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Implementation Guide for Using Vehicle-to-Everything Enabled School Buses as Mobile Power Units to Enhance Resilience During Emergencies

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Executive Summary

The need for additional power sources to bolster critical infrastructure resilience and reliability will continue to increase over time due to the expected rise in extreme weather events. Electric school buses with vehicle-to-everything technology can serve as emergency mobile power units, representing a new resource for emergency backup power for disaster response, thereby enhancing infrastructure resilience. This implementation guide details the necessary steps to be taken before, during, and after an emergency occurs to ensure the necessary infrastructure and procedures are in place for these technologies to be used as part of an equity-oriented disaster response strategy. The guide recommends that vehicle-to-everything-enabled electric school buses become recognized resources within the federal National Incident Management System and integrated into emergency plans in accordance with the Incident Command System to expand interest in, and accelerated deployment of these technologies.

Keywords: BEV (battery electric vehicle), bus, energy security, reliability, V2G (vehicle to grid)

1 Introduction

Our increasingly digital society and a transition toward a more electrified transportation future will require electric system infrastructure to be more reliable, resilient, and robust. The expected rise over time in extreme weather events as well as in cybersecurity and physical security threats that are projected to lead to more widespread and extended power outages also will require enhanced adaptation and resilience of the United States' electric system [1].

Underserved communities (i.e., rural, low-income, Indigenous, and/or other communities composed primarily of people of color) often bear the brunt of extreme weather events and their impacts. As just one example of these disproportionate effects, recent reports indicate that "Black and Hispanic people are 50 percent more vulnerable to the impacts of wildfires than white people, and Native Americans are six times more vulnerable." [2]

Underserved communities tend to be among the first to lose power in such disasters because they typically lack robust housing and electric system infrastructure to withstand the worst extreme weather events that are anticipated to increase in frequency and severity in the future. In fact, research has revealed that 47 percent of diesel generators in California's Southern Coast are in communities that are considered most vulnerable; such generators pollute the environment and, as a result, can pose serious health threats, as well [3]. Underserved populations also can least afford to leave their communities when a disaster strikes. Therefore, solutions that promote an equitable approach will be especially important.

Electric school buses (ESBs) continue to proliferate, boosted by unprecedented federal sums from the U.S. Environmental Protection Agency's (EPA) "Clean School Bus Program," which recently awarded funding for nearly 2,500 additional ESBs [4]. ESBs have large onboard batteries, and predictable routes and schedules, the latter of which include sitting idle for many hours at a time, especially during summer months.

ESBs also typically are not used during extreme weather-related emergencies. Therefore, those ESBs that are enabled with bidirectional charging capability have the potential, and are well-suited, to deliver resilience services. V2X technology exists, though it is not yet familiar to the broad public. Serving as "mobile power units," ESBs, therefore, could provide backup power in emergencies and thereby enhance much-needed infrastructure resilience and aid in emergency planning, preparedness, and response efforts.

This implementation guide (guide) describes the potential to use V2X-enabled ESBs as alternative emergency backup power sources during a power outage. Such services will be needed to a greater extent over time. The guide details the steps required before, during, and after an emergency to make this happen. It aims to have ESBs equipped with onboard batteries and bidirectional charging capability to ultimately become recognized resources within the federal National Incident Management System (NIMS) and to expand awareness of, and interest in, these resources for resilience-related emergency response measures [5].

1.1 Benefits of V2X-Enabled ESBs

The myriad ways in which EVs acting as mobile power units could provide power to a broad range of critical facilities when needed and in emergency situations are profound. When ESBs are used in these ways, V2X has the potential to improve the resilience of U.S. critical infrastructure and thereby strengthen our energy and national security.

Because underserved communities tend to be most affected by disaster impacts, they also stand to benefit most from mobile power units to enhance resilience when outages occur. The growing large-scale deployment of thousands of ESBs across 38 states to date represents an important opportunity to use these buses as resilience assets that can maintain essential services during more frequent extreme weather events facing communities, helping to protect human health and save lives [6].

