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Technical Assistance Help Sheet

Battery Energy Storage for Electric Vehicle Charging Stations

Introduction

This help sheet provides information on how battery energy storage systems can support electric vehicle (EV) fast charging infrastructure. It is an informative resource that may help states, communities, and other stakeholders plan for EV infrastructure deployment, but it is not intended to be used as guidance, set policy, or establish or replace any standards under state or federal law.

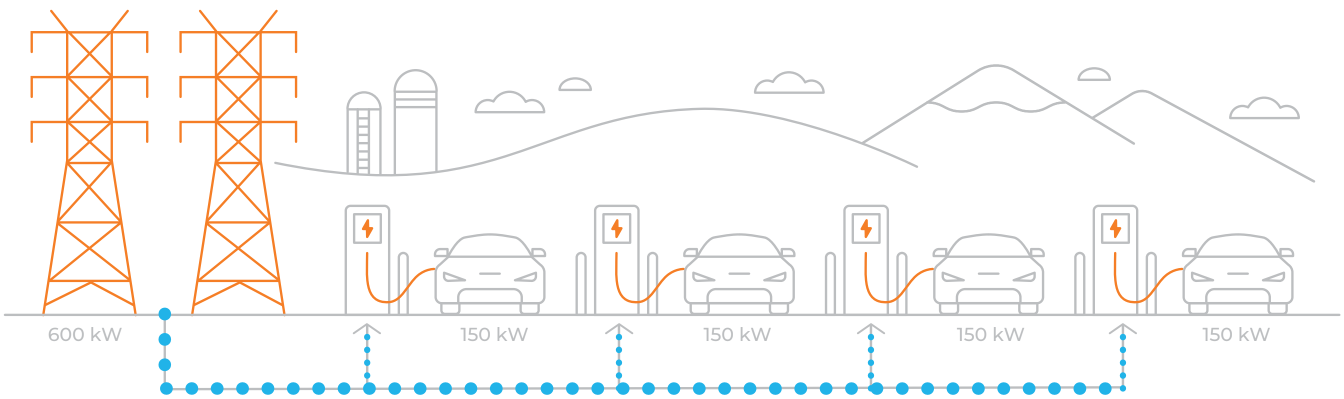
Battery energy storage systems can enable EV fast charging build-out in areas with limited power grid capacity, reduce charging and utility costs through peak shaving, and boost energy storage capacity to allow for EV charging in the event of a power grid disruption or outage. Adding battery energy storage systems will also increase capital costs for a deployment of EV charging stations, which should be weighed against potential benefits before implementation.

What Is Battery-Buffered Fast Charging?

A battery energy storage system can store up electricity by drawing energy from the power grid at a continuous, moderate rate. When an EV requests power from a battery-buffered direct current fast charging (DCFC) station, the battery energy storage system can discharge stored energy rapidly, providing EV charging at a rate far greater than the rate at which it draws energy from the power grid.

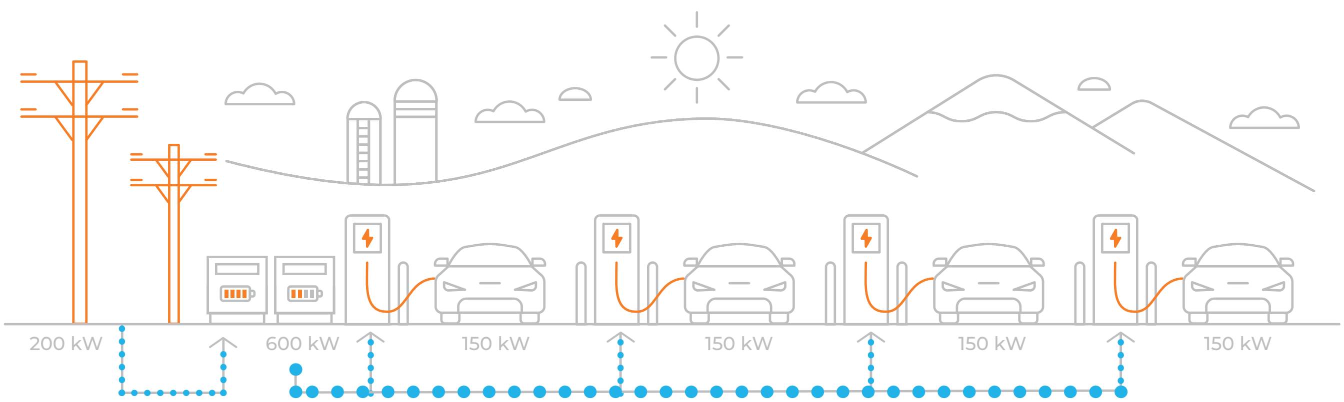
Standard Fast Charging

High-Capacity Infrastructure | Intermittent Vehicle Charging | Short Charging Times



Battery-Buffered Fast Charging

Low-Cost Infrastructure | Continuous Battery Charging | Intermittent Vehicle Charging | Short Charging Times



Why Consider Battery Energy Storage?

