoption rate, the report emphasizes the need for strategic planning, including the deployment of mobile charging

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| units and the expansion of fast-charging networks, to ensure effective and safe evacuations. |
| **Resources**<br>• [California's Deployment Plan for the National Electric Vehicle Infrastructure Program](#) **\| California Energy Commission**<br>• [Emergency Evacuation of Florida](#) **\| Central Florida Clean Cities Coalition** |

## CEP4. Community has plans to conduct emergency response of EVs-based evacuation

| **CEP4** | **Community evacuation plans include procedures for safely removing battery EVs, which may pose fire and contamination risks if left behind** |
|---|---|
| **Objective and Description**<br>As EV adoption increases, emergency evacuation planning must address the specific hazards posed by EVs left behind during disasters, particularly in fire-prone regions. EV battery fires present risks not only of intense heat and toxic smoke, but also of re-ignition and environmental contamination.<br>If an evacuation extends over several days, EVs that catch fire may continue to emit toxic substances, putting nearby residents and emergency workers at risk. Air quality must be monitored around burned vehicles to reduce exposure to harmful micro-particles. Similarly, runoff water may be contaminated by lithium-ion battery byproducts—such as heavy metals and fluorides—which can spread beyond the evacuation zone and impact water systems in surrounding communities.<br>Research confirms that thermal runaway events release hazardous substances into soot and firefighting water at concentrations well above safety thresholds [1]. Real-life events, such as California wildfires, have shown that abandoned EVs can reignite and exacerbate contamination risks.<br>A comprehensive plan should include:<br>- Specialized first responder training;<br>- Standard procedures for isolation, firefighting, and environmental monitoring;<br>- Deployment of air and water quality sensors;<br>- Post-fire handling and storage of EVs to prevent further incidents. | |
| **Recommended Verification**<br>✓ Documentation of Standard Operating Procedures (SOPs) for managing EVs during evacuations, including fire suppression, vehicle isolation, and hazardous material containment.<br>✓ Evidence of air and water quality monitoring protocols, especially near EV fire sites or storage locations.<br>✓ Records of training sessions or technical guidance provided to first responders on EV-specific risks (e.g., battery fires, re-ignition, contamination).<br>✓ Emergency planning documents that include post-incident procedures for transport and safe storage of damaged EVs. | |

**Example**

i. **Thermal Runaway and fire of electric vehicle lithium-ion battery and contamination of infrastructure facility | Renewable and Sustainable Energy Reviews**

The water used to extinguish an EV battery fire showed extremely high contamination levels. Storage water exhibited a pH of 12 and fluoride concentrations 220 times above Swiss drinking water limits. Lithium concentrations exceeded typical German drinking water levels by over 30,000 times, while heavy metals such as nickel, cobalt, and manganese exceeded permissible drinking water thresholds by factors of 1,000–2,800. These findings, supported by the table below, highlight the severe environmental hazards of battery fires, with potential risks to water quality and public health in the aftermath of EV incidents.

**Table 13**
Comparison of contamination of sprinkling and storage water with limit and background levels.

| Contaminant/ Parameter | Unit | Sprinkling water | Storage water | Process water | Drinking water limit values [1] | Industrial effluent limit value [2] |
|---|---|---|---|---|---|---|
| pH value | - | 8.2 | 12.3 | 8 | 6.8 - 8.2 | 6.5 - 9.0 |
| Chloride | mg/l | 2 | 22 | 3 | 250 | n.s. |
| Sulphate | mg/l | 34 | 98 | 2 | 250 | n.s. |
| Nitrate | mg/l | 2 | < 1 | < 1 | 40 | n.s. |
| Phosphate | mg/l | <1 | < 1 | < 1 | 1 | n.s. |
| Fluoride | mg/l | 8 | 330 | < 1 | 1.5 | n.s. |
| PAH [c] | µg/l | 0.001 [a]<br>0.36 [b] | 0.02 [a]<br>0.02 [b] | 0.001 [a]<br>< 0.001 [b] | 0.1 | n.s. |
| Benzo[a]pyrene | µg/l | < 0.001 [a]<br>0.07 [b] | 0.004 [a]<br>0.01 [b] | < 0.001 [a]<br>< 0.001 [b] | 0.01 | n.s. |
| Nickel | µg/l | 36000 [a]<br>48400 [b] | 55000 [a]<br>181000 [b] | < 700 | 20 | 2000 |
| Cobalt | µg/l | 36000 [a]<br>46000 [b] | 50000 [a]<br>181000 [b] | < 400 | n.s. (≤ 70) | 500 |
| Manganese | µg/l | 36000 [a]<br>44000 [b] | 53000 [a]<br>199000 [b] | < 1300 | 50 | n.s. |
| Lithium | µg/l | 7000 [a]<br>2200 [b] | 1460000 [a]<br>31000 [b] | < 1300 | n.s. (≤ 40) | n.s. |

[a] Content, dissolved/ [b] Content, particle-bound/ [c] Sum of Benzo[b]fluoranthene, Benzo[k]fluoranthene, Benzo[ghi]perylene, Indeno[1,2,3-cd]pyrene
[1] Limit values for drinking water in Switzerland in accordance with the Decree of the Swiss Federal Department of Home Affairs (EDI) regarding the water and drinking water in baths and shower facilities that are accessible to the public (TBDV, 2016)
[2] Discharge limit values for industrial effluent into Swiss sewage system in accordance with the Swiss Waters Protection Ordinance (GSchV) (2014)
n.s. = not specified
Color code key for the table:
green = lower than limit value for drinking water
yellow = up to 10x over the limit value for drinking water
orange = 50x to 200x over the limit value for drinking water
red = > 500x over the limit value for drinking water

Fig. 5. Comparison of contamination levels in sprinkling and storage water from EV battery fires, adapted from Held et al. [14].

**Resources**

- **EV: Emergency operating best practices | Delaware Valley Regional Planning Commission**
- **California Wildfires Show Challenges Of EV Battery Disposal After Car Accident or Explosion | PiTTMAN Law Firm**

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|---|
| • **Best Practices for Emergency Response to Incidents Involving EVs Battery Hazards \| The Fire Protection Research Foundation** |

# CI. Charging Infrastructure

## CI1. Community has access to mobile charging/backup power to support EV chargers that are at high risk of congestion or loss of power

<table>
<tr><th>CI1</th><th>Community has access to mobile charging/backup power to support EV chargers that are at high risk of congestion or loss of power</th></tr>
<tr><td colspan="2">Objective and Description<br>The community has secured access to mobile charging and backup power resources to support EV chargers in areas at high risk of congestion or power loss during emergencies. These resources, including portable EV chargers and mobile power stations, can be strategically deployed to critical locations such as evacuation routes and disaster-prone zones. By pre-positioning and coordinating these assets with emergency response teams and private operators, the community can mitigate the risk of stranded vehicles due to low battery levels.<br>In addition to serving as emergency response tools, mobile charging systems can act as substitutes for fixed installations in areas where budget constraints, grid limitations, or site barriers prevent permanent EV infrastructure. These units draw and store power at flexible locations, allowing them to be used without requiring major grid upgrades or installations. Mobile chargers can also charge during non-emergency periods, reducing electricity costs and grid strain. However, these solutions come with high upfront costs and operational limitations, such as battery capacity constraints and potential staffing needs for proper operation.<br>To maximize their effectiveness, the community must:<br>– Provide a real-time communication system to inform residents about the availability and location of emergency charging options.<br>– Establish agreements (MoU) with possible site hosts to facilitate the deployment and maintenance of mobile chargers.<br>– Assess feasibility and cost-effectiveness by considering mobile chargers as temporary solutions or complements to permanent charging infrastructure.</td></tr>
<tr><td colspan="2">Recommended Verification<br>✓ Documentation of the deployment strategy for mobile chargers (e.g., number of units, deployment locations, responsible entities).<br>✓ Evidence of agreements with site hosts and emergency response agencies.<br>✓ Cost-benefit analysis comparing mobile chargers and fixed EV charging solutions.</td></tr>
<tr><td colspan="2">Example<br>i. Mobile EV Chargers Provide Florida Evacuation Security | DesignNews<br>In October 2024, the Florida Department of Emergency Management installed up to 10 temporary, single-port, 50 kW fast EV charging stations along the I-75 and I-4 evacuation corridors to assist EV drivers during Hurricane Milton evacuations.</td></tr>
</table>


Fig. 6. Mobile EV chargers by Mullen Automotive's truck, adapted from Carney [15].

