Megapack 2 XL System Specification

Revision 2.0

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PRODUCT SPECIFICATIONS

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Symbols in this Publication

This publication may use the following symbols to highlight important information:

DANGER: Indicates a hazardous situation which, if not avoided, could result in severe injury or death.

WARNING: Indicates a hazardous situation which, if not avoided, could result in injury.

CAUTION: Indicates a hazardous situation which, if not avoided, could result in minor injury or damage to the equipment.

NOTE: Indicates an important step or tip that leads to best results but is not safety- or damage-related.

1 Introduction

Electric grids around the world are embarking on the journey to 100% sustainable, reliable, and affordable energy. Tesla's mission is to enable and accelerate this transition.

Energy storage is required to make variable renewable energy such as solar and wind reliable and affordable. It also enables more efficient utilization of all electricity-generating assets supplying power to the local grid. This efficiency gain translates directly into savings for behind-the-meter sites and revenue for front-of-meter sites, while also helping to stabilize the grid and prevent outages.

The **Megapack 2 XL System** (Megapack System) is an all-in-one industrial-scale energy storage system built to address this mission. Although the sustainable energy transition is a global mission, different locations and grids have diverse near-term and long-term needs. This is why the Megapack System is also built to be scalable and configurable to the space, power, and energy requirements of any site from 1 MWh to 1 GWh+. The Megapack System also supports various Archetypes (*Archetypes on page 31*), which are types of projects that specify metering installation requirements, pre-defined control functions, and system behavior based on the project's electrical topology.

This publication provides a high-level overview of the Megapack System and its Archetypes for customers who are considering Megapack for their projects in support of various applications, including:

- **Renewable Smoothing** – Balancing the power output of renewables to the grid by storing and discharging energy
- **Demand Support** – Discharging energy during peak demand to support distribution infrastructure
- **Infrastructure Investment** – Postponing costly grid infrastructure upgrades by storing power at a single location
- **Voltage & Frequency Regulation** – Stabilizing voltage and frequency levels by absorbing and injecting reactive and real power
- **Market Participation** – Providing energy support to the grid in response to system operator alerts
- **Microgrid** – Building a localized grid that can disconnect from the main power grid

The Megapack System consists of one or more **Megapack 2 XL units** (Megapacks) and the Tesla System Controller. Each Megapack contains battery modules with integrated inverter modules, a thermal system, and the Customer Interface Bay, all factory-integrated within an enclosure.

The Tesla System Controller uses intelligent software to control and monitor Megapacks across the Megapack site.

1.1 Additional Information

Visit the Tesla Partner Portal at *https://partners.tesla.com/* to find detailed information referred to in this document. The Partner Portal also hosts a variety of video content (select the *Videos* tab).

Visit Tesla.com to find additional resources that are available to the public:

- Industrial Lithium-Ion Battery Emergency Response Guide - *https://www.tesla.com/firstresponders/*
- Megapack on Tesla.com - *https://www.tesla.com/megapack*
- Megapack Resources on Tesla.com - *https://www.tesla.com/support/energy/megapack/resources*

2 Megapack System Components

A Megapack System consists of the following components:

- One or more Megapacks – part number 1848844-XX-Y[1] (*Megapack on page 4*)
- Tesla System Controller: Standard Tesla System Controller – part number 1471208-XX-Y[1], or Large Tesla System Controller – part number 1700130-XX-Y[1] or 1459155-XX-Y[1] (*Tesla System Controller on page 10*)