In addition, bidirectionally-enabled ESBs would offer the following additional benefits when used for resilience purposes: ESBs with on-board energy storage and bidirectional charging capabilities would reduce the need to deploy—and pay for—additional diesel generators or separate stationary energy storage units in emergency situations, because bidirectionally-enabled ESBs can move from site to site. This would reduce the costs associated with purchasing and maintaining separate backup power sources, including the cost of diesel fuel, which has a shelf life. Supply chain interruptions could minimize the availability of diesel fuel needed to run existing generators. Avoiding the use of diesel generators also would decrease the environmental and health impacts associated with their use. As one expert interviewed for this guide noted, during widespread emergencies, traditional high-capacity mobile generators often are extremely scarce [7].

1.2 Vehicle-to-Everything (V2X) Technology: Definitions and Technical Requirements

Until recently, virtually all EVs and chargers on the market were unidirectional, meaning electricity flows in one direction from the grid to the charger and then to the EV. V2X capability refers to an EV and/or an EV charger equipped with bidirectional, or two-way, charging capability that enables the battery on board the vehicle to discharge power to a home, building, the electric grid, or other facility—with broad applications, thereby acting like, or creating, a "mobile power unit."

V2X requires a bidirectional inverter and additional controls and software functionality. If an EV (i.e., an ESB for the purposes of this guide) does not possess an on-board bidirectional inverter, then a bidirectional inverter would be required in the EV charger or in a different device located at the host site, i.e., school building premises. To isolate, or "island," a building from the grid, an automatic transfer switch (ATS) or microgrid interface/interconnection device (MID), otherwise referred to as a grid isolation device, located on the host site premises will be needed to signal to the inverter when the building has been disconnected from the grid [8]. This equipment ensures that it is safe to enable the ESB's battery to provide emergency backup power only to the school building or other critical loads, and not all the way back to the grid, so power will not be causing risks to facility employees, utility linemen, or other workers. As V2X technology is adapted for more use cases, various configurations of the ESB, charger, and grid isolation device will emerge that might require additional technical considerations. These underlying technologies are standard today for stationary battery storage devices that provide backup power, and companies could begin offering resilience services using an ESB battery rather than a stationary battery, in combination with the technologies described.

V2X-enabled EVs, including ESBs, are already providing grid services in non-emergency situations [9]. For example, Highland Electric coordinated a V2X program with ESBs in Beverly, Massachusetts. During the summer of 2022, ESBs sent three Megawatt-Hours (MWh) of electricity back to the grid over nearly 60 hours, spanning 30 events. Three MWhs is the amount of electricity equivalent to that needed to power nearly 600 homes for one day [10]. These demonstrations have enabled bidirectional technology to be tested in low-pressure situations and prove its value and effectiveness.

As school districts make ESB and electric charging infrastructure purchasing decisions, they are encouraged to work to ensure this equipment is bidirectionally enabled. As we advance, vehicle and charging equipment manufacturers should incorporate bidirectionality into ESBs and charging infrastructure as a standard practice. This would reduce the burden on the school districts to research and decide whether to include this capability as part of their ESB and charging infrastructure purchases. This guide is all the more timely and important to help facilitate actual ESB V2X resilience-related deployments, based on the handful of V2X pilot projects that exist and the pace at which V2X technology is evolving.

1.3 Contents of this Guide

This document is a step-by-step implementation guide that highlights the key technical requirements and directs communities how to use ESBs equipped with V2X technology as mobile energy storage units, including by comprising part of a stand-alone microgrid, to power a shelters and other critical facilities or infrastructure. Specifically, this guide provides concrete planning steps for emergency managers and other identified stakeholders to consider and implement in advance of and leading up to an event requiring an emergency response, as well as during and after the event.