**Resource**

- EV Charging Access for Multifamily Housing Residents CLEE Report | **Berkeley**

## CI2. Community is aware of charging energy needs for evacuation

| CI2 | Community has estimated the amount of energy required to evacuate various parts of evacuation zone |
|---|---|

**Objective and Description**:

During an EV-based evacuation, there might be a significant increase in energy demand, as more EVs will require charging, especially if evacuation distance is high. This surge in electricity consumption will impact both the evacuation zone and the surrounding areas. To address this challenge, the community should develop a mechanism to estimate the amount of power and energy required for residents to evacuate safely. This estimation should include multiple factors, such as:

- Evacuation distance,
- Number of EVs,
- Time to evacuate,
- Number of charging stations.

Additionally, the community can use the EVI-X Toolbox to estimate how much EV infrastructure is needed to support typical daily travel in a given state or metropolitan area, with an option to account for ride-hailing applications.

By considering these factors, the community can ensure that sufficient energy resources are available during an evacuation, reducing the risk of power shortages and enabling a smoother response in times of crisis.

**Recommended Verification**

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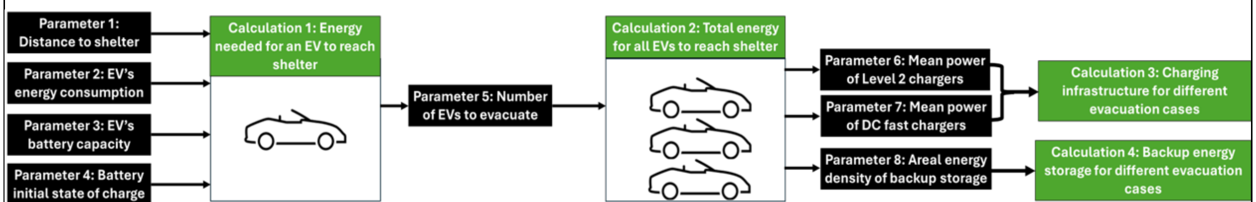
| ✓ Documentation of energy demand estimations based on different evacuation scenarios (e.g., number of EVs, distance to shelters, variable charging levels).<br>✓ Use of modeling tools such as EVI-X Toolbox to determine necessary EV infrastructure and power requirements. |
| **Example**<br>**i. Planning for electric-vehicle evacuations: energy, infrastructure, and storage needs \| IEEE VPPC**<br>This tool uses a pragmatic stochastic method for estimating the energy needs for EVs during evacuation and the power needs of charging infrastructure and also the size of the required backup energy storage to power the EVs for different evacuation scenarios [2].<br><br>Figure 1. Planning for EV Evacuation: Summary of the tool developed [2] |
| **Resources**<br>• **How much electricity would it take to power all cars if they were electric? \| USA Facts**<br>• **Can we evacuate from hurricanes with electric vehicles? \|Science direct**<br>This paper discusses and analyzes the energy needs of Florida during the evacuation via EVs because of hurricane Irma. |



## CI3. Assessment of Public EV Charging Infrastructure for Emergency Evacuations

| **CI3** | **Assessment of Public EV Charging Infrastructure for Emergency Evacuations** |
|---|---|
| **Objective and Description**:<br>This indicator deals with all the available L2/DC fast chargers in the evacuation region or the specified region under analysis. The private/shared level 1 chargers are considered in the previous indicators mainly. This indicator specifically deals with the number of commercial chargers available for the charging of EVs.<br>This includes comparing the number of chargers available and the number of EVs in the region then carrying out analysis to understand the following:<br>- What is the ratio between the number of chargers and total number of EVs and is there any region under stress under normal conditions.<br>- What are the risks of congestion at certain charger locations under evacuation process. | |

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| - Point out the areas of concern and take steps to make sure that the unforeseen circumstances don’t occur during the evacuation process.<br>- Carry out sensitivity analysis using different number of EVs and different evacuation times to understand the impact of changing each parameter on the traffic and congestion. |
| **Recommended Verification** |

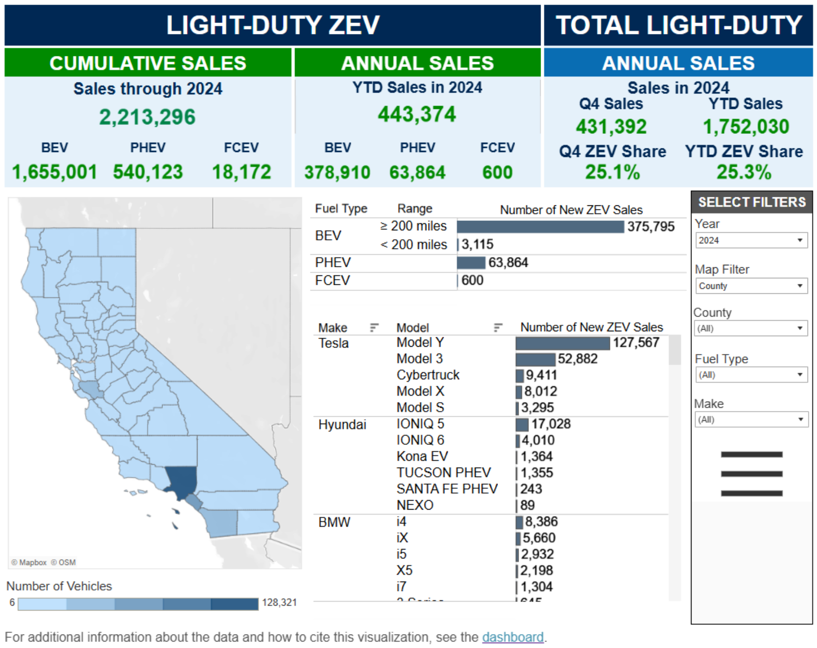


Figure 2. New ZEV Sales in California: Dashboard (from California Energy Commission)

✓ Check out the number of EV chargers Electric vehicle chargers from California and total number of EVs from New ZEV Sales in California (data from California Energy Commission official website).

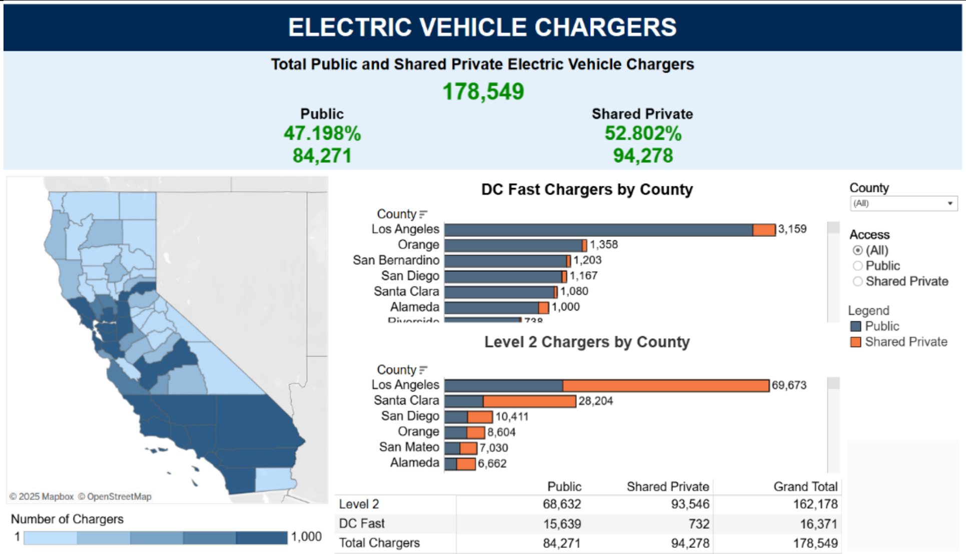


Figure 9. Electric vehicle chargers: Dashboard from California Energy Commission [18]