Battery energy storage systems can enable EV charging in areas with limited power grid capacity and can also help reduce operating costs by reducing the peak power needed from the power grid each month. An analysis by the National Renewable Energy Laboratory (NREL) shows that appropriately sized battery-buffered systems can reduce power grid service capacity needs by approximately 50% to 80% compared to a charging station that is powered entirely by the power grid, while offering an identical charging experience for motorists.[1]

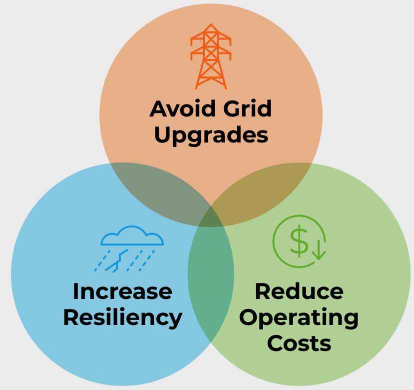
[1] NREL prepared a set of reference tables that provide recommended minimum energy storage (kWh) capacity for a 150kW battery-buffered corridor DCFC station at combinations of grid-supported power (kW) and Design Day charging demand (Appendix: Reference Tables). This approximation is derived from these output tables. Note that assumptions can be made available upon request at driveelectric.gov/contact.

What Are Potential Risks?

Battery-buffered DCFC stations come with new considerations—the addition of a battery energy storage system adds a potential equipment failure point, and if undersized, batteries may become fully depleted, leading to severely reduced charging power.

Use Cases for Battery-Buffered Fast Charging

1. **Increase EV charging capacity while avoiding power grid infrastructure upgrades**
   Supplemental power in areas with limited power grid capacity.
2. **Reduce operating costs**
   Demand charge mitigation strategy to lessen peak demand.
3. **Increase resiliency**
   Provides an emergency backup power supply during a power outage or other power grid disruptions.



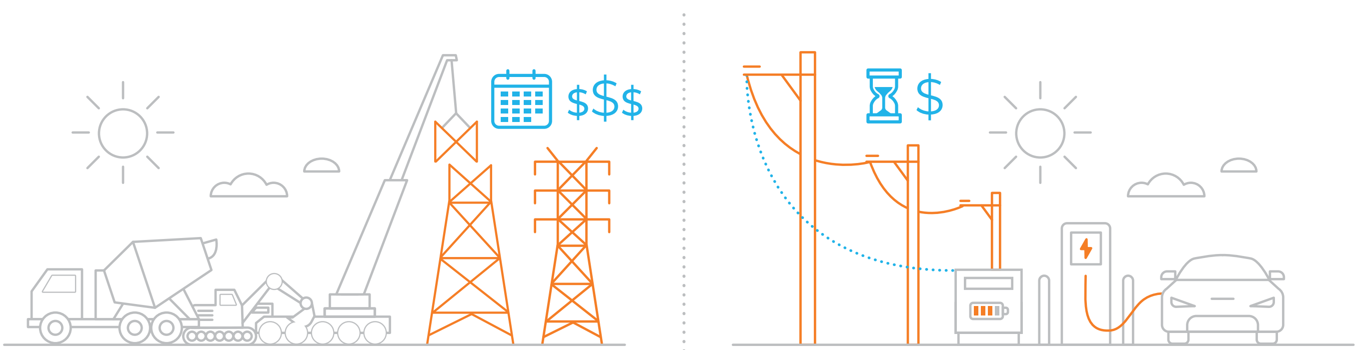
Use Case 1

Increase EV Charging Capacity While Avoiding Power Grid Infrastructure Upgrades

DCFC requires electricity to be dispensed at very high power to enable short vehicle charging times. Power grid infrastructure is usually built to accommodate the maximum power output of a DCFC station. However, DCFC stations only need maximum power intermittently. Placing a battery between the power grid and the DCFC station may reduce the scale of power grid infrastructure needed, thereby reducing costs and shortening construction timelines.

Battery-buffered fast charging can expand the availability of public fast charging for motorists traveling through power grid-constrained and low-utilization areas. In theory, battery energy storage systems could be paired with on-site power generation to help provide fast charging in fully off-grid areas, though the heavy energy needs of fast charging present challenges for this use case.

Conventional vs. Battery: Avoid Grid Infrastructure Upgrades



Considerations

- Can the proposed system provide 150 kWh from each port concurrently in 1 hour to be aligned with federal and industry benchmarks?
- Are the proposed system's battery capacity and power grid connection adequate to meet uptime requirements given the projected charging demand at the site?