[1]*Where X is a number between 0 and 9, and Y is a letter.*

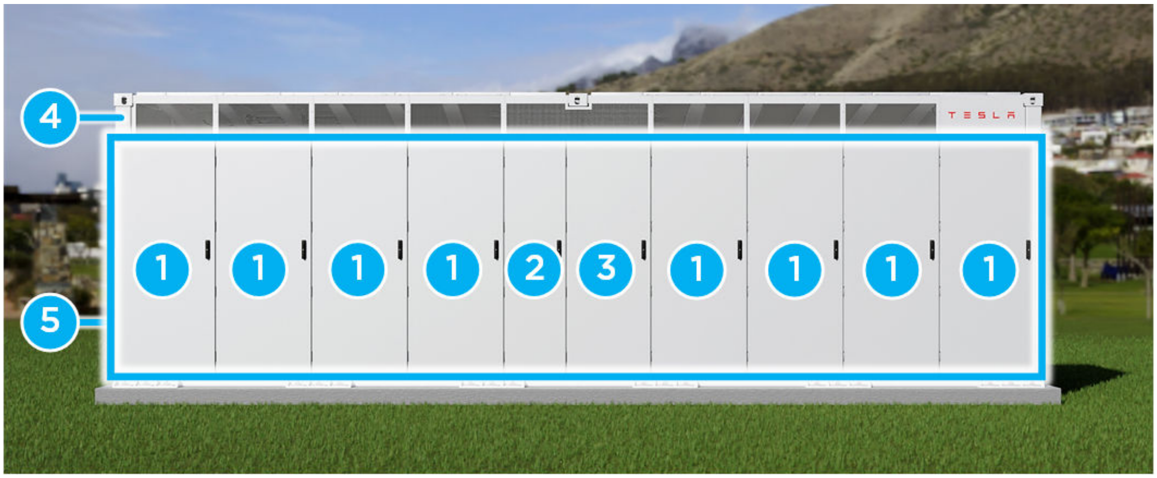
Figure 1. Example Megapack Site

2.1 Megapack

Megapack is a fully integrated battery energy storage unit capable of charging and discharging real power and injecting and absorbing reactive power. Megapack converts power for storage in rechargeable lithium-ion battery modules and is designed to support a range of AC power and energy.

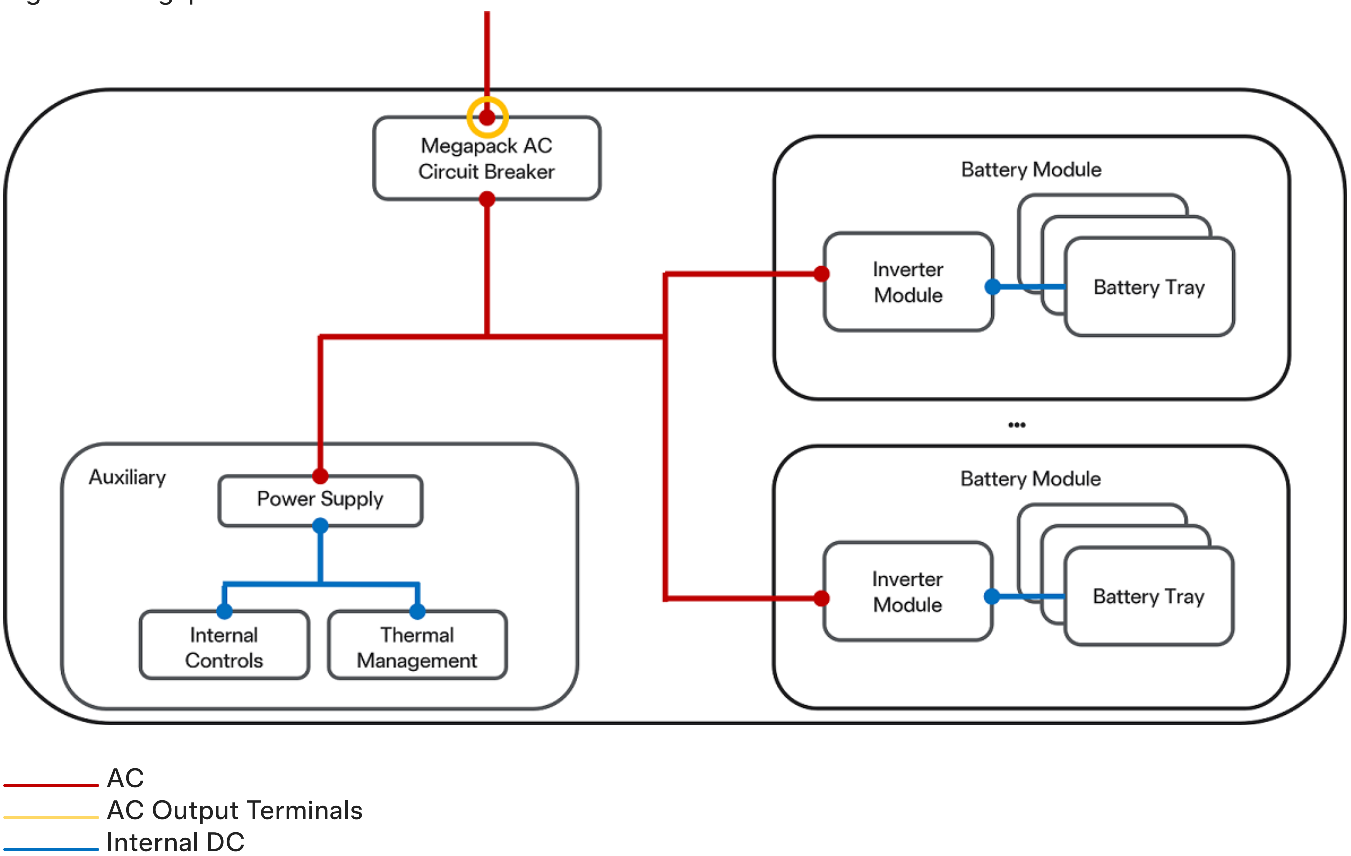
A Megapack unit consists of the following components:

Figure 2. Megapack Overview



1. Battery module bays (*Battery Modules on page 8*)
2. Thermal cabinet (*Thermal System on page 9*)
3. Customer Interface Bay (*Customer Interface Bay on page 9*)
4. Thermal roof (*Thermal System on page 9*)
5. IP66 enclosure (*Enclosure on page 10*)

Figure 3. Megapack Internal Architecture



The AC output terminals are the point on the AC bus bars at which the external AC connections to the Megapack are terminated (*Power and Energy on page 13*).

2.1.1 Product Configurations

A Megapack unit is configurable and may vary based on **product options** or **product variants**. The product (Megapack unit) as built or later reconfigured, complete with its customizations including variants and options, is known as a **configuration**.

2.1.1.1 Product Options

An **option** is a product difference that is optionally configured to meet project requirements, such as number of battery modules or cell type (*Battery Modules on page 8*). Product options are defined using **option codes**. Not all combinations of option codes are possible, as some option codes are pre-defined by other option codes.

Option codes are described at a high level below. Refer to the *Megapack 2 XL Option Codes Quick Reference Guide* on the Tesla Partner Portal for detailed calculation and ratings information.

Table 1. Product Options

<table>
<tr><th>Option</th><th>Option Code</th><th>Description</th></tr>
<tr><td>Cell</td><td>C###</td><td>Cell options can denote different cell characteristics such as specifications or manufacturing location. The following cell options are available:
<table>
<tr><th>Option</th><th>Manufacturing Location</th></tr>
<tr><td>C010</td><td>China</td></tr>
<tr><td>C011</td><td>United States</td></tr>
<tr><td>C012</td><td>China</td></tr>
</table></td></tr>
<tr><td>Fan Type</td><td>FN##</td><td>Fan type options affect the maximum audible noise specification (Noise Specification and Guidance on page 29). The following fan type options are available:
• FN01
• FN02
• FN03</td></tr>
<tr><td>Number of Battery Modules</td><td>EC##</td><td>Where ## is a number between 08 and 24, which indicates the number of battery modules.

Combine with GT## to derive the Megapack unit's energy capacity (kWh).

Combine with GT## and P### to derive the Megapack unit's real power capability (kW).</td></tr>
<tr><td>Inverter Module Configuration</td><td>GT##</td><td>GT01: 4-Hour inverter module configuration

GT02: 2-Hour inverter module configuration

Combine with EC## to derive the Megapack unit's energy capacity (kWh).</td></tr>
<tr><td>Apparent Power Configuration</td><td>P###</td><td>Where ### is a number between 040 - 240, which indicates the Megapack unit's apparent power capability.</td></tr>
</table>

Option	Option Code	Description
		Additionally allows for calculation of maximum continuous charge/discharge current (A).
Low-Voltage Augmentation Configuration	CMA#	CMA0: The hardware configuration does not support future low-voltage battery augmentation CMA1: The hardware configuration supports future low-voltage battery augmentation
Grid-Forming Firmware Configuration	VF##	VF00: The configuration does not support grid-forming VF01: The configuration supports grid-forming

Tesla may also configure options (**manufacturing options**) that become part of the product's option codes, such as circuit breaker manufacturing options. Manufacturing options are not customer-configurable.