**Example:**

*i. See example given in CI2.*

**Resources:**

- EV Charging Guidebook | **California governor's office of business and economic development**

CI4. Community has considered the charging of electric heavy-duty vehicles which are either helping in charging (mobile charging units) or needed in evacuation

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|---|---|
| **CI4** | **Community has considered the charging of electric heavy-duty vehicles which are either helping in charging (mobile charging units) or directly in evacuation** |

**Objective and Description**

This indicator caters for the possibility of having electric heavy-duty vehicles that can provide the basis for having a mobile energy storage unit which can be used to charge EVs that are not being able to evacuate due to power loss and low battery power. These Evacuation Support Vehicles (ESVs), *such as e-buses,* can also be used to help a group of people to reach safe locations or shelters.

The following are a few of the key points that should be kept in mind while thinking about deploying ESVs for charging or evacuation purposes.

- ESVs will require a significant amount of power, but only for a relatively short duration. Given this brief yet intense energy demand, communities should estimate the expected surge in power consumption during an evacuation and determine how long this peak is likely to last. These estimates can be based on previously available local data, such as past vehicle deployments, usage profiles, and energy consumption patterns.

- The number of ESVs that need to be deployed for evacuation should be considered based on certain parameters such as: the ability of the zone's power system to withhold the surge in power consumption under stress, road conditions and effective number of EVs that would be used during an evacuation.
- Community has reserved L-2 or DC fast chargers for the charge of these ESVs. These chargers can either be deployed in certain locations that can only be used by ESVs or reserved at already available charging stations can be designated as "only for ESVs".

This indicator would help the community deploy ESVs more efficiently while making sure it does not put the power system under major stress.

**Recommended Verification**

✓ Consult official data from the California Energy Commission to identify the number of electric heavy-duty vehicles currently available in the region.

✓ Availability of ESVs at different routes is being updated in real-time to an app so that users can plan their routes accordingly.

**Example**

i. **Flexible Off-Grid Mobile EV Charging Service | SparkCharge**
SparkCharge's Charging-as-a-Service (CaaS) provides a flexible and scalable solution for EV charging needs, particularly in scenarios where traditional infrastructure is lacking or insufficient.

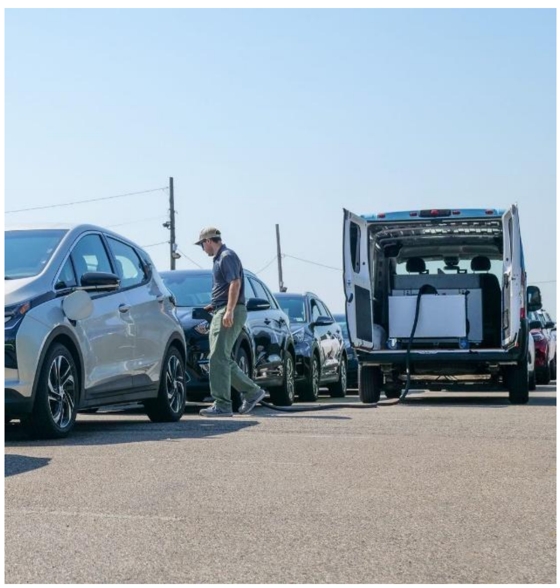

Fig. 10. Flexible off-grid mobile EV charging service, adapted from SparkCharge [19].

**Resources**

- **Hurricane Milton Example | DriveElectric**
- **Standalone systems | energy.gov**
- **Tesla Deployment of Megapack Superchargers | Tesla**
- **Lightning emotors Simulation and ESV info | Lightning emotors**

## CI5. EV Charging Management and Allocation During Emergencies

| **CI5** | **EV Charging Management and Allocation During Emergencies** |
|---|---|
| **Objective and Description**<br>During evacuations involving EVs, public charging infrastructure must be effectively managed and dimensioned to handle surges in demand and ensure that EV users can reach their final evacuation destinations safely.<br>This indicator evaluates whether the community has established clear operational procedures to:<br>- Prioritize access to EV charging stations (e.g., for emergency responders, vulnerable populations),<br>- Limit individual charging sessions to promote station turnover,<br>- Deploy on-site personnel or use digital tools (e.g., apps, SMS, signage) to coordinate charging flows and communicate real-time availability.<br>A key component is capacity planning: communities should estimate the number of EVs expected per evacuation zone or route, and determine whether available infrastructure can absorb projected demand. Where necessary, temporary or mobile charging units should be pre-positioned to close the gap. *(see indicator CI2)*<br>Most modern chargers offer load management capabilities, enabling dynamic power allocation across multiple EVs. In addition, real-time routing tools (maps or notifications) should guide evacuees to available chargers. In coordination with utility providers, load shedding protocols may also be activated to avoid local grid failures and maintain system stability during peak demand. | |
| **Recommended Verification**<br>✓ Documented emergency procedures for regulating public EV charging access, including prioritization criteria and time limits per user.<br>✓ Use of real-time management tools, such as mobile apps, queue systems, or dynamic signage to coordinate access and provide live updates.<br>✓ Evidence of capacity planning that estimates the number of EVs expected per evacuation zone or route, compares it to existing charging infrastructure, and outlines the deployment of temporary or mobile chargers when demand exceeds capacity. | |
| **Example**<br>i. Smart Charge Management Applications and Benefits for Federal Fleets **\| US DoE**<br>The U.S. Department of Energy has developed Smart Charge Management systems that optimize EV charging schedules, reduce load peaks, and support critical operations by prioritizing vehicle and facility energy needs. These smart systems can be used during emergency evacuations to dynamically manage charger availability, prevent grid overloads, and ensure charging access for prioritized users. | |

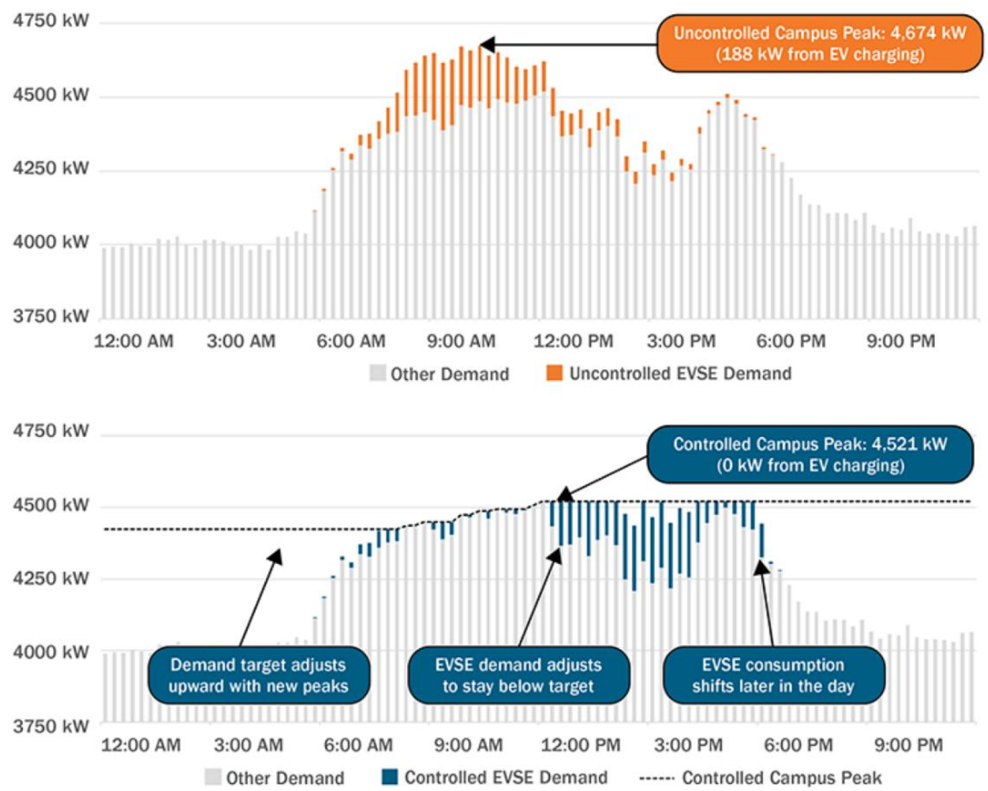


Fig. 11. Smart charge management for federal EV fleets, adapted from U.S. Department of Energy [20]