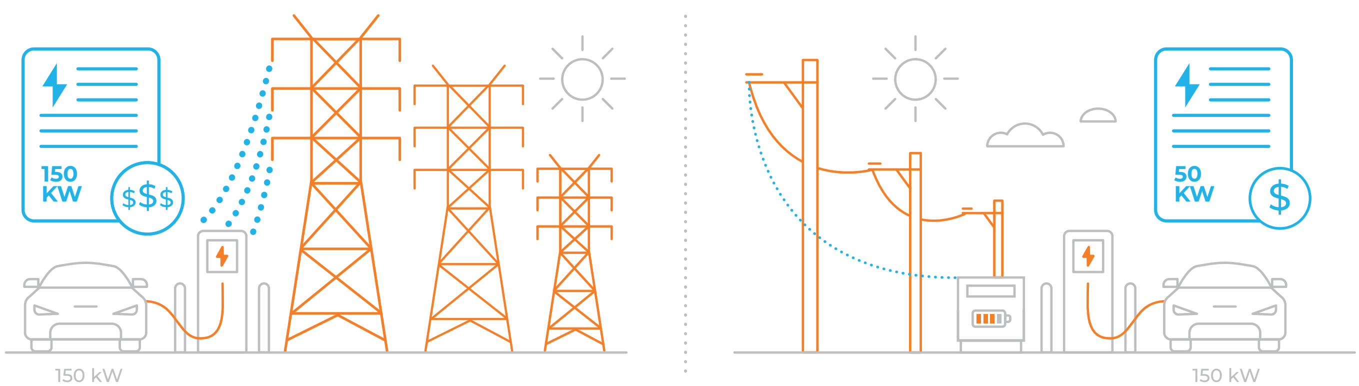
EXAMPLE
A remote, rural site is selected to host 600kW of DCFC. The site has only 100 kW available from the existing power grid, but charging station utilization there will never exceed 80 kW average over 24 hours. A 500-kWh battery-buffered DCFC can serve projected charging utilization and is also prepared for a one-hour surge in charging demand with capacity to charge four extended-range EV pickups to 80% state of charge (150kWh) concurrently in one hour.

For another example, review the Joint Office of Energy and Transportation's (Joint Office's) technical assistance case study **Grid-Constrained Electric Vehicle Fast Charging Sites: Battery-Buffered Options**.

Use Case 2
Reduce Operating Costs

A battery energy storage system can help manage DCFC energy use to reduce strain on the power grid during high-cost times of day. A properly managed battery energy storage system can reduce electric utility bills for the charging station owner if the local utility employs demand charges or time-of-use rates. With certain types of utility demand-response programs, the battery energy storage system can earn compensation for discharging energy to reduce strain on the power grid during high-cost times of day.

Conventional vs. Battery: Reduce Operating Costs



Considerations

- How much will the battery energy storage system reduce demand charges, given projected utilization?
- Do savings or revenue justify the added costs of the battery energy storage system?
- Does the battery energy storage system come with additional software or maintenance costs?

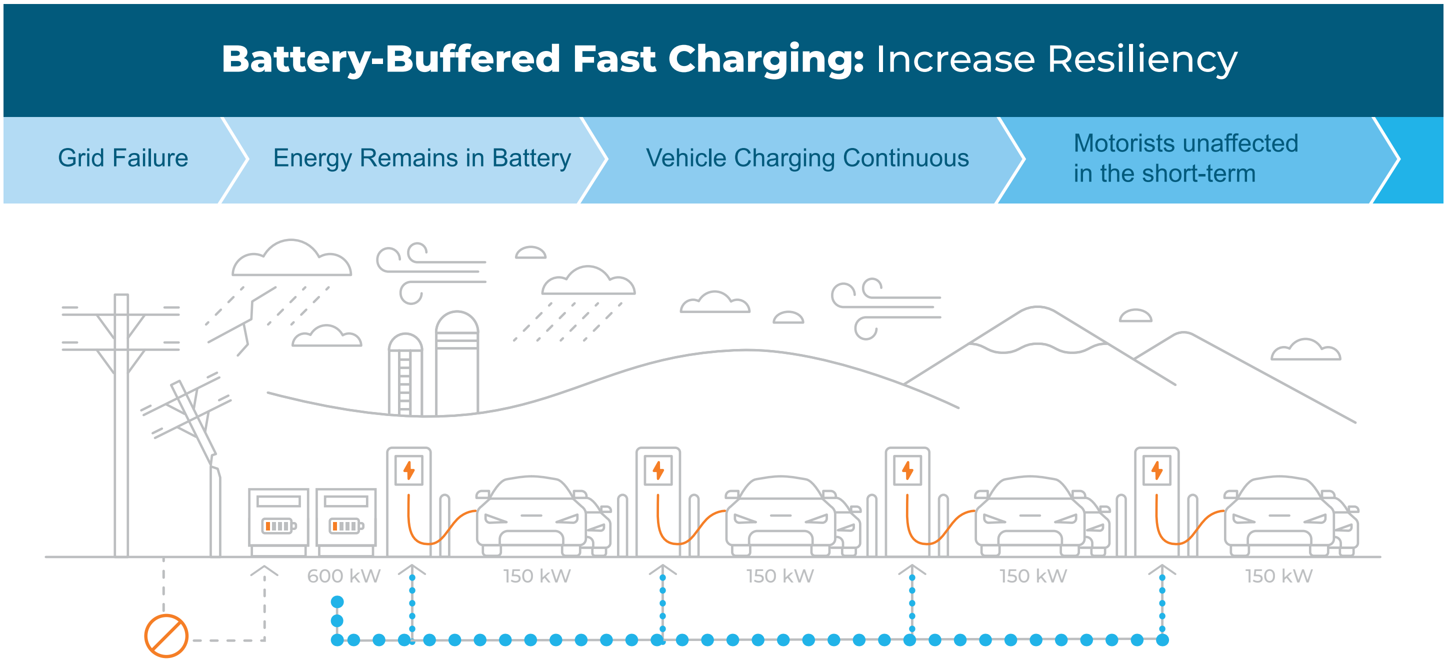
EXAMPLE
The hosts of the battery-buffered rural EV charging station will never incur a utility bill for more than 100 kW of demand charges. Without battery energy storage, a comparable 600-kW DCFC station could potentially incur 600 kW of demand charges, which would result in higher utility bills.