Although not included within this document, a Mutual Aid Agreement (MAA) template was also created as a part of this effort to assist stakeholders to begin the process of V2X-enabled ESB deployment. The MAA template follows the elements and requirements provided within the National Incident Management System (NIMS) Guideline for Mutual Aid and the existing federal Incident Command System (ICS), so it can be more readily integrated into local, state, and federal emergency plans [11].

1.4 Background on National Incident Management System and Incident Command System

The United States' National Preparedness System consists of multiple operational documents, structures, emergency planning, preparedness, response, and recovery efforts to help prepare for a range of natural and human-caused disasters [12]. This guide aims to track and fit in with the NIMS, which is part of the National Preparedness System [13]. NIMS guides how emergency response personnel at all levels of government, as well as non-governmental entities and the private sector, are supposed to work together when responding to incidents. It achieves this by defining “operational systems, including the ICS, Emergency Operations Center (EOC) structures, and Multiagency Coordination Groups (MAC Groups) that guide” this process [14]. Not only does NIMS apply to all incidents, but it also helps make the ICS guidance applicable to all incidents and hazards, as well [15]. The NIMS and ICS aim to provide common terminology and standardize operational procedures, while also providing flexibility for different circumstances, types of incidents, and so forth. The federal Stafford Act generally governs disaster and post-disaster recovery mechanisms and procedures, including reimbursements for the use of equipment during disaster emergencies and reimbursements for property loss.

To elaborate on these structures and the stakeholders involved, NIMS and ICS have formal incident command structures with an Incident Commander in charge. Emergency Operations Centers (EOCs) are staffed with key personnel who are identified during planning processes well before incidents. These generally include utility representatives, staff from other emergency response organizations (e.g., Federal Emergency Management Agency [FEMA] and state and local emergency managers), and relevant Department personnel with substantive expertise (e.g., Department of Energy [DOE] and/or state energy officers) that report to these EOCs during an incident. More details about the formal structures the federal government has created to plan for and respond to emergency incidents can be found in the *ICS Review Document* [16].

One of the key functions of NIMS is resource typing, i.e., “defining and categorizing, by capability, the resources requested, deployed, and used in incidents. Resource typing definitions [further] establish a common language and defines a resource’s (for equipment, teams, and units) minimum capabilities. NIMS resource typing definitions serve as the common language for the mobilization of resources.” [17] FEMA has established an online tool, called the Resource Typing Library Tool, which contains all of the different types of resources across personnel and equipment that exist, and the potential use for, or application of, each resource [18]. This implementation guide and the uses of ESBs discussed herein are intended to be compatible with the NIMS and the ICS, so they ultimately can be implemented as part of these larger organizational and operational structures. This guide employs the basic steps and nomenclature of the NIMS and ICS where applicable.

Because ESB V2X resilience applications are still being developed and deployed, it will take time for ESBs to be designated as recognized resources and incorporated into the NIMS and ICS systems. To avoid potential incompatibility between a bidirectional charger and an ESB(s), it would ultimately be worth providing as much technical information as possible in the resource typing systems. As detailed in *Section 2*, related potential equipment, software, and/ or hardware compatibility and requirements, including interconnection and charging hookup requirements, should be addressed well before an emergency. However, ultimately including such information in the resource typing tool also merits consideration.

As at least one expert reiterated it should not be essential for bidirectionally-enabled ESBs to be part of a resource typing system, particularly in the near term. ESB V2X opportunities should be supported, regardless. Best practices should be applied to expedite the process of incorporating ESB V2X technology into resource typing systems to expand awareness of such resources, where they are available.