**Resources**

- **Kempower company, Blink | Standalone systems and mobile charging support**
- **Standalone systems | energy.gov**
- **Tesla Deployment of Megapack Superchargers | Tesla**

CI6. Protocols are in place to ensure priority access for ZEV-based emergency vehicles at public and private charging stations during disasters.

| | |
|---|---|
| **CI6** | **Protocols are in place to ensure priority access for ZEV-based emergency vehicles at public and private charging stations during disasters.** |

**Objective and Description**

During emergencies, zero-emission emergency vehicles—such as electric ambulances, fire trucks, or police vehicles—must remain operational to ensure public safety and response efficiency. This indicator assesses whether communities have established protocols that guarantee priority access to public and private EV charging stations for these critical vehicles during disasters or evacuations.

Such protocols may include pre-established agreements with charging infrastructure providers, dynamic access control mechanisms, and dedicated charging slots or time

| |
|---|
| windows for first responders. The involvement of both utilities and charging operators is essential to coordinate service continuity and avoid congestion during high-demand periods.<br>Priority charging protocols improve community resilience by reducing downtime for emergency fleets, particularly in disaster-prone or high-risk areas. These measures must be integrated into broader emergency planning and supported by appropriate communication systems. |
| **Recommended Verification**<br>✓ Existence of formal protocols or MOUs ensuring priority charging access for emergency ZEVs during disasters.<br>✓ Documentation showing coordination between public agencies, utilities, and charging providers on emergency access.<br>✓ Evidence of dedicated charging access (e.g., reserved ports, time windows) for first responders in emergency plans.<br>✓ Inclusion of priority charging measures in the community's emergency preparedness or transportation resilience strategy. |
| **Example**<br>As of today, there is no regulatory framework in place for prioritizing electric emergency vehicles at charging stations during natural disasters. |
| **Resources**<br>• See References [3], [4], [5] |

# MB. Mobile and Backup Power

## MB1. Planning and Deployment of Mobile Charging and Backup Power Units During Emergencies

| **MB1** | **Planning and Deployment of Mobile Charging and Backup Power Units During Emergencies** |
|---|---|
| **Objective and Description**<br>In emergency situations where the electric grid is disrupted or existing EV infrastructure is overwhelmed, communities must ensure both access to mobile charging and backup power units and the strategic pre-positioning of these resources at safe and accessible sites [6], [7].<br>These resources may include portable battery trailers, generator-based chargers (e.g., diesel, hydrogen), and vehicle-to-everything (V2X) systems capable of temporarily supplying energy to electric vehicles.<br>This indicator assesses whether the community has:<br>- Determined and secured the minimum number of mobile charging units needed, based on the difference between the local ZEV population, existing charging capacity, expected energy demand during emergencies, and blackout risk;<br>- Pre-identified safe, low-risk deployment locations using spatial analysis (e.g., proximity to evacuation routes, land use, power outage risk, road network density);<br>- Established agreements (MOUs) with public or private site hosts to guarantee site accessibility during crises;<br>- Developed clear activation protocols, specifying how and when mobile units are deployed and who coordinates operations with utilities and emergency services.<br>Special attention must be given to rural or geographically isolated areas where fixed infrastructure may be unavailable. Planning ahead ensures that all EV users, particularly those in underserved areas, have safe and reliable access to energy during evacuations, supporting equitable mobility and community resilience. | |
| **Recommended Verification**<br>✓ Inventory of mobile charging and backup power units, specifying quantity, type, and storage location.<br>✓ Risk-based site selection analysis identifying prioritized deployment sites along evacuation routes.<br>✓ Emergency deployment protocols detailing activation triggers, responsible entities, and coordination with utilities or emergency managers.<br>✓ Signed MOUs or agreements with site hosts ensuring access during emergencies. (See indicators CI1 and CI4). | |
| **Example**<br>i. Florida's Mobile EV Charging Deployment during Hurricane Milton \| **Joint Office of Energy and Transportation** *(link to MC1 example)*<br>In preparation for hurricane season, the Florida Department of Emergency Management, in coordination with Garner Environmental Services, identified and | |

mapped strategic deployment sites along major evacuation routes for mobile EV charging units. These sites included rest stops, shopping center parking lots, and other large public-access locations deemed safe, accessible, and low-risk.

**Resources**

- How to Calculate Your Power Needs **| UC Denver**
- Electric Vehicle Charging Station Permitting Guidebook **| California governor's office of business and economic development**

## MB2. Large EV vehicles with V2X can be mobilized as mobile chargers (e.g. to power shelters or stranded EVs)

| MB2 | Large EV vehicles with V2X can be mobilized as mobile chargers (e.g. to power shelters or stranded EVs) |
|---|---|

**Objective and Description**

During disasters or extended outages, V2X, such as bidirectional electric school buses, transit vehicles, or fleet trucks, can act as mobile power sources to support critical community needs. These vehicles can supply electricity to shelters, stranded EVs, emergency centers, or key infrastructure when the grid is compromised.

This indicator assesses whether communities have integrated V2X-equipped large vehicles into their emergency preparedness strategies. Effective planning should include:

- Mapping available V2X-capable vehicles and their technical capabilities (power output, duration of supply);
- Identifying priority loads and facilities (e.g., emergency shelters, communication hubs) where mobile energy support is critical;
- Establishing pre-disaster agreements (MOUs) with fleet owners (e.g., school districts, municipal services, private operators) to deploy V2X assets rapidly;
- Ensuring vehicles are pre-equipped with the necessary hardware and software for safe bidirectional energy transfer;
- Coordinating dispatch and operation protocols between fleet managers, utilities, and emergency management agencies.

**Recommended Verification**

- ✓ Inventory of available V2X, including vehicle types, technical specifications (power output, energy storage capacity), and their deployment readiness.
- ✓ Signed MOUs or agreements with fleet owners (e.g., school districts, municipal fleets, private operators) outlining conditions for emergency deployment and energy support.
- ✓ Operational deployment plan identifying critical facilities to be powered, dispatch protocols for V2X vehicles, and coordination strategies with utilities and emergency management agencies.

**Example**

i. Emergency response concept EV powered by CHAdeMO's bi-directional (V2X) function **| CHAdeMO**

Nissan's "RE-LEAF" concept, a prototype EV designed to provide mobile power in the aftermath of natural disasters, using V2X functionality to power essential equipment on the ground.

Fig. 12. Nissan's "RE-LEAF" concept to provide power following a natural disaster, adapted from CHAdeMO [21].

**Resources**

- V2X Implementation Guide **| Electrification Coalition**
- Vehicles-to-Grid Integration Assessment Report **| U.S DoE**

## MB3. Critical EV charger locations are identified, and availability of backup power is confirmed

| **MB3** | **Critical EV charger locations are diagnosed, and availability of backup power is confirmed** |
|---|---|

**Objective and Description**:

This indicator focuses on identifying strategically important EV charging stations and ensuring they are equipped with reliable backup power to maintain continuous charging availability during emergency evacuations or grid disruptions [7], [8].