Use Case 3

Increase Resiliency

A battery energy storage system can potentially allow a DCFC station to operate for a short time even when there is a problem with the energy supply from the power grid.

If the battery energy storage system is configured to power the charging station when the power grid is unavailable, vehicle charging can continue as normal during a power grid disruption until the battery is depleted. The capacity of the battery will determine the number of charging sessions that can be supported before the system must shut down and wait for power grid service to be restored.



Considerations

- A battery energy storage system alone does not guarantee that a DCFC will operate during a power grid disruption. Hardware and software must be configured for this use case.
- Are power grid outages expected to happen frequently enough to justify this use case?

EXAMPLE

The equipment at the remote station is configured and designed such that if utility power fails, the battery-buffered DCFC will continue to dispense energy until the battery energy storage system is depleted. With a 500-kWh battery and average charging demand of 50 kW, the system might continue serving motorists for up to 10 hours without access to the power grid.

Where to Start?

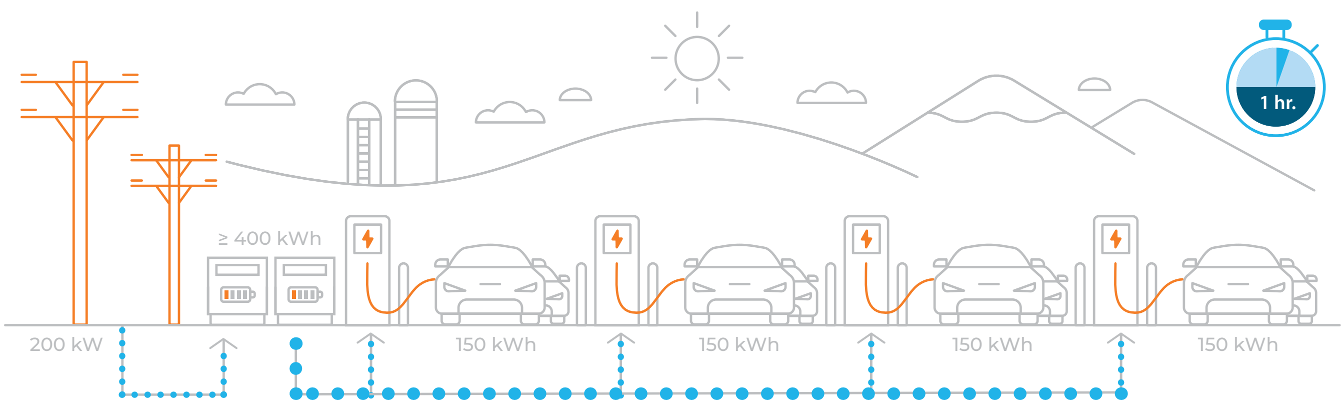
While it is challenging to precisely predict future EV adoption and technological change, NREL has developed criteria that provide a starting point for evaluating battery capacity at a battery-buffered corridor DCFC station—First Hour and Design Day. To ensure a high-quality user experience, the battery must be sized appropriately to avoid running out of energy.

For an example of how First Hour and Design Day were used to evaluate options for a specific site, review the Joint Office technical assistance case study Grid-Constrained Electric Vehicle Fast Charging Sites: Battery-Buffered Options.

First Hour

The First Hour criterion is intended to ensure that any station, no matter how lightly utilized, can serve a sudden surge in charging demand.

Battery-Buffered Fast Charging: First Hour



Question to ask: Can the proposed system provide 150 kWh from each port concurrently in 1 hour?

EXAMPLE

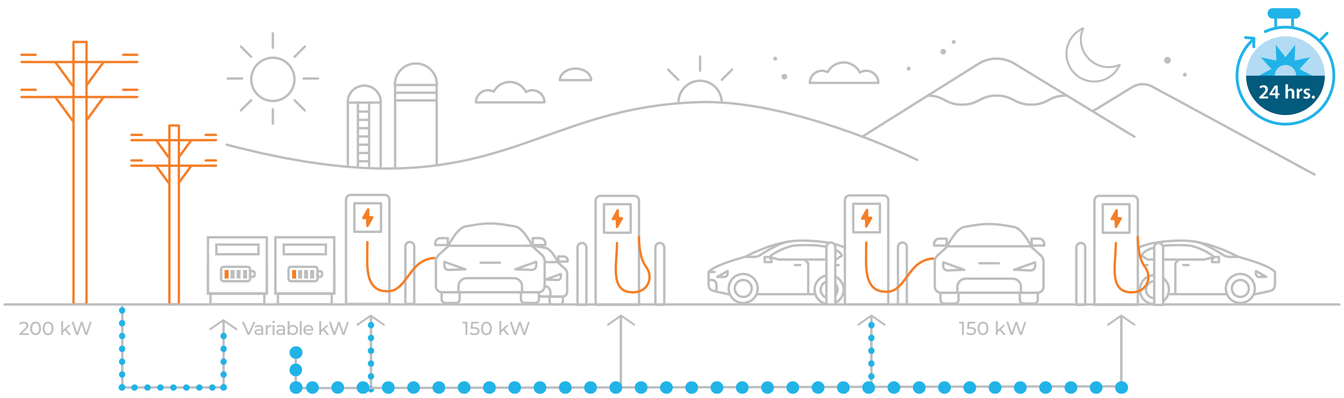
- A four-port charging station is supplied with 100 kW from the power grid, supporting 100 kWh in the first hour.
- The station would need at least 500 kWh of energy storage to provide 150 kWh from four ports concurrently (600 kWh) in the first hour of charging.