2 Advance Steps Needed to Use V2X-Enabled ESBs as Mobile Power Units in an Emergency to Enhance Infrastructure Resilience (Pre-Disaster Phase)

This section highlights the key steps that merit consideration by relevant stakeholders in advance of an emergency outage resulting, for example, from an anticipated extreme weather event, which is the use case for this guide, so that ESBs and V2X can be used to provide backup power in such situations. Of course, V2X-enabled ESBs could be used to provide emergency backup power to other critical facilities and for outages caused by physical security or cybersecurity events, as noted in the Introduction. The steps highlighted herein apply broadly to a wide range of natural disasters that can lead to power outages, such as wildfires, floods, extreme heat or cold, and so forth, and pertain to the various geographic regions of the United States.

Knowing in advance the relevant procedures, personnel, and stakeholders that must be involved will facilitate the processes for deploying ESBs as backup power resources during an emergency. In addition, implementing such steps will ensure the requisite mechanisms are in place, including compensating (or reimbursing) the personnel and equipment used in an emergency. This ESB V2X guide is intended to be compatible with the existing NIMS and ICS structures described in the *Introduction* and should be adapted accordingly.

Because federal, state, and local emergency managers are tasked with conducting emergency management planning, executing existing operational plans, and performing other duties before, during, and after an incident, they are familiar with these planning and operational procedures. However, considering that ESBs and V2X technologies are still nascent, these officials and other key stakeholders will need to be educated about the potential emergency response capabilities of V2X-enabled ESBs to ascertain whether, where, and how to incorporate these resources into emergency response procedures.

As part of the NIMS and ICS processes, stakeholders are encouraged to consider working with FEMA to ensure that V2X-enabled ESBs, and charging infrastructure, are integrated as resources at the federal level into FEMA's Resource Typing Library Tool [19]. Being a part of this Resource Typing Library is vital to V2X-enabled ESBs becoming a known resource that can be requested and deployed during an emergency, as resource considerations are identified and evaluated, including cost considerations. The ESB drivers, i.e., "equipment operators," also should be included in the Resource Typing Library Tool, particularly if any specialized knowledge or training is required to connect the bus to a charger (or eventually, perhaps, directly to a school building to provide emergency backup power).

Most, or all, states have similar resource typing catalogs that contain all deployable resources in a database system. A number of cities and counties have similar online resource typing library tools. To ensure a cohesive emergency response system across all levels of government, it is crucial to get ESBs, drivers, and any other necessary equipment operators (e.g., charging providers, engineers, school facility managers) added to these state and local resource tools, as well. Following are the additional specific steps needed for bidirectionally-enabled ESBs to be used as mobile power units. Following are the additional specific steps needed for bidirectionally-enabled ESBs to be used as mobile power units.

2.1 Identify the Resource Needs (Load and Duration of Backup Power)

The first step is to determine the load that must be served. While some locations and incident personnel will indicate somewhat generically that they have a need for electric power over a certain period, emergency managers and the federal government instead are increasingly moving toward identifying the specific function(s) or load(s) that must be covered to ensure the power capability exists to meet those functional needs and over the requisite time duration [20].

- The types of circumstances in which ESBs would be deployed, e.g., different types of weather events, should be determined in advance. For instance, ESBs could be well suited to certain types of emergencies, e.g., extreme heat during the summer, when school is not in session and ESBs tend to sit idle for days at a time.
- The parties to the MAA will need to coordinate with emergency officials at the local level, and possibly also at the state level, to ensure in advance that an ESB will be an available emergency resource. They also will need to stipulate the instances in which this resource will be used.
- Once the parties determine how much emergency backup power they need, they also can assess the number of ESBs it will take to meet this requirement. If multiple ESBs are used, then the parties can establish whether these will be used sequentially or simultaneously. The number of ESBs needed and whether ESBs will be used sequentially or simultaneously will depend, at least in part, on charging infrastructure availability or planning for anticipated chargers.

When selecting appropriate resources, it is important for emergency officials to be aware that different sizes and types of school buses exist.

- Type A is a relatively smaller vehicle that is typically used to transport children with special needs or those in remote or underserved areas;
- Type C buses are "typical" school buses; and,
- Type D buses are nearly the same size as Type C school buses but have a flat front, so they have a little more capacity and other capabilities [21].