Key evaluation steps include:

- Mapping the ratio of EV chargers to EVs within the community. Communities must identify high-demand or vulnerable charging stations most critical during evacuations.
- Prioritizing charging stations based on the city's or region's official evacuation plans. Stations located along primary evacuation routes, near critical shelters, or in remote areas should be prioritized for support.
- Applying network analysis and queuing models (as discussed in recent research) to estimate service rates, congestion risk, and identify key bottleneck chargers that must remain operational during an evacuation.

- Once strategic sites are selected, assessing backup power solutions based on available space, energy requirements, and emergency deployment feasibility.
- Solutions may include battery storage systems, renewable energy microgrids, and -where necessary- fossil fuel generators such as diesel or hydrogen-based units.
  Implementing real-time monitoring of charger availability and functionality to optimize usage distribution and relieve pressure on overburdened sites.

**Recommended Verification**

- ✓ Mapping of critical charging stations prioritized based on evacuation routes, shelter proximity, and congestion risk (supported by evacuation plans or local emergency response documents).
- ✓ Backup power feasibility assessment for each prioritized charging location, detailing the type of backup system installed (battery, microgrid, fossil generator).
- ✓ Service capacity analysis or queueing model results demonstrating identification of high-stress or bottleneck charging stations during evacuation scenarios.
  Real-time monitoring protocols or contingency plans for charger status updates during emergencies to optimize user guidance and load balancing.

**Example**

i. [Renewable Energy Generation Operations Begin at Electrify America Solar Glow™ 1] **| Electrify America**

Electrify America has deployed battery energy storage systems at over 150 of its fast-charging stations across the United States. These installations store energy during off-peak hours and improve station reliability by reducing grid demand during peak periods. The battery systems enhance the resilience of the charging infrastructure, helping to maintain service continuity even during grid instability.

Fig. 13. Solar Energy Generation, adapted from Electrify America [22].

**Resources**

- California Energy Commission website for the number of EV chargers **| CEC**
- California Energy Commission website for the number of EVs **| CEC**
- Standalone systems **| energy.gov**
- Kempower company, Lightning emotors & Blink **| Standalone systems and mobile charging support**

| |
|---|
| • **Tesla Deployment of Megapack Superchargers \| Tesla** |

## MB4. Resilience of power systems at remote location is maintained and dependable alternatives are suggested

| **MB4** | **Resilience of power systems at remote location is maintained and dependable alternatives are suggested** |
|---|---|
| **Objective and Description**<br>During evacuations, evacuees that have access to urban areas and EV chargers near their homes would have higher chances of getting their EVs charged and leave the hazard location faster. The only thing that would slow down the process of evacuation would be the evacuees that don't have access to DC fast chargers and power cuts can cause some of evacuee stress as it would hinder the initial charging of the EVs [9].<br>For the readiness of this indicator the following measures can be taken:<br>- All the residents are advised to keep their EVs charged to at least 40-50% at any time.<br>- Residents are suggested to keep private backup power at their residence that can be used in the case of emergency.<br>- ESVs can be placed in the middle of the remote location and nearest shelter/Major EV charging location to make sure everyone evacuates the remote area safely.<br>Installing the standalones system would also help a lot in this aspect as it would not require any connection to the power grid and works on its own. These points would make sure this indicator is checked for before the evacuation. This would confirm that every resident of the rural area is evacuated safely. | |
| **Recommended Verification**<br>✓ Residents have private backup power at their residence that has enough supply to charge a EV to make sure that it can reach a shelter location or EV charging spot.<br>✓ Residents keep their EVs charged at least 40-50% so that in case of emergency they can leave the hazard location.<br>✓ ESVs with remote charging units are placed in between the remote locations and the major EV charging spots (this can be mobile EV charging locations or the already available EV charging locations with huge backup power to support the surge of EVs).<br>✓ ESVs are then used to evacuate any remaining residents who have not been able to leave the location. | |
| **Example**<br>i. **Blink Mobile Level 2 chargers that can provide assistance in case of emergency \| Blink**<br>Blink Charging has introduced a mobile Level 2 charger designed to provide emergency EV charging, enhancing range confidence for drivers in areas lacking traditional charging infrastructure such as remote locations. | |


Fig. 14. Blink Mobile Chargers for Emergency EV Charging, adapted from Blink Charging [23].

**Resources**

- **[Energy Reliability and Resilience](#) | US DoE**

MB5. Re-charging options for ZEVs with alternative fuels (e.g. hydrogen) are identified and available

| **MB5** | **Re-charging options for ZEVs with alternative fuels (e.g. hydrogen) are identified and available** |
|---|---|

**Objective and Description**

ZEVs require resilient recharging solutions to ensure their operability during emergency evacuations, especially in areas where grid-dependent infrastructure may be disrupted or unavailable. Beyond battery-based mobile chargers, communities must plan for off-grid recharging options using alternative fuels.

These solutions include:

- Hydrogen fuel cell generators, offering mobile, zero-emission power for EV fast charging;
- Biodiesel-powered generators, providing a flexible, widely available, and lower-carbon alternative to conventional diesel for temporary EV charging stations;
- Hybrid microgrids integrating renewables with backup fossil or biofuel generators to stabilize energy supply during peak evacuation periods.

To enhance energy resilience, the community should:

- Identify and map hydrogen, biodiesel, and other alternative fuel recharging assets available for emergency use;
- Assess technical and logistical feasibility of deploying these systems at critical locations along evacuation corridors and in remote areas;
- Establish MOUs or partnerships with hydrogen suppliers, biodiesel fuel providers, and mobile charging service operators;
- Integrate off-grid and alternative fuel charging solutions into emergency response plans, ensuring continuous access for EV users even under severe grid disruptions.

- Integrate mobile and stationary hydrogen-based charging solutions into evacuation and emergency response planning.

Hydrogen fuel storage systems, such as those from GKN Hydrogen, allow for long-term energy storage and decentralized power generation, ensuring uninterrupted EV charging. Companies like Nuvera and Exponent are also advancing fuel cell-powered EV charging solutions that can be rapidly deployed to areas in need.

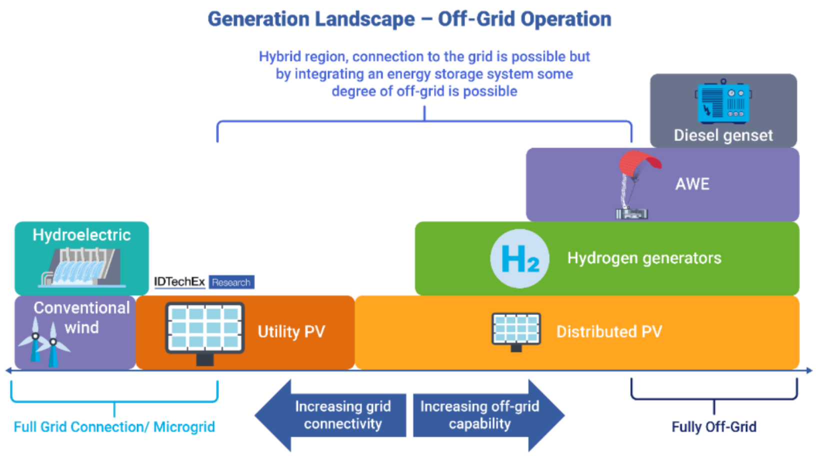


Fig. 15. Off-Grid Operation Landscape, adapted from IDTechEx [24].