Table 2. Manufacturing Options

<table>
<tr><th>Option</th><th>Option Code</th><th>Description</th></tr>
<tr><td>Thermal Configuration</td><td>TC##</td><td>Preconfigured based on heat rejection requirements of the power electronics and battery module count.
<table>
<tr><th>Option</th><th>Refrigerant</th></tr>
<tr><td>TC2P</td><td>R-1234yf</td></tr>
<tr><td>TC4P</td><td>R-1234yf</td></tr>
<tr><td>TC2H</td><td>R-134a</td></tr>
<tr><td>TC4H</td><td>R-134a</td></tr>
</table></td></tr>
<tr><td>Internal Bussing Configuration</td><td>QB##</td><td>Preconfigured based on the inverter module and apparent power configurations.

QB01: 1600 A

QB02: 3000 A</td></tr>
<tr><td>Megapack AC Circuit Breaker</td><td>BB##</td><td>Preconfigured based on the inverter module and apparent power configuration.

BB01: 1600 A

BB02: 3000 A</td></tr>
<tr><td>Shipping Firmware Configuration</td><td>SE##</td><td>Preconfigured based on delivery location of the Megapack.

SE00: Configuration supports transportation over water

SE01: Configuration supports transportation over land only</td></tr>
<tr><td>Cellular Configuration</td><td>CR##</td><td>Preconfigured based on delivery location of the Megapack.</td></tr>
</table>

Option	Option Code	Description
		CRNA: North America CRCN: China CRRW: Rest of world

2.1.1.2 Product Variants

A **variant** is a part or product difference that is not optionally configured but is, for example, an incremental product improvement, such as an enclosure variant (*Enclosure on page 10*).

2.1.2 Battery Modules

Battery modules are factory-installed into Megapack battery module bays and contain prismatic lithium-ion battery cells, the smallest non-divisible energy storage components of the Megapack. A battery module in turn is the smallest field-replaceable battery unit. Each Megapack contains up to 24 battery modules.

Battery modules may consist of C010, C011, or C012 cell options.

Figure 4. Battery Module - C010 or C011 Cell Option

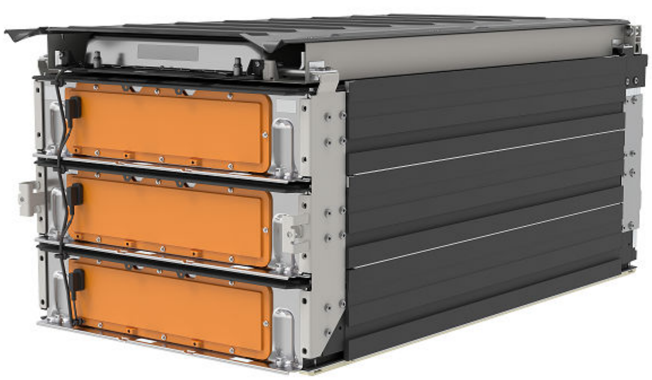


Figure 5. Battery Module - C012 Cell Option

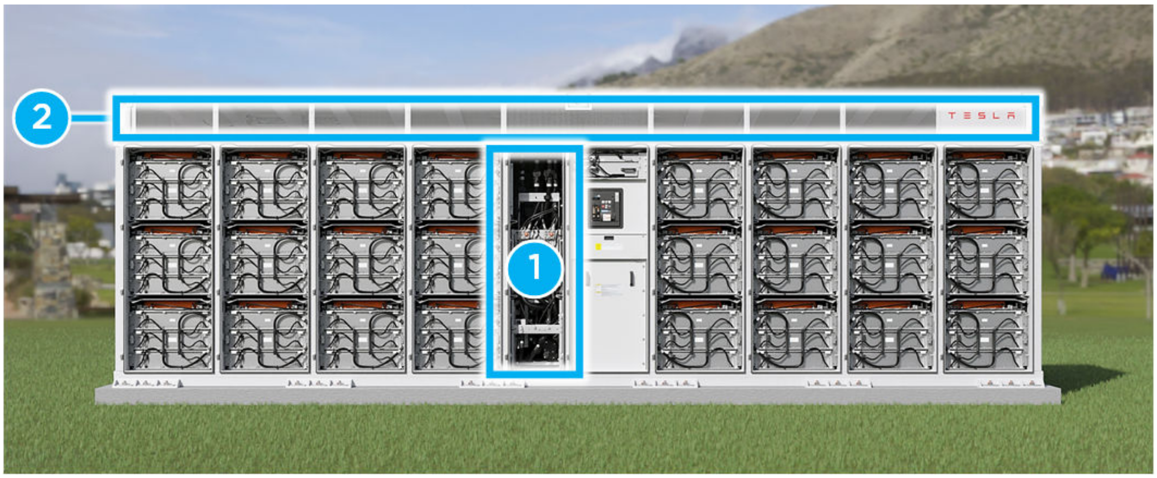
Each battery module includes an integrated inverter module for power conversion. Battery modules are connected in parallel to Megapack's internal AC bus, each with an AC power and communications output connection. The modules do not require any field assembly or adjustments and may only be replaced by Service Providers.