This information, once known, is then combined with the knowledge of the battery capacity, which is known for each sized ESB, bearing in mind that 80 percent of an ESB's battery typically can be discharged to preserve battery health [22]. The World Resources Institute (WRI) has published an ESB purchasing guide that offers further basic technical features for different types of buses [23].

One expert suggested building on a current utility best practice of integrating backup resources or systems into daily operations, or at least on a "one-off" basis, to the extent practicable [24]. Doing so would enable operators to become familiar with the use of such resources and would help address any potential issues prior to an emergency. Then, the resources, i.e., ESBs and associated equipment, in this instance, would, in fact, be performing well and able to provide emergency backup power, when needed.

If more power is needed for a given emergency situation than that which one fully charged ESB can provide, then there might be a need for multiple ESBs to be used sequentially. Alternatively, if needed, several ESBs—or a fleet—could be used simultaneously to provide more power and/or to provide power over a longer duration.

2.2 Specify the Requisite Personnel and/or Other Stakeholders

The requisite personnel resources and/or stakeholders must be identified to ensure they are aware of V2X-enabled ESBs' resilience capabilities, including as an emergency backup power resource, and they have met, are familiar with one another in advance of an emergency, and that they develop or facilitate lines of coordination and communication. In doing so, they will select those stakeholders that will be parties to implementing an MAA or a Memorandum of Understanding (MOU), among other needs.

In some parts of the United States, counties and school districts are managed separately. In addition, not all school districts own school buses; often, the buses and the hiring of drivers, maintenance, and other functions are fulfilled by contractors. Bus depots or lots also might be leased rather than owned. These factors could change the nature of, or parties involved in, an MAA.

2.3 Specify the Requisite Personnel and/or Other Stakeholders

The parties to an MAA likely will consist of a relatively small number of stakeholders, but the range of stakeholders to consider in such emergency situations consists of:

- School district official(s);
- School building facility manager, custodian, or administrator(s);
- First responders, e.g., local fire and police departments;
- Incident facility manager, e.g., at the school (in this instance) that will be the site for which a V2X-enabled ESB will provide backup power;
- State and/or county and/or city emergency manager— in many instances, the county or city does not manage the school district;
- ESB manufacturer/provider (original equipment manufacturer);
- Charging station provider;
- Service provider (aggregator using the ESB to provide emergency backup power);
- Electric utility;

- Local electrical contractor; and,
- the state Public Utility Commission (PUC) and the Regional Transmission Organization (RTO), i.e., regional grid operator, also known as an Independent System Operator, where these exist, also might need to be involved or at least notified.

2.4 Determine Software, Hardware, and Interconnection Needs and Other Logistical Priorities

To be able to use ESBs as backup power at a pre-selected school building, the associated hardware and software must be identified and installed well in advance of an emergency [25].

- Once a facility has been identified, and a V2X-enabled ESB has been selected as a potential power resource, the school district will need to work with the school facility manager, the charging station provider, electric utility, electrical engineers, and any other partners or stakeholders, which might include the bus manufacturer, to ascertain and install the additional hardware (e.g., wiring, distribution lines, switch gear) and software. This equipment will be needed at the school, so ESBs and bidirectional chargers can be used to provide emergency backup power. Ideally, these considerations would be considered in advance of a school district designing its charging infrastructure. It will be less expensive to plan for backup power functionality in advance of building the charging infrastructure, rather than retrofitting the site after the charging infrastructure has been installed.
- In most current circumstances, chargers, rather than ESBs, are equipped with bidirectional inverters. The inverter could be integrated into the charger or located on the host site premises.
- Depending on the circumstances, the local electric utility might need to be notified and/or verify that the ESB and charger can be safely and reliably "islanded," i.e., equipped with an inverter and a grid isolation device, so that power can be routed to the school building/shelter during a power outage but isolated from the rest of the grid for safety purposes. The electrical connection to the building must include an ATS or MID that signals to the inverter when it is safe to begin providing backup power to the building once an outage has occurred.
- Other technical changes might need to be made to the building or part of a building or load within it, such as a separate critical load panel.
- As noted above, this guide assumes that the ESB will be parked at the location where it would be providing backup power during outages.