**Recommended Verification**

- ✓ Mapping of available hydrogen, biodiesel, and alternative fuel-based recharging solutions in the region.
- ✓ Technical assessments on the deployment feasibility of these systems in critical or remote locations.
- ✓ MOUs with fuel suppliers and mobile recharging service operators (hydrogen, biodiesel).
- ✓ Emergency response plans integrating off-grid and alternative fuel recharging strategies.

**Example**

i. **kvyreen Fuel Cell Power Products | H2 energy**

The kvyreen is a mobile, zero-emission power and charging solution developed by H2 Energy. Utilizing green hydrogen, it offers flexible power outputs of 80 or 160 kW in both DC and AC configurations, enabling reliable EV fast charging and power supply in locations lacking sufficient grid capacity or availability.


Fig. 16. Zero-emission Power, adapted from H2 Energy [25].

| **Resources** |
|---|
| • **Off-Grid Charging For Electric Vehicles 2024-2034: Technologies, Benchmarking, Players and Forecasts \| IDtechEx**<br>• **Renewable Diesel \| U.S. DoE** |

MB6. Policies and incentives are in place to support private and public investment in backup power for EV charging infrastructure.

| **MB6** | **Policies and incentives are in place to support private and public investment in backup power for EV charging infrastructure.** |
|---|---|
| **Objective and Description**<br>This indicator evaluates whether supportive frameworks exist to encourage or require investments in backup power systems, particularly through:<br>• Incentive programs (e.g., rebates, tax credits, grants),<br>• Mandates or building codes that require backup systems for critical EV infrastructure, (streamline of permitting process?)<br>• Public-private partnerships to deploy resilient charging hubs in vulnerable areas.<br>Possible implications of implementing these policies and incentives include:<br>• Increased reliability and preparedness during natural disasters and grid disruptions,<br>• Reduced range anxiety in evacuation scenarios, particularly in underserved or rural areas,<br>• Higher upfront costs for infrastructure developers, which may necessitate greater public funding or cost-sharing models,<br>• Acceleration of solar and battery storage integration, driving broader grid decarbonization and energy resilience goals,<br>• Equity-focused outcomes, by ensuring that backup-powered stations are deployed in areas where residents are least likely to have access to alternative transportation or home charging. | |
| **Recommended Verification**<br>✓ Review state-level incentive databases (e.g., DSIRE) for rebates or grants focused on backup systems for EV charging.<br>✓ Examine local building codes or zoning requirements for backup power mandates at charging installations.<br>✓ Identify utility programs or resilience initiatives that promote storage-backed EVSE (Electric Vehicle Supply Equipment).<br>✓ Review recent or pending state-level legislation (e.g., California Senate Bills or Assembly Bills) focused on infrastructure resilience, energy storage mandates, or EV charging reliability during emergencies — particularly bills like SB 350, SB 1000. | |
| **Example**<br>**i. Energiize \| State of California**<br>The California Energy Commission's *EnergIIZE Commercial Vehicles Project* offers incentives through its "Resilient Solutions" funding lane, which specifically supports solar and battery storage integration for EV charging stations. This | |

program is designed to reduce emissions while also maintaining functionality during grid failures, directly encouraging backup power installations at both private and public EVSE sites.

Fig. 17. Commercial Vehicle Energize, adapted from State of California [26].

**Resources**

- **California's Deployment Plan | California's Deployment Plan for the National Electric Vehicle Infrastructure (NEVI) Program**
- **DSIRE | Database of State Incentives for Renewables & Efficiency (DSIRE)**
- **EnergIIZE Resilient Solutions Incentives Manual | EnergIIZE Resilient Solutions Incentives**

# T. Transportation

## T1. Ensuring EV-Ready and Resilient Evacuation Routes

| **T1** | **Ensuring EV-Ready and Resilient Evacuation Routes** |
|---|---|
| **Objective and Description**<br>Ensuring that evacuation routes are safe, accessible, and specifically adapted for EVs is critical for effective disaster response. An EV-friendly evacuation route must enable EV users to reach safety efficiently, either without the need to recharge or with access to strategically placed, resilient charging infrastructure [10].<br>This indicator evaluates whether the community has:<br>– Identified and mapped EV-friendly evacuation routes with strategically placed charging stations;<br>– Assessed the accessibility and safety of charging stations, ensuring compliance with disability access standards;<br>– Deployed mobile charging units to assist stranded EVs along evacuation routes;<br>– Integrated emergency management strategies, including first responder roadside protocols and contraflow lane operations;<br>– Addressed risk factors such as flood-prone areas, fire hazards, or saltwater contamination risks at charging locations;<br>– Ensured backup power availability at critical charging points to maintain functionality during outages;<br>– Provided real-time navigation and status updates to EV users during evacuations.<br>Particular attention should be given to areas classified as critical evacuation zones, where evacuation route access is limited, based on national mapping resources (e.g., StreetLight's Emergency Evacuation Routes database).<br>An EV-friendly evacuation plan must comply with supporting readiness indicators such as *T3: First responders* have protocols for EV roadside incidents and *CI1: Community has access to mobile charging/backup power to support EV chargers that are at high risk of congestion or loss of power*. | |
| **Recommended Verification**<br>✓ Mapping of EV-friendly evacuation routes with charging infrastructure and mobile charging deployment zones.<br>✓ Accessibility audit reports for EV charging stations (American with Disabilities Acts for example).<br>✓ Risk assessments identifying hazards (e.g., flood zones, fire risks) and relocation plans for at-risk chargers.<br>✓ Evidence of integration of real-time traffic, road safety, and charging station data into public navigation apps or communication systems.<br>✓ Public documentation or communication plans informing residents about EV evacuation routes and accessible charging points. | |
| **Examples**<br>i. Hurricane preparation - evacuation and contraflow routes **\| Texas Department of Transportation** | |

Overview of evacuation routes for different regions of Texas in case of a hurricane, along with guidelines on the implementation and use of contraflow lanes to facilitate evacuation. Figure below presents one of the maps that has been created. In the state of California, evacuation route maps are harder to find online. The following example illustrates an evacuation route map developed for Soda Bay.

**ii. [Soda Bay Corridor Evacuation Route Plan] | Lake County**

This evacuation plan, funded by the California Fire Safe Council through the Konocti Fire Safe Council, outlines procedures and recommendations for the Soda Bay Corridor in Lake County, CA, aiming to enhance short-term disaster preparedness and future evacuation planning for communities relying on Soda Bay Road, State Route 281, and Point Lakeview Road.

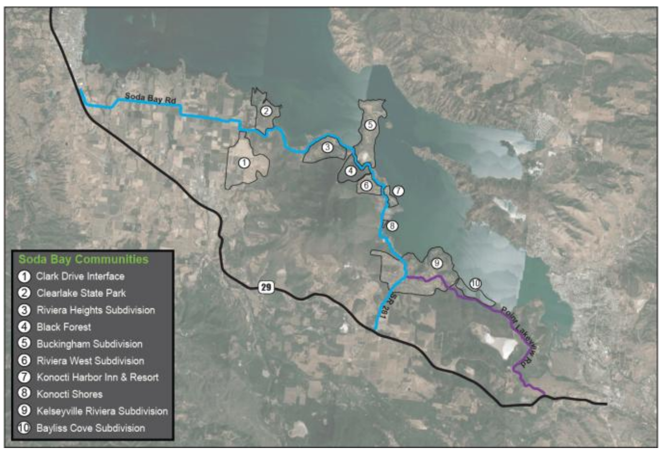


Fig. 18. Hurricane evacuation and contraflow routes in Texas, adapted from Texas Department of Transportation [27].