Note to consider: 150 kWh approximates the energy needed to charge a long-range EV pickup truck with a 200-kWh battery to 80% state of charge. This methodology therefore applies to any port with 150-kW or greater capacity.

Design Day

The Design Day criterion is meant to provide reasonable assurance that the battery-buffered DCFC will deliver energy to all motorists as requested on a busy day.

Battery-Buffered Fast Charging: Design Day



Design Day is the heaviest day of charging energy demand that the station is intended to serve without interruption to service due to a depleted battery (for example, the 99th percentile day in 2030).

Question to ask: Are the proposed system's battery and power grid connection adequate to meet uptime requirements given the projected charging demand at the charging station?

- All ports should be able to meet charging demand on the Design Day without fully depleting the battery.
- The battery-buffered DCFC should have input power available equal to or greater than the 24-hour average Design Day charging demand.

Forecasting charging demand is complex, and there are a variety of methods to estimate demand. For help with estimating charging demand for a particular site or group of sites, **submit a request to the Joint Office to receive free technical assistance**.

Checklist

Below is a checklist to help estimate if a battery-buffered DCFC is suitable for a proposed charging station.

- [ ] **Step 1:** Determine the number of planned charging ports for the charging station.

- [ ] **Step 2:** Determine the continuous power available from the power grid to the battery-buffered DCFC, expressed in DC kilowatts. *To meet the First Hour criterion, usable battery kWh must be: (Battery kWh) >= 150kWh * (#Ports) – [(Grid kW) * (1 hour)]*

- [ ] **Step 3:** Determine the target Design Day. Plan for the busiest day at that the charging station will need to serve without curtailing power output. For example, the target Design Day might be the 99th percentile day in the fifth year of charging station operation.

- [ ] **Step 4:** Forecast Design Day charging demand.

  Charging demand could be expressed as average charging kW over 24 hours, 24-hour total kWh dispensed, or 24-hour energy utilization percentage. NREL's EVI-RoadTrip tool and other analytical tools or methodologies can help with the complex process of forecasting charging demand.

- [ ] **Step 5:** Use your Design Day charging demand estimate along with the available power grid capacity at the site (Step 2) to find recommended minimum battery-buffered DCFC energy storage capacity in the reference tables in the Appendix.

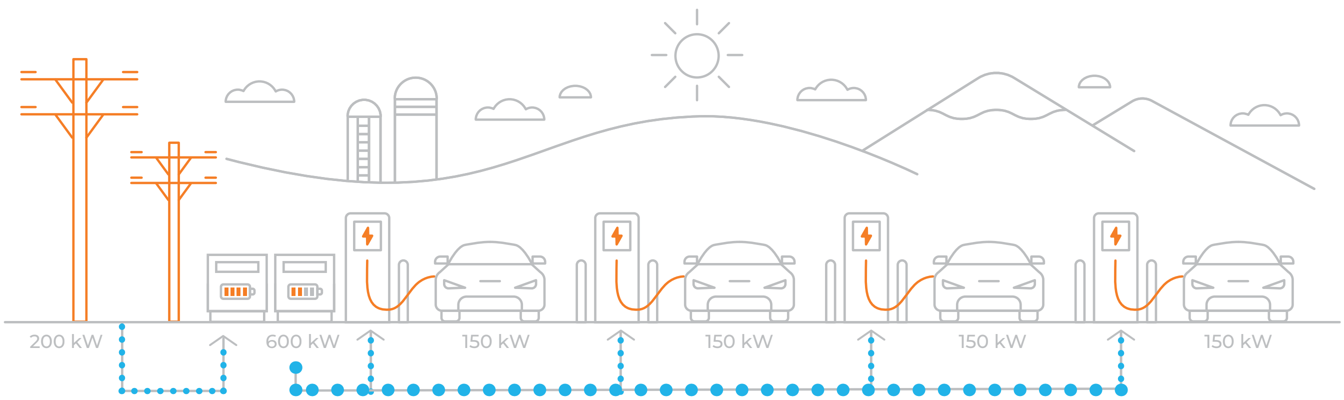
Appendix: Reference Tables

The following tables provide recommended minimum energy storage (kWh) capacity for a corridor charging station with 150-kW DCFC at combinations of power grid-supported power (kW) and Design Day average demand (kW).

When all ports have access to a pool of stored energy, this pooling allows for the most efficient utilization of power grid capacity. This document refers to this scenario as a "pooled" system. In contrast, "separate" systems have a dedicated energy storage system for each port, requiring more energy per port to ensure that no individual port fully depletes its battery. Each table cell contains kilowatt-hour values for a pooled system (e.g., "80") and separate systems (e.g., "20*4").