If the ESB will not be on-site at the location where it will be used as a mobile power unit, the relevant incident personnel/parties will need to determine how the ESB will get to the location, ensuring sufficient charge remains for the return route to charge again (re-charge), including identifying the shortest and other potential travel routes. Regardless of whether the ESB typically is parked at the location where it is providing backup power during an outage, the bidirectional charging equipment, including the bidirectional inverter and the islanding hardware mentioned above, will need to be installed at the school, i.e., the site that will require backup power during an emergency.

2.5 Develop and Execute a Mutual Aid Agreement

Typically, there are state-wide and local agreements for mobilizing resources. Typically, too, a county or local emergency manager acts as the intermediary to activate or execute an MAA. A county emergency manager would work with the state emergency manager and resource tools, such as those identified at the beginning of this section, and with the school district in the instance at hand to identify and assess available resources and to mobilize those resources.

An MAA would establish the contact information and procedures between counties and/ or between states to reserve and deploy ESBs as mobile power units for emergency backup power purposes. If a school district has an ESB, then an MAA could detail:

- The circumstances under which a county would require the use of this ESB as an emergency resource and associated logistical details;
- The parameters of use;
- The daily rate for the ESB operator;
- Resilience services contract terms, including the ability to use the ESB and its battery capacity in an emergency situation for backup power, as well as the reimbursement rate and structure for charging and using the ESB's battery capacity; and,
- Any other specific requirements or considerations that need to be determined in advance.

2.6 Undertake Coordination Efforts

Familiarity among the relevant parties and stakeholders is essential prior to an emergency so that once an emergency occurs, the parties can call one another or take the requisite steps required in the MAA and implementation phase. Identifying roles and establishing direct personal relationships can be invaluable in saving time and facilitating coordination and collaboration when an emergency arises. It is important for contact lists to be verified, maintained, and updated regularly, e.g., at least annually. Coordination efforts similarly must occur prior to an emergency, so that each party knows their role and responsibilities, including vis-a-vis other parties, stakeholders, and partners. Training and exercises are an important part of such coordination efforts. Experts recommended that training and exercises be provided not only for those who would be involved in the emergency operation phase but also to stakeholders who would be involved in other phases and aspects of such efforts, including, for example, those who would be involved in the preparatory phase as well as site and equipment maintenance. It is critical to prepare in advance as many potential facilities and/or loads to be able to use ESBs as "mobile" generators when emergency circumstances arise.

2.7 Analyze Additional Potential Needs

Local resources typically are exhausted—at the city or county level—before going to the state level with requests for additional resources. As part of this process, emergency managers would assess the array of tools or equipment that could be available to best meet their needs (e.g., stationary diesel generators or bidirectionally-enabled ESBs) and help locate and deploy those assets. Resources are exhausted within a state before requesting mutual aid from another state or region.

FEMA requires every state and local jurisdiction to have a Hazard Mitigation Plan (HMP) to receive any disaster- or hazard mitigation-related funding. Redundant (or backup) power often is the highest priority need identified in a state or local HMP—to be addressed as additional financial resources become available. These planning approaches provide a systemic way in which to identify and minimize vulnerabilities. Such opportunities also might be tied to climate change mitigation, adaptation, resilience, and/or sustainability plans or goals.