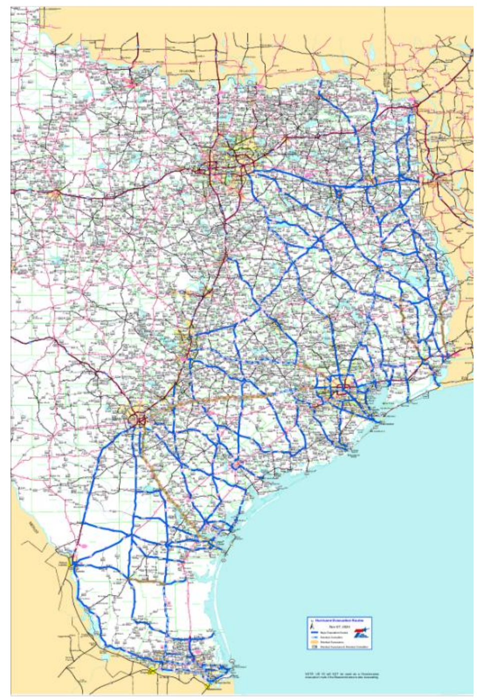

Fig. 19. Soda Bay Corridor evacuation route plan, adapted from Lake County [28].

**Resources**

- **Design Recommendations for Accessible Electric Vehicle Charging Stations | U.S. Access Board**
- **Emergency evacuation routes | SREETLIGHT**

  The figures below are sourced from the Emergency Evacuation Routes website. The first figure displays a table listing communities with limited access to evacuation routes. The second figure presents the same information in a map format, where red areas indicate the communities with the poorest access to evacuation routes.

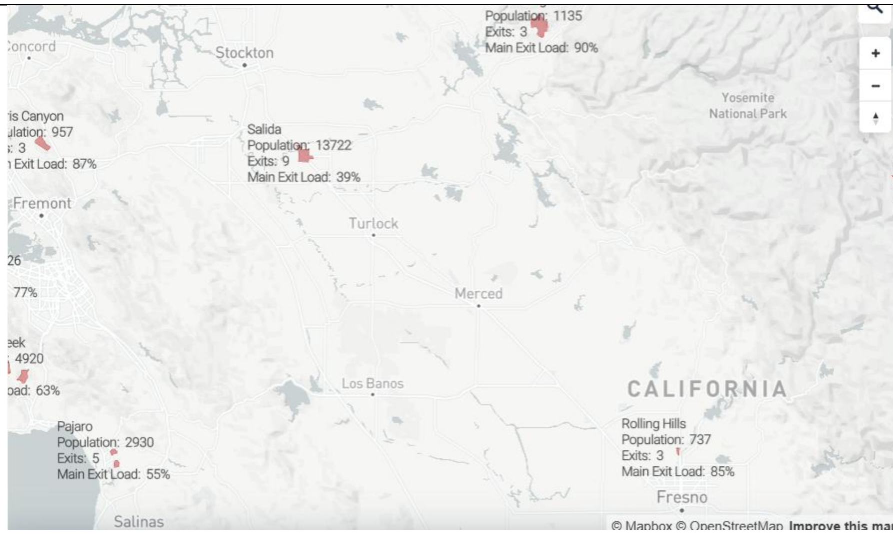


Fig. 20. Communities with limited access to evacuation routes (table format), adapted from Streetlight [29].

List is ordered alphabetically by state... with towns within each state ordered by U.S. Risk Rank*

Page 1

| Risk Rank | Town Name | State | Population | Main Exit Load | Number of Exits | Risk Rank | Town Name | State | Population | Main Exit Load | Number of Exits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | Brooktrails | California | 3,251 | 95% | 3 | 637 | Cohasset | California | 573 | 86% | 4 |
| 19 | Lake California | California | 3,054 | 93% | 3 | 661 | Salida | California | 13,722 | 39% | 9 |
| 23 | North Shore | California | 3,477 | 78% | 3 | 671 | Hawaiian Gardens | California | 14,393 | 42% | 10 |
| 34 | Coto de Caza | California | 15,294 | 57% | 5 | 682 | Richgrove | California | 2,882 | 56% | 6 |
| 40 | Coronado | California | 24,582 | 70% | 8 | 684 | Golden Hills | California | 8,656 | 43% | 8 |
| 49 | Pine Canyon | California | 1,816 | 91% | 3 | 85 | Roxborough Park | Colorado | 9,102 | 47% | 4 |
| 55 | Imperial Beach | California | 26,371 | 46% | 6 | 120 | Alamosa East | Colorado | 1,453 | 80% | 3 |
| 72 | Fillmore | California | 14,923 | 38% | 4 | 184 | Acres Green | Colorado | 3,007 | 63% | 4 |
| 76 | Temescal Valley | California | 22,542 | 46% | 6 | 227 | Green Mountain Falls | Colorado | 616 | 64% | 2 |
| 80 | Isla Vista | California | 23,066 | 30% | 4 | 262 | Gunnison | Colorado | 5,816 | 49% | 5 |
| 81 | Santa Venetia | California | 4,132 | 88% | 5 | 275 | Pueblo West | Colorado | 29,591 | 51% | 12 |
| 84 | Squirrel Mountain Valley | California | 547 | 96% | 2 | 319 | Manitou Springs | Colorado | 4,994 | 67% | 7 |
| 86 | Fetters Hot Springs-Agua Caliente | California | 4,099 | 70% | 4 | 321 | Lyons | Colorado | 2,097 | 59% | 4 |
| 90 | Forest Ranch | California | 1,184 | 96% | 3 | 529 | Nucla | Colorado | 714 | 82% | 4 |
| 96 | Paradise | California | 25,947 | 40% | 6 | 238 | Woodmont | Connecticut | 1,502 | 60% | 3 |

Fig. 21. Communities with limited access to evacuation routes (map format), adapted from Streetlight [29].

## T2. Navigation apps used by community have awareness about EV charging availability

| **T2** | **Navigation apps used by community have awareness about EV charging availability** |
|---|---|
| **Objective and Description**:<br>Ensuring that navigation apps provide real-time information about EV charging station availability is critical for safe and efficient evacuations. During natural disasters, road conditions can change rapidly, and access to charging infrastructure may be compromised due to power outages, congestion, or damaged roads. Navigation tools should integrate real-time data on traffic, road closures, and the operational status of charging stations to assist EV drivers in planning their routes effectively [7].<br>Additionally, backup communication systems such as satellite phones or radio networks should be considered to ensure access to essential information in case of cellular network failures. Real-time evacuation tools can also be leveraged to facilitate EV charging reservations along major evacuation corridors, preventing bottlenecks and ensuring that drivers reach safety without running out of charge.<br>Strategic planning should also include the deployment of emergency charging zones along key evacuation routes to support EVs with limited range. Traffic management systems should be implemented to coordinate EV flow and prevent congestion at charging stations. | |
| **Recommended Verification**<br>✓ Integration of real-time EV charging station data into widely used navigation applications.<br>✓ Evidence of backup communication systems to ensure continuous access to EV route planning.<br>✓ Implementation of a reservation system for EV charging along major evacuation routes. | |
| **Example:**<br>**i.** ABBetterRoutePlanner<br>A Better Route Planner (ABRP) is a navigation app designed specifically for EV drivers to optimize long-distance travel. It allows users to plan routes with charging stops, considering factors like battery capacity, driving style, weather, and terrain. The app provides real-time charging station availability, estimated charging times, and alternative routes. ABRP supports various EV models and integrates with live vehicle data for more accurate trip planning. It is widely used by EV owners to minimize charging stops and avoid range anxiety.<br>The figure illustrates the trip planning for an ACURA ZDX AWD electric vehicle from Merced to San Francisco, starting with a 50% SOC and arriving in San Francisco with a minimum SOC of 10%. | |