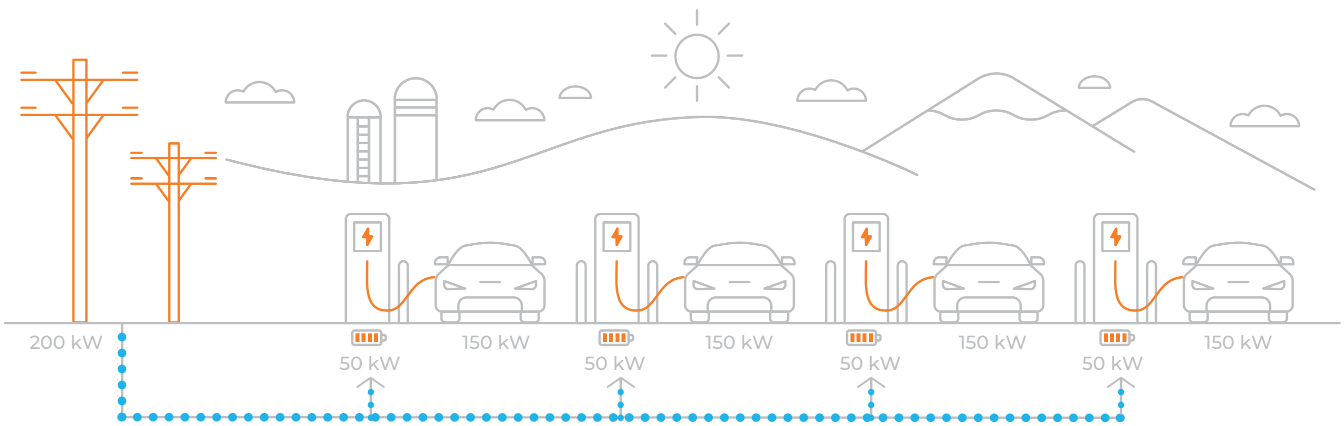
Battery-Buffered Fast Charging: Pooled Systems

All ports have access to a pool of stored energy



Battery-Buffered Fast Charging: Separate Systems

Separate systems have a dedicated energy storage system for each port



Four-Port Corridor Site

Minimum Recommended Energy Storage Capacity (kWh) [**Pooled System** or Separate Systems]

Design Day Utilization (%)		10%	13%	17%	20%	23%	27%	33%	40%
Design Day Energy Need (kWh)		1,440	1,920	2,400	2,880	3,360	3,840	4,800	5,760
Design Day Average Charging Demand (kW)		60	80	100	120	140	160	200	240
Existing Grid Capacity at Site (kW DC)	**520 or** 130×4	**80 or** 20×4	**80 or** 20×4	**80 or** 20×4	**80 or** 20×4	**80 or** 20×4	**80 or** 20×4	**80 or** 20×4	**80 or** 20×4
	480 or 120×4	**120 or** 30×4	**120 or** 30×4	**120 or** 30×4	**120 or** 30×4	**120 or** 30×4	**120 or** 30×4	**120 or** 30×4	**120 or** 30×4
	440 or 110×4	**160 or** 40×4	**160 or** 40×4	**160 or** 40×4	**160 or** 40×4	**160 or** 40×4	**160 or** 40×4	**160 or** 50×4	**160 or** 55×4
	400 or 100×4	**200 or** 50×4	**200 or** 50×4	**200 or** 50×4	**200 or** 50×4	**200 or** 50×4	**200 or** 50×4	**200 or** 70×4	**200 or** 95×4
	360 or 90×4	**240 or** 60×4	**240 or** 60×4	**240 or** 60×4	**240 or** 60×4	**240 or** 60×4	**240 or** 65×4	**240 or** 90×4	**360 or** 135×4
	320 or 80×4	**280 or** 70×4	**280 or** 70×4	**280 or** 70×4	**280 or** 70×4	**280 or** 70×4	**280 or** 95×4	**280 or** 135×4	**580 or** 200×4
	280 or 70×4	**320 or** 80×4	**320 or** 80×4	**320 or** 80×4	**320 or** 80×4	**320 or** 100x4	**320 or** 130×4	**460 or** 190×4	**880 or** 280×4
	240 or 60×4	**360 or** 90×4	**360 or** 90×4	**360 or** 90×4	**360 or** 105×4	**360 or** 135×4	**360 or** 170×4	**740 or** 270×4	**1,280 or** 385×4
	200 or 50×4	**400 or** 100×4	**400 or** 100×4	**400 or** 110×4	**400 or** 145×4	**400 or** 185×4	**560 or** 240×4	**1,120 or** 365×4	
	160 or 40×4	**440 or** 110×4	**440 or** 110×4	**440 or** 150×4	**440 or** 200×4	**640 or** 265×4	**940 or** 340×4		
	140 or 35x4	**460 or** 115×4	**460 or** 130×4	**460 or** 180×4	**560 or** 240×4	**840 or** 315×4			
	120 or 30×4	**480 or** 120×4	**480 or** 155×4	**480 or** 220×4	**760 or** 295×4				
	100 or 25×4	**500 or** 130×4	**500 or** 190×4	**660 or** 265×4					
	80 or 20×4	**520 or** 160×4	**560 or** 235×4						
	60 or 15×4	**540 or** 205×4							

Transportation Demand Scenarios

Existing Grid Capacity at Site (kW DC)

Minimum Recommended Capacity (kWh)

Five-Port Corridor Site

Minimum Recommended Energy Storage Capacity (kWh) [**Pooled System** or Separate Systems]