2.8 Conduct Education and Outreach; Build Support

Recognizing the benefits of using bidirectionally-enabled ESBs as mobile power units will help to create awareness among school districts and emergency managers. Such benefits are highlighted at the beginning of the *Introduction* to this guide, though, to underscore, these include the potential to avoid the need for having to install—and pay for—stationary backup power sources (e.g., generators) at multiple facilities within a given area because bidirectionally- enabled ESBs can move from site to site. As such, these ESBs also might be able to be used to power multiple sites during an emergency outage. Creating awareness and building additional support from the community and schools, e.g., teachers, parents, and students, due to the environmental and public health benefits, should facilitate and accelerate ESB adoption and their deployment as emergency assets as well. Raising awareness regarding the related ability to potentially tap into multiple funding "pots" or opportunities to help make the case for using ESBs as mobile power units for resilience is discussed in the conclusion.

3 Steps Involved in Deploying V2X-Enabled ESBs as Mobile Power Units During an Emergency Outage (Disaster Phase)

Once a disaster or emergency has struck a community or an area, the bulk of the work to be able to deploy a V2X- enabled ESB will already have been accomplished during the aforementioned preparatory steps (i.e., *Section 2* above). At this stage, the process becomes a matter for local, city, and/or county emergency management personnel to manage, e.g., in terms of identifying and securing the resources needed for the disaster or emergency at hand. The relevant steps of the MAA will guide this phase of the implementation or deployment process.

3.1 Identify and Secure V2X-Enabled ESBs for the Disaster at Hand

As noted in the prior Sections, emergency managers tend to indicate the amount of power needed or a function for which power is needed. Assuming V2X-enabled ESBs have been included in the relevant databases and lists of resources, a school district could request from a city or county emergency manager emergency backup power for a particular load or building and perhaps also could specifically request a V2X-enabled ESB from among the available resources—or coordinate with the local, city, and county personnel to try to secure a V2X-enabled ESB.

With natural disasters that emergency management personnel can see coming, such as hurricanes or snowstorms, they can coordinate with bus manufacturers (referred to herein as original equipment manufacturers [OEMs]), charging-related service providers (software-as-a-service [SaaS]), the school district, and others to ensure that ESBs are fully charged prior to an emergency. For those natural disasters or emergency scenarios that emergency management personnel cannot see coming, it still is highly likely that an ESB will not be in use and will be charged or able to be charged fairly quickly for backup power deployment purposes. Resources should be reserved for a specific emergency purpose, such as for backup power for a shelter, and the relevant aspects of an MAA should stipulate the steps to deploy the V2X-enabled ESBs to the shelter.

3.2 Deploy V2X-Enabled ESBs

The timelines for using an ESB as the emergency management resource should already be written into the MAA or MOU. These time frames likely would be broken down into stages—typically focused on the first 72 hours (and likely also the first 24 and 48 hours) from the time the disaster strikes and/or an ESB as an emergency resource is requested, and the period that follows the initial 72- hour period. School districts and emergency management personnel should be cognizant of these time frames during an emergency because the first function of the ESBs is to transport children to school, and the ESBs likely need to be available to resume their transport duties following an emergency. However, should an ESB still be in use as a resource in an emergency/disaster situation, the emergency management staff should be able to provide other school buses back to the local school district should schools resume their normal operations.

3.3 Notify Utility of Use of V2X-Enabled ESB for Backup Power

Several experts noted the importance of making the local utility aware of backup power resources being deployed, though they are in “islanded mode,” so the utility can work with the school facility manager and its own personnel to prevent accidents when the grid goes back up (“live”), as needed. When a system is installed, the utility will inspect the ATS and other components to make sure they are functioning and will avoid power possibly being able to be inadvertently routed back to the grid (referred to as “back-feeding” of power to the grid) during an outage, which could be dangerous from a load management perspective and, most especially, from a worker safety perspective. This final step involves islanding the ESB and making sure the ESB is properly connected to the charger and the building.