2.1.3 Thermal System

The thermal system provides active cooling and heating to the internal Megapack components. An external HVAC or thermal system is therefore not required for Megapack to operate.

The thermal system is comprised of the thermal cabinet and the thermal roof.

Figure 6. Thermal System



1. Thermal cabinet
2. Thermal roof

See *Thermal Specifications on page 27* for more information.

2.1.4 Customer Interface Bay

The Customer Interface Bay is a single bay that includes all the external connections needed for initial installation (the customer I/O area and the AC bus bar area) and the Megapack AC circuit breaker.

Figure 7. Customer Interface Bay

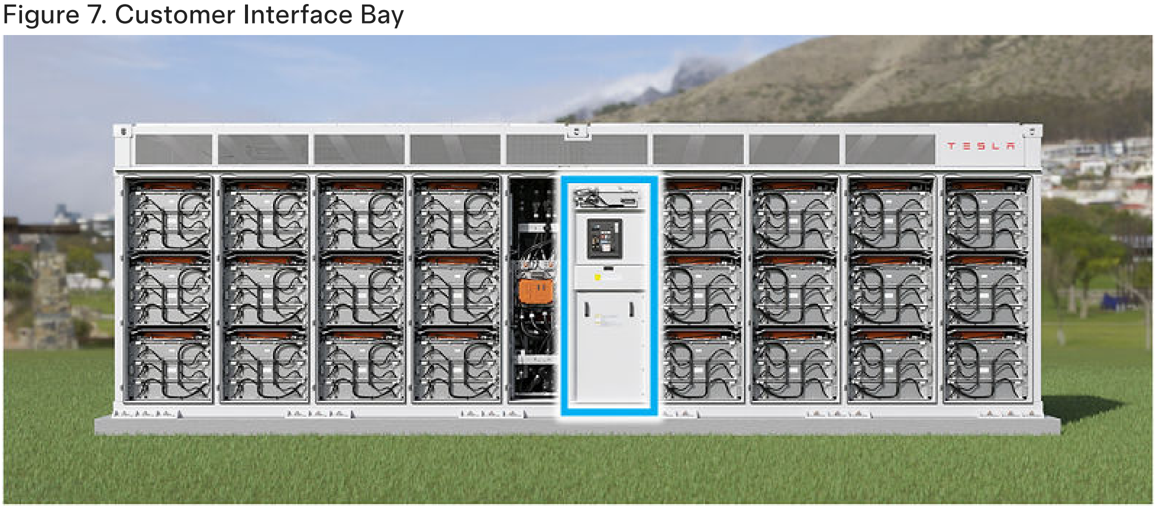


Figure 8. Customer Interface Bay Details

1. Megapack AC circuit breaker - provides distribution system protection
2. Customer I/O area - where all terminations aside from AC bus bars are made
3. AC bus bar area - where terminations to the site distribution transformer or AC distribution panel are made
4. Wireway openings

2.1.5 Enclosure

Megapack's enclosure is rated according to IP (ingress protection) code IP66. This means it provides a high level of protection against particle and water ingress for components internal to the enclosure.

This high protection rating must be maintained at all times. In particular, special precautions must be observed while installing or servicing Megapack to prevent particles, water, or debris from entering the enclosure.

There are two enclosure variants:

Table 3. Megapack Enclosure Variants

Variant	Number of Anchor Brackets	Wireway Configuration
-C enclosure	12	Two single-channel trays
-D enclosure	10	Two four-channel trays

Graphics in this publication reflect the -C enclosure variant unless otherwise specified.

Refer to the *Megapack 2 XL Layout* drawings in the *Megapack 2 XL Drawings* package on the Tesla Partner Portal for detailed information.