	Design Day Utilization (%)	10%	13%	17%	20%	23%	27%	33%	40%
	Design Day Energy Need (kWh)	1,800	2,400	3,000	3,600	4,200	4,800	6,000	7,200
	Design Day Average Charging Demand (kW)	75	100	125	150	175	200	250	300
Existing Grid Capacity at Site (kW DC)	**650 or** 130×5	**100 or** 20×5	**100 or** 20×5	**100 or** 20×5	**100 or** 20×5	**100 or** 20×5	**100 or** 20×5	**100 or** 20×5	**100 or** 20×5
	600 or 120×5	**150 or** 30×5	**150 or** 30×5	**150 or** 30×5	**150 or** 30×5	**150 or** 30×5	**150 or** 30×5	**150 or** 30×5	**150 or** 30×5
	550 or 110×5	**200 or** 40×5	**200 or** 40×5	**200 or** 40×5	**200 or** 40×5	**200 or** 40×5	**200 or** 40×5	**200 or** 50×5	**200 or** 55×5
	500 or 100×5	**250 or** 50×5	**250 or** 50×5	**250 or** 50×5	**250 or** 50×5	**250 or** 50×5	**250 or** 50×5	**250 or** 70×5	**250 or** 95×5
	450 or 90×5	**300 or** 60×5	**300 or** 60×5	**300 or** 60×5	**300 or** 60×5	**300 or** 60×5	**300 or** 65×5	**300 or** 90×5	**450 or** 135×5
	400 or 80×5	**350 or** 70×5	**350 or** 70×5	**350 or** 70×5	**350 or** 70×5	**350 or** 70×5	**350 or** 95×5	**350 or** 135×5	**725 or** 200×5
	350 or 70×5	**400 or** 80×5	**400 or** 80×5	**400 or** 80×5	**400 or** 80×5	**400 or** 100×5	**400 or** 130×5	**575 or** 190×5	**1,100 or** 280×5
	300 or 60×5	**450 or** 90×5	**450 or** 90×5	**450 or** 90×5	**450 or** 105×5	**450 or** 135×5	**450 or** 170×5	**925 or** 270×5	**1,600 or** 385×5
	250 or 50×5	**500 or** 100×5	**500 or** 100×5	**500 or** 110×5	**500 or** 145×5	**500 or** 185×5	**700 or** 240×5	**1,400 or** 365×5	
	200 or 40×5	**550 or** 110×5	**550 or** 110×5	**550 or** 150×5	**550 or** 200×5	**800 or** 265×5	**1,175 or** 340×5		
	175 or 35×5	**575 or** 115×5	**575 or** 130×5	**575 or** 180×5	**700 or** 240×5	**1,050 or** 315×5			
	150 or 30×5	**600 or** 120×5	**600 or** 155×5	**600 or** 220×5	**950 or** 295×5				
	125 or 25×5	**625 or** 130×5	**625 or** 190×5	**825 or** 265×5					
	100 or 20×5	**650 or** 160×5	**700 or** 235×5						
	75 or 15×5	**675 or** 205×5							

Transportation Demand Scenarios

Existing Grid Capacity at Site (kW DC)

Minimum Recommended Capacity (kWh)

Six-Port Corridor Site

Minimum Recommended Energy Storage Capacity (kWh) [**Pooled System** or Separate Systems]

Design Day Utilization (%)		10%	13%	17%	20%	23%	27%	33%	40%
Design Day Energy Need (kWh)		2,160	2,880	3,600	4,320	5,040	5,760	7,200	8,640
Design Day Average Charging Demand (kW)		90	120	150	180	210	240	300	360
Existing Grid Capacity at Site (kW DC)	**780 or** 130×6	**120 or** 20×6	**120 or** 20×6	**120 or** 20×6	**120 or** 20×6	**120 or** 20×6	**120 or** 20×6	**120 or** 20×6	**120 or** 20×6
	720 or 120×6	**180 or** 30×6	**180 or** 30×6	**180 or** 30×6	**180 or** 30×6	**180 or** 30×6	**180 or** 30×6	**180 or** 30×6	**180 or** 30×6
	660 or 110×6	**240 or** 40×6	**240 or** 40×6	**240 or** 40×6	**240 or** 40×6	**240 or** 40×6	**240 or** 40×6	**240 or** 50×6	**240 or** 55×6
	600 or 100×6	**300 or** 50×6	**300 or** 50×6	**300 or** 50×6	**300 or** 50×6	**300 or** 50×6	**300 or** 50×6	**300 or** 70×6	**300 or** 95×6
	540 or 90×6	**360 or** 60×6	**360 or** 60×6	**360 or** 60×6	**360 or** 60×6	**360 or** 60×6	**360 or** 65×6	**360 or** 90×6	**540 or** 135×6
	480 or 80×6	**420 or** 70×6	**420 or** 70×6	**420 or** 70×6	**420 or** 70×6	**420 or** 70×6	**420 or** 95×6	**420 or** 135×6	**870 or** 200×6
	420 or 70×6	**480 or** 80×6	**480 or** 80×6	**480 or** 80×6	**480 or** 80×6	**480 or** 100x6	**480 or** 130×6	**690 or** 190×6	**1,320 or** 280×6
	360 or 60×6	**540 or** 90×6	**540 or** 90×6	**540 or** 90×6	**540 or** 105×6	**540 or** 135×6	**540 or** 170×6	**1,110 or** 270×6	**1,920 or** 385×6
	300 or 50×6	**600 or** 100×6	**600 or** 100x6	**600 or** 110×6	**600 or** 145×6	**600 or** 185×6	**840 or** 240×6	**1,680 or** 365×6	
	240 or 40×6	**660 or** 110x6	**660 or** 110x6	**660 or** 150×6	**660 or** 200×6	**960 or** 265×6	**1,410 or** 340×6		
	210 or 35×6	**690 or** 115×6	**690 or** 130×6	**690 or** 180×6	**840 or** 240×6	**1,260 or** 315×6			
	180 or 30×6	**720 or** 120×6	**720 or** 155×6	**720 or** 220×6	**1,140 or** 295×6				
	150 or 25×6	**750 or** 130×6	**750 or** 190×6	**990 or** 265×6					
	120 or 20×6	**780 or** 160×6	**840 or** 235×6						
	90 or 15×6	**810 or** 205×6							