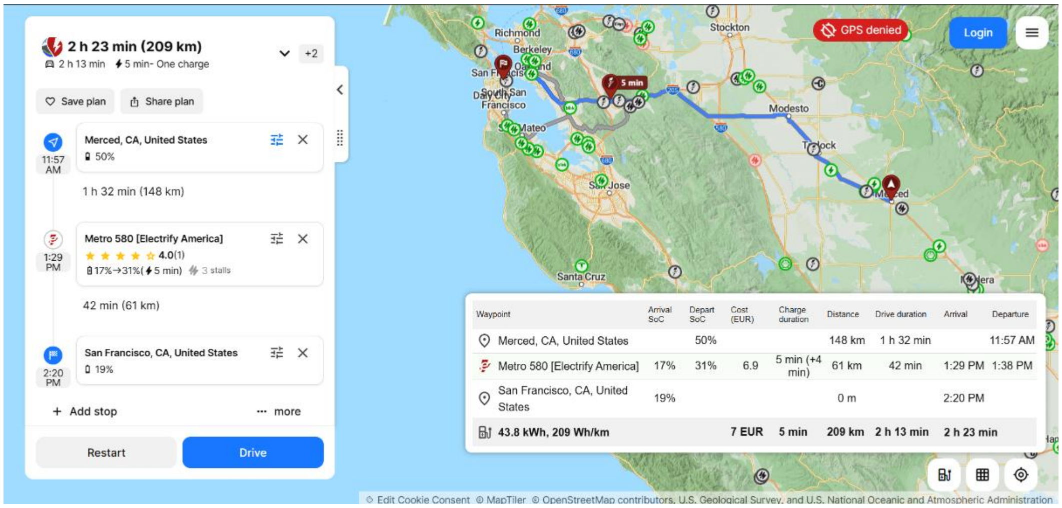


Fig. 22. EV trip planning from Merced to San Francusci, adapted from A Better Route Planner [30].

**Resources**

- Florida Alternative Transportation Fuel Resilience Plan | **NREL**

## T3. First responders have protocols in place to deal with EV fires and roadside assistance to EVs

| **T3** | **First responders have protocols in place to deal with EV fires and roadside assistance to EVs** |
| --- | --- |

**Objective and Description**

As EVs become more prevalent, it is essential to ensure that first responders are equipped with the necessary protocols to handle EV-related emergencies, such as battery fires, roadside assistance, and mass evacuations. Unlike conventional vehicles, EVs present unique challenges, including thermal runaway risks in battery fires and the need for specialized towing and charging support.

To enhance emergency response readiness, it is crucial to train firefighters, police officers, and emergency personnel on EV-specific safety measures. Collaboration between government agencies, private charging providers, and emergency response units can improve evacuation strategies and roadside assistance availability. Additionally, highways could be equipped with large water-filled containers at regular interval to submerge EVs experiencing thermal runaway, effectively containing fires and preventing reignition.

Incorporating electric buses and shuttles into evacuation plans can serve both as transportation solutions and as mobile energy sources during disasters. EV-friendly roadside assistance, including tow trucks equipped to handle EVs and mobile charging units, should be deployed along major evacuation routes.

Proper driver education on EV evacuation best practices—such as optimizing battery range and identifying safe charging locations—can further enhance community preparedness.

**Recommended Verification**

- ✓ Implementation of EV-specific training for first responders.
- ✓ Availability of EV-compatible roadside assistance (tow trucks, mobile charging).
- ✓ Inclusion of electric buses in emergency evacuation plans.
- ✓ Established collaboration between public agencies and private sector partners.

**Example:**

**i.** EV Safety Training **| NFPA**
Emergency Response Guides from alternative fuel vehicle manufacturers

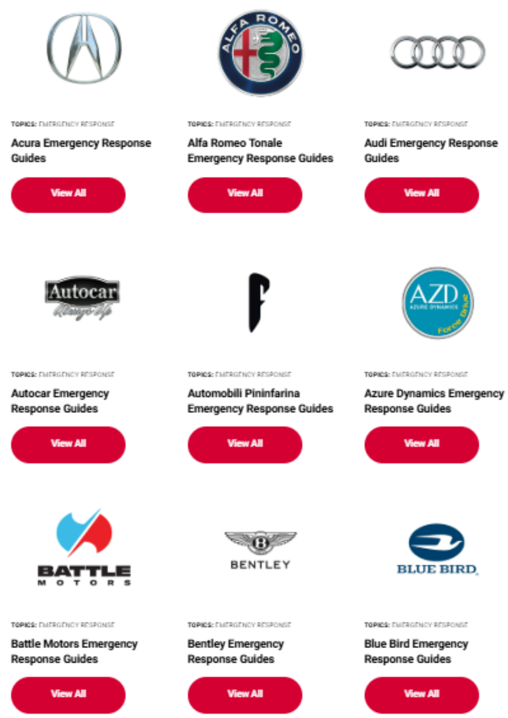


Fig. 23. EV safety training and emergency response guides, adapted from NFPA [31].

**Resources**

- Florida Alternative Transportation Fuel Resilience Plan **| NREL**
- Electric Vehicle Safety Training Resources for First and Second Responders **| U.S. DoE**
  List of known available training and educational resources for first and second responders specific to alternative fuel vehicles, with a particular focus on EV resources.
- National alternative fuels training consortium **| NVFC**
  The National Volunteer Fire Council (NVFC) offers a free, one-hour online course titled "Electric Vehicle Safety: An Awareness Level Training," sponsored by General Motors. This training is designed to educate first responders on the unique challenges and considerations when handling incidents involving hybrid and electric vehicles, equipping them with the necessary knowledge and tools to respond safely and effectively.

# E. Equity

<table>
<tr><td>E</td><td>Equity-driven strategies ensure that underserved communities have access to emergency EV charging</td></tr>
<tr><td colspan="2">Objective and Description:<br>This indicator deals with the identification of low-income and high-density areas with limited home charging access. This can include any place where huge numbers of EVs are being used but the power supply conditions are not up to par. Community can consider these housing areas and take steps to ensure safe evacuation via EVs in case of any natural disaster.<br>Few of the steps can involve:<br>– In any case, the community has a fleet of mobile chargers available to answer any sudden need of charging EVs.<br>– Community has also made an arrangements of emergency EVs, and public EVs to provide transportation of evacuees in stress.<br>These steps would ensure that the underserved communities have access to EV charging, and every resident is attended in case of emergency evacuation.</td></tr>
<tr><td colspan="2">Recommended Verification<br>✓ Programs should be in place to ensure residents regularly maintain their EV batteries, minimizing the risk of electrical or mechanical failure during emergencies.<br>✓ It is critical to verify that the electrical distribution networks serving these neighborhoods are well-maintained and resilient against outages.<br>✓ Communities should invest in a fleet of mobile EV chargers that can be dispatched during emergencies to locations with high demand or limited fixed infrastructure.<br>✓ Public agencies or community groups should maintain a stock of emergency EVs and public EV shuttles to transport evacuees, particularly those without personal vehicles.</td></tr>
<tr><td colspan="2">Example:<br>i. <u>California's Deployment Plan for the National Electric Vehicle Infrastructure Program</u> | State of California<br>To promote equitable access to EV infrastructure, it is essential to prioritize deployment in disadvantaged and low-income communities, where home charging access is often limited. This includes installing chargers in multi-unit residential buildings, enhancing infrastructure resilience through backup power systems, and preparing for emergencies by mobilizing portable EV chargers to serve areas with limited resources.<br>This approach aligns with recommendations outlined in the California Electric Vehicle Infrastructure Deployment Plan developed by the California Energy Commission (CEC) and the California Air Resources Board (CARB) in 2022.</td></tr>
<tr><td colspan="2">Resources<br>• <u>California's Deployment Plan</u> | California's Deployment Plan for the National Electric Vehicle Infrastructure (NEVI) Program</td></tr>
</table>

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# Notes

This work has already been the subject of a publication :

O. Saleem, K. Corzine, L. Parsa and R. de Castro, "Development of Zero-Emission Vehicle Evacuation Readiness Score Formulation Methodology," *2024 IEEE 67th International Midwest Symposium on Circuits and Systems (MWSCAS)*, Springfield, MA, USA, 2024, pp. 744-748, doi: 10.1109/MWSCAS60917.2024.10658929.

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