



Building a Resilient Electric School Bus Fleet: San Marcos Unified School District



Figure 1: Electric school buses beside DC fast chargers at SMUSD's transportation yard.

Establishing a resilient electric school bus fleet

San Marcos Unified School District (SMUSD) is a public school district more than 19,000 students in San Diego County, California. The district is electrifying its school bus fleet. It will also reduce emissions and lower operating costs. It will also replace aging diesel vehicles at the end of their useful life. SMUSD currently operates 35 electric school buses. The district has more on order to reach 58 electric buses out of a total fleet of 94 buses. State and federal grants fund these purchases. The district is also purchasing electric light-duty support vehicles such as the Ford E-Transit vans.

As SMUSD expands its electric fleet, the district must also be ready for power outages. The yard is on a utility line that may be shut off during Public Safety Power Shutoff (PSPS) events. PSPS events are planned utility shutoffs during high wildfire risks conditions. These events can last up to four days. During outages, SMUSD must continue transporting students safely and reliably.

Charging infrastructure for high-mileage operations

All electric school buses return to one transportation yard for charging. SMUSD has one charger for each bus, allowing every bus to plug in at the same time. The district uses charge management software to automate fleet charging schedules. The software uses each bus's unique vehicle ID to collect real-time state of charge (SOC). The SOC indicates how much battery life remains. While all buses can be plugged in at the same time, the software controls when each bus charges and how quickly it charges. This system helps reduce energy costs. It does so by spreading charging across different times and avoiding periods of high energy demand.

SMUSD uses:

- **Level 3 DC Chargers** (30 kW per port)
- **Level 3 DC Fast Chargers** (120 kW per port)

The 30 kW chargers provide most overnight charging for a full charge before their morning route. The 120 kW fast chargers support quick daytime charging between morning and afternoon routes.

Bus routes vary widely, from 20 miles to over 110 miles per day. Because of this, buses return with different battery levels. To reduce costs, SMUSD avoids charging during peak electricity pricing hours from 4:00 p.m.–9:00 p.m. Buses that return in the afternoon can be plugged in right away. However, the software may wait until low-cost hours to charge them. The software manages charging, so buses are ready for service the next morning. Buses can get a quick charge between morning and afternoon routes. This helps them finish the rest of their route for the school day.

Develop a resiliency strategy

Both planned and unplanned power outages occur in the San Marcos area. This is a key factor in SMUSD's decision to incorporate resiliency technologies. To keep its electric buses running during outages, SMUSD looked at its energy needs. It then sought funding for resilience improvements at its bus yard.

Assess fleet energy needs



Build energy models based on fleet size, routes, and weather

To find out how much backup power its bus yard would need, SMUSD worked with Opterra Energy Services to design a resiliency system. To prepare for outages, the project team used a modeling software to estimate the fleet's energy needs. The model included fleet size, daily bus routes, battery capacity, expected battery level (state of charge) when buses return to the yard, charging schedules, and local weather conditions (e.g., sunny and cloudy days). The results helped SMUSD understand how much energy the fleet would need to continue operating during an outage.

Each electric bus has a 210 kWh battery. However, buses return with different battery levels because route lengths vary. Some buses travel 20 miles each day, while others travel more than 110 miles. The model showed how much solar, battery storage, and generator power the fleet would need during a multi-day outage. As SMUSD received more grant funding, the district expanded its electric bus fleet faster than originally planned. The resiliency system was scaled to support the larger fleet.

Secure funding to enable resiliency

SMUSD funded its electric bus fleet through multiple state and federal grant programs, including the Carl Moyer Program, the VW Mitigation Fund (managed by the San Joaquin Valley Air District), and the Zero Emission School Bus Initiative (ZESBE), which is administered by the California Air Pollution Control District and the California Energy Commission. As additional grants became available, the district expanded its fleet. It also adjusted its charging and resiliency infrastructure plans to support the growth. SMUSD is applying for federal funding through the Inflation Reduction Act. The funding would help pay for solar panels and battery storage.



Figure 2: Diagram showing solar panels, battery storage, switchgear and a backup generator supporting bus charging operations.

Deploy resiliency technologies

After assessing its energy needs and securing funding, SMUSD selected several technologies to help keep its electric buses running during power outages. SMUSD selected a combination of solar, battery storage, and diesel generator technologies.

Microgrid with Solar, BESS, and Diesel Generator

SMUSD installed a microgrid at its bus yard, built in two phases. The system includes solar panels, a battery energy storage system (BESS), switchgear, and a diesel backup generator.



1 MW of solar panels



1.25 MW of BESS



600 kW Generator

A battery energy storage system (BESS) stores energy from solar panels. The stored energy can be used when solar production is low or not available. This can happen overnight or during an outage. Switchgear controls and protects the flow of electricity throughout the system to keep systems safe and reliable.

Phase 1 supports 40 chargers and includes dedicated switchgear. **Phase 2** is under construction and will support additional chargers with its own switchgear. SMUSD designed Phase 1 with the electrical connections needed for future expansion. This approach allows the district to expand without rebuilding existing infrastructure. During an outage, the microgrid disconnects from the utility grid and operates independently. The system uses power from solar panels, battery storage, and diesel generators to keep operations running.

The microgrid includes a permanent 600 kW diesel generator. The generator was designed to help keep the battery storage charged. It was not designed to power the entire bus fleet by itself. For example, solar panels may produce less energy during cloudy weather. If the battery levels become too low, the system automatically starts the generator. The generator provides additional power to help maintain battery charge levels.

The generator has a 1,000-gallon fuel tank. At full output, it uses about 40 gallons per hour. This allows the generator to operate for about 25 hours before refueling is needed. SMUSD also has an agreement with a local fuel supplier that can provide fuel during emergencies. A fuel tanker truck can refuel the generator on-site. This helps the district maintain backup power during outages.

Key takeaways

1 Evaluate outage risk in your area

Power outages vary by location. Think about how often outages happen in your area and how long they typically last. Use this information to determine the back up power your fleet may need. At SMUSD, power shutoffs can happen and may last several days. Because of this, the district chose permanent backup power instead of portable generators. Portable generators may not be available during outages due to limited supply.

2 Pursue multiple funding sources

State and federal grant programs can help organizations get funding to grow their fleets and build resilience over time. Applying for more than one funding program can help organizations get the funding they need to grow their fleets over time. SMUSD funded its electric buses through Carl Moyer, the VW Mitigation Fund, and ZESBE programs. The district is also pursuing Inflation Reduction Act funding for solar and battery storage projects.

3 Pilot technologies before scale

Start with a plan that can grow with your fleet. Assess your resiliency needs and design an infrastructure plan. Test new technologies on a small scale first. This helps you learn what works before expanding. SMUSD built the first phase of its microgrid as its fleet grew. The district is now constructing the second phase based on insights from the first build.

4 Layer backup power for extended outages

Solar and battery energy systems (BESS) can provide immediate backup power during an outage. However, they may not be enough during long outages or periods of low solar output. Adding a secondary power source can help keep batteries charged when solar generation is limited. SMUSD uses a diesel generator to support its solar and battery systems. This helps maintain fleet operations through multi day outages.

Prepare your electric vehicle (EV) fleet for power outages with support from PG&E's EV Advisory Services. Contact [PG&E EV Advisory Services](#).



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