4 Steps Involved Following the Disaster (Recovery or Post-Disaster Phase)

Once the disaster is over and the power grid returns "online," the parties move into the recovery phase. This consists of the following steps:

4.1 Notify Utility that the ESB is Being Disconnected from the School Building

With the example at hand, this step might not be necessary, but several interviewees noted the importance of providing such notification to the utility to ensure maximum safety for all involved. The person in charge of this step will be identified in the MAA. Once they are contacted, ensure there is no more discharging of power from the ESB to the school building and no "backflow" of power to the grid. Disconnect the ESB from its "islanded" mode.

4.2 Determine the Amount of Power Consumed, then Recharge and Park the ESB (or Return to the School District or Contractor, If Necessary); Conduct Safety Check

The school facility manager or electrical engineer and/or ESB driver should determine how much electricity was used during the emergency for reimbursement purposes. If not already done, the ESB's battery must be fully recharged before or after being returned to the school district or contractor. The ESB driver then parks the ESB at the school (in certain circumstances, the ESB driver might need to return the ESB to a different location, such as a school district lot or contractor lot). The school's fleet operator should perform a safety check of the ESB, including a standard routine vehicle inspection, such as noting the tire pressure and general cleanliness of the ESB before it embarks on a school route to pick up children. This common-sense step ensures the vehicle operates as it did prior to the emergency. The charging infrastructure and school building also should be checked—in coordination with the local utility—to ensure the islanding, power restoration, and equipment functions all work as they did prior to the emergency.

4.3 Compensation, Reimbursement, and Assessment

This step concludes the activity between the parties on the MOU or MAA for the particular disaster or emergency response situation. For local emergencies or disaster situations, the contract terms and payment, including the daily or per event rate for usage of the ESB as a resource, already will have been specified on the resource list and/or elsewhere in the MAA, so all that remains is for the emergency management staff to compensate the school district or ESB owner for the use of the ESB and the electricity consumed from its battery. This can be accomplished based on pre-determined rates or rate structures, which will be established in the MAA (for instance, based on kilowatt-Hours (kWh) used or on the percentage of decrease in the battery's charge (which can be determined when the battery is recharged). FEMA or a state's database also will provide the hourly or daily rate for personnel required to drive or operate the ESB and other requisite personnel to deploy and use the ESB as a mobile power unit.

Following the disaster and emergency response, the parties to the MAA should assess the efforts that worked well, and potential areas for improvement, including any outstanding needs and areas for improved coordination. The specifications for ESBs and associated equipment and personnel should be updated on the emergency resource list, if necessary.

5 Conclusion

As the United States experiences more extreme weather events and plans for greater infrastructure resilience, ESBs should be one of the top resources federal, state, and local emergency management staff consider as a replacement for stationary diesel generators to provide emergency backup power during grid outages, including as part of a microgrid. ESBs have large batteries, predictable routes and usage times, and their mobility makes them even more well-suited to provide backup power during emergency situations.

To facilitate the widespread deployment of bidirectionally- enabled ESBs for resilience purposes, significant time and effort will be needed to educate federal, state, and local emergency managers, as well as school districts, electric utilities, transportation managers, and other relevant stakeholders regarding the potential for such uses. This guide and the separate MAA [26] intend to educate and encourage stakeholders to consider

ESB and V2X for emergency response situations and to lead to the adoption of the policies and structures necessary for their future use in such roles.

Given that federal funding for ESBs is increasing substantially, school districts, emergency management staff, and city and county officials are encouraged to work together to make agency staff responsible for distributing these funds aware that V2X-enabled ESBs can add value with their resilience capabilities. In doing so, the officials could help leverage the federal dollars, so they maximize ESB-related opportunities to deploy bidirectionally-enabled ESBs, particularly for resilience purposes. These funds also could go toward preparing shelters, hospitals, and other critical facilities and loads to accept V2X-enabled ESBs as backup power sources. This includes ensuring the relevant bidirectional charging capabilities and any additional software, hardware, or other equipment and services are installed and ready for use. Not only can ESBs provide a safe and healthy ride to school for the current and future generations, but these vehicles also can help all communities better withstand future disasters.

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