2.2 Tesla System Controller

The Tesla System Controller is the single point of interface with which to monitor and control the entire Tesla System and approved third-party generation sources as specified in the *Tesla Industrial Energy Approved Vendor List* on the Tesla Partner Portal. It manages control functions of the Tesla System and approved third-party generation sources, aggregating real-time information and using it to optimize commands. The Tesla System Controller communicates over a private TCP network.

By default, Tesla provides two Tesla System Controllers (with the same part number). Refer to the *SCADA Design Manual* on the Tesla Partner Portal for additional details on alternative configurations. Tesla does not include additional networking equipment that may be required for the system to operate.

The Tesla System Controller has three network interfaces:

- LAN 1 RJ45/Ethernet port, which connects to the Customer Network and can be configured for WAN access
- LAN 2 RJ45/Ethernet port, which connects to the Tesla Network
- Integrated cellular modem, which by default provides cellular access for Tesla's remote connection (part numbers 1471208 and 1700130)

Tesla requires network separation between the Tesla Network and the Customer Network. The Tesla Network shall only contain devices that are critical for Tesla System operation. System operators can interface with the Tesla System Controller over the Customer Network.

There are two physical variations of the Tesla System Controller:

- **Standard Tesla System Controller**: Used in Tesla Systems with up to 16 battery units (not including augmentation units). Delivered in the Standard Tesla System Controller Enclosure, which includes two Standard Tesla System Controllers. Refer to the *Standard Tesla System Controller Enclosure Installation Manual* on the Tesla Partner Portal for installation details.
- **Large Tesla System Controller**: Used in Tesla Systems with greater than 16 and up to 1,000 battery units (not including augmentation units). A single Large Tesla System Controller (or pair of controllers acting in automatic failover) supports up to 1,000 battery units. For projects with more than 1,000 battery units, additional Large Tesla System Controller(s) may be required. Contact your Tesla representative for more information on controller architectures for larger system sizes.

NOTE: If you have contracted a Certified Service Provider to operate and maintain your Tesla System, contact your Tesla representative for requirements.

2.3 Hazard Mitigation Features

There are hazards inherent in any energy system. In battery energy storage systems, chemical energy in the battery cells can be transmitted as electricity or heat and gases which, when unmitigated, may result in fire.

Hazards are mitigated in multiple ways by the Tesla System, as described in this section.

2.3.1 Electrical Hazard Mitigation

Electrical hazards can include shock from unexpected voltage, heat from unanticipated escape of stored energy, and environmental hazards such as electrical storms. Megapack's electrical hazard mitigation includes:

- **Battery module overcurrent protection:** The battery modules contain DC single-use fusible links.
- **Inverter DC protection:** Each inverter module is equipped with its own high-speed DC disconnect.
- **Inverter AC protection:** Each inverter module is equipped with its own AC contactor and AC fuses.
- **Ground fault protection:** Megapack is provided with a DC ground fault detection system. Megapack measures insulation resistance prior to operation and looks for ground fault during operation. Megapack also contains an AC circuit breaker with ground-fault trip settings.
- **Protective internal frame**: The enclosure's internal frame can act like a Faraday cage, diverting currents from electrical storms to flow around the internal components but not through them to ground.
- **Power electronics sizing:** The power electronics of the unit provides component sizing and creepage clearance in addition to monitored surge protection on the load side of the Megapack breaker.

2.3.2 Explosion Hazard Mitigation

The Megapack battery enclosure has an explosion control system that mitigates the potential of the enclosure to fail in the event of a deflagration. This system includes:

- **Sparker System:** A protective feature that uses spark plugs ("Sparkers") to proactively ignite flammable discharge gases from compromised battery cells before the gases accumulate within the enclosure and could lead to an explosion hazard.
- **Overpressure vents:** Vents installed in the ceiling of the battery bay's IP66 enclosure that are designed to open during an overpressure event, such as the rapid ignition of flammable gases by a Sparker. Once opened, the overpressure vents permit gases, products of combustion, and flames to exhaust in a controlled path from the battery bay into the thermal roof. From the thermal roof, this exhaust releases out of the roof vents.

2.3.3 Fire Hazard Mitigation

If fire occurs as a result of these hazards, the battery enclosure is designed to prevent it from propagating to nearby enclosures or exposures.

2.3.4 Other Safety Features

In addition to features provided to mitigate hazards, the Tesla System provides additional features that you can use to enhance safety, including:

- **Megapack AC circuit breaker:** The Customer Interface Bay contains an AC circuit breaker that can be locked in the open position.
- **Enable circuit:** Megapack includes an enable circuit that shuts down all major power components whenever the circuit is opened. Certain factors trigger opening this circuit, including opening bay doors or turning the enable switch off. The Customer Interface Bay door is not part of the enable circuit. The enable circuit does not trip the Megapack AC circuit breaker.
- **Enable switch:** The customer I/O area in the Customer Interface Bay includes an enable switch that can interrupt the enable circuit and prevent the Megapack from energizing.
- **Remote shutdown terminals:** The customer I/O area in the Customer Interface Bay contains a pair of terminals used to perform a remote shutdown, which commands the inverter to cease operation and opens the Megapack AC circuit breaker.
- **Battery management system:** Megapack provides firmware and software that can be used to monitor the system including battery cell temperature and fault tolerance.

3 Megapack Specifications

3.1 Power and Energy

A Megapack unit's apparent power capability (kVA), real power capability (kW), and energy capacity (kWh) are specified at its AC output terminals (as described in *Megapack Internal Architecture on page 5*) and include Megapack auxiliary power as well as battery inverter losses (*Appendix A: Glossary on page 75*). Losses between the AC output terminals and the point of interconnection with the customer or utility are site-dependent and excluded from the Megapack unit ratings.

At beginning of life, Megapack can provide energy capacity at real power capability when discharged from 100% SOE at STC. Megapack is also capable of storing energy capacity at real power capability when charged from 0% SOE at STC.

Megapack is capable of charging or discharging at real power capability for the life of the Megapack. The amount of energy Megapack can store will decrease over time.

NOTE: The Megapack System can be augmented to maintain power and energy capacity over the life of the product if arranged for at the time of contracting. Contact Tesla for more information.

Megapack standard configurations have the following ratings at 480 V AC:

Table 4. Megapack Standard Configuration Ratings

Configuration	Apparent Power Capability (kVA)	Real Power Capability (kW)	Energy Capacity (kWh)	Associated Option Codes
2-Hour C010 / C011	2400.0	1927.2	3854.4	C010 or C011, EC24, GT02, P240
4-Hour C010 / C011	1320.0	979.2	3916.8	C010 or C011, EC24, GT01, P132
4-Hour C012	1320.0	1075.0	4300.0	C012, EC24, GT01, P132

Megapack can be requested to be factory-configured with lower apparent power capability to meet specific project needs within the following ranges, in 50 kVA scaling increments from the minimum:

Table 5. Apparent Power Capability Configuration

Configuration	Minimum Apparent Power Capability (kVA)	Maximum Apparent Power Capability (kVA)
2-Hour C010 / C011	400	2400
4-Hour C010 / C011	400	1320
4-Hour C012	400	1320

NOTE: Megapack should be configured with a kVA rating that considers and includes the Megapack auxiliary power (*Megapack Maximum Auxiliary Power on page 16*).

Megapack can be requested with fewer battery modules to meet specific project needs within the following ranges and scaling increments:

Table 6. Real Power Capability and Energy Capacity Configuration

Configuration	Minimum Real Power Capability (kW) / Minimum Energy Capacity (kWh)	Maximum Real Power Capability (kW) / Maximum Energy Capacity (kWh)	Real Power Scaling Increment (kW) Energy Capacity Scaling Increment (kWh)
2-Hour C010 / C011	642.4 / 1284.8	1927.2 / 3854.4	80.3 / 160.6
4-Hour C010 / C011	326.4 / 1305.6	979.2 / 3916.8	40.8 / 163.2
4-Hour C012	358.3 / 1433.3	1075.0 / 4300.0	44.8 / 179.1

NOTE: If the configured Apparent Power Capability is less than the Real Power Capability, then the Real Power Capability of Megapack shall be equal to the configured Apparent Power Capability.

A Megapack unit is capable of configurations other than standard 2-Hour and 4-Hour configurations. To enable longer configurations, the P### option code is configured such that the power configuration is lower than the available real power from the batteries. For example, an 8-Hour non-standard configuration would reduce the P### option code of a standard 4-Hour configuration.

3.2 Round-Trip Efficiency

The round-trip efficiency (RTE), which includes Megapack energy consumption during the cycle (*Appendix A: Glossary on page 75*), is specified in the table below:

Table 7. Round-Trip Efficiency