Transportation Demand Scenarios

Existing Grid Capacity at Site (kW DC)

Minimum Recommended Capacity (kWh)

Eight-Port Corridor Site

Minimum Recommended Energy Storage Capacity (kWh) [**Pooled System** or Separate Systems]

Design Day Utilization (%)		10%	13%	17%	20%	23%	27%	33%	40%
Design Day Energy Need (kWh)		2,880	3,840	4,800	5,760	6,720	7,680	9,600	11,520
Design Day Average Charging Demand (kW)		120	160	200	240	280	320	400	480
Existing Grid Capacity at Site (kW DC)	**1,040 or** 130×8	**160 or** 20×8	**160 or** 20×8	**160 or** 20×8	**160 or** 20×8	**160 or** 20×8	**160 or** 20×8	**160 or** 20×8	**160 or** 20×8
	960 or 120×8	**240 or** 30×8	**240 or** 30×8	**240 or** 30×8	**240 or** 30×8	**240 or** 30×8	**240 or** 30×8	**240 or** 30×8	**240 or** 30×8
	880 or 110×8	**320 or** 40×8	**320 or** 40×8	**320 or** 40×8	**320 or** 40×8	**320 or** 40×8	**320 or** 40×8	**320 or** 50×8	**320 or** 55×8
	800 or 100×8	**400 or** 50×8	**400 or** 50×8	**400 or** 50×8	**400 or** 50×8	**400 or** 50×8	**400 or** 50×8	**400 or** 70×8	**400 or** 95×8
	720 or 90×8	**480 or** 60×8	**480 or** 60×8	**480 or** 60×8	**480 or** 60×8	**480 or** 60×8	**480 or** 65×8	**480 or** 90×8	**720 or** 135×8
	640 or 80×8	**560 or** 70×8	**560 or** 70×8	**560 or** 70×8	**560 or** 70×8	**560 or** 70×8	**560 or** 95×8	**560 or** 135×8	**1,160 or** 200×8
	560 or 70×8	**640 or** 80×8	**640 or** 80×8	**640 or** 80×8	**640 or** 80×8	**640 or** 100×8	**640 or** 130×8	**920 or** 190×8	**1,760 or** 280×8
	480 or 60×8	**720 or** 90×8	**720 or** 90×8	**720 or** 90×8	**720 or** 105×8	**720 or** 135×8	**720 or** 170×8	**1,480 or** 270×8	**2,560 or** 385×8
	400 or 50×8	**800 or** 100×8	**800 or** 100×8	**800 or** 110×8	**800 or** 145×8	**800 or** 185×8	**1,120 or** 240×8	**2,240 or** 365×8	
	320 or 40×8	**880 or** 110×8	**880 or** 110×8	**880 or** 150×8	**880 or** 200×8	**1,280 or** 265×8	**1,880 or** 340×8		
	280 or 35×8	**920 or** 115×8	**920 or** 130×8	**920 or** 180×8	**1,120 or** 240×8	**1,680 or** 315×8			
	240 or 30×8	**960 or** 120×8	**960 or** 155×8	**960 or** 220×8	**1,520 or** 295×8				
	200 or 25×8	**1,000 or** 130×8	**1,000 or** 190×8	**1,320 or** 265×8					
	160 or 20×8	**1,040 or** 160×8	**1,120 or** 235×8						
	120 or 15×8	**1,080 or** 205×8							

Transportation Demand Scenarios

Existing Grid Capacity at Site (kW DC)

Minimum Recommended Capacity (kWh)


Photo from Getty Images 1331069376

How Can Joint Office Technical Assistance Help?

The Joint Office provides technical assistance to a multitude of stakeholders and programs that seek to deploy a network of EV chargers, zero-emission fueling infrastructure, and zero-emission transit and school buses. Joint Office technical assistance can help evaluate whether a battery energy storage system is appropriate. Contact us at DriveElectric.gov/contact and review the Joint Office technical assistance case study Grid-Constrained Electric Vehicle Fast Charging Sites: Battery-Buffered Options to learn more.

Joint Office of Energy and Transportation

The Joint Office of Energy and Transportation is a collaboration between the U.S. Department of Energy and U.S. Department of Transportation to support the buildout of a nationwide network of EV chargers, zero-emission fueling infrastructure, and zero-emission transit and school buses.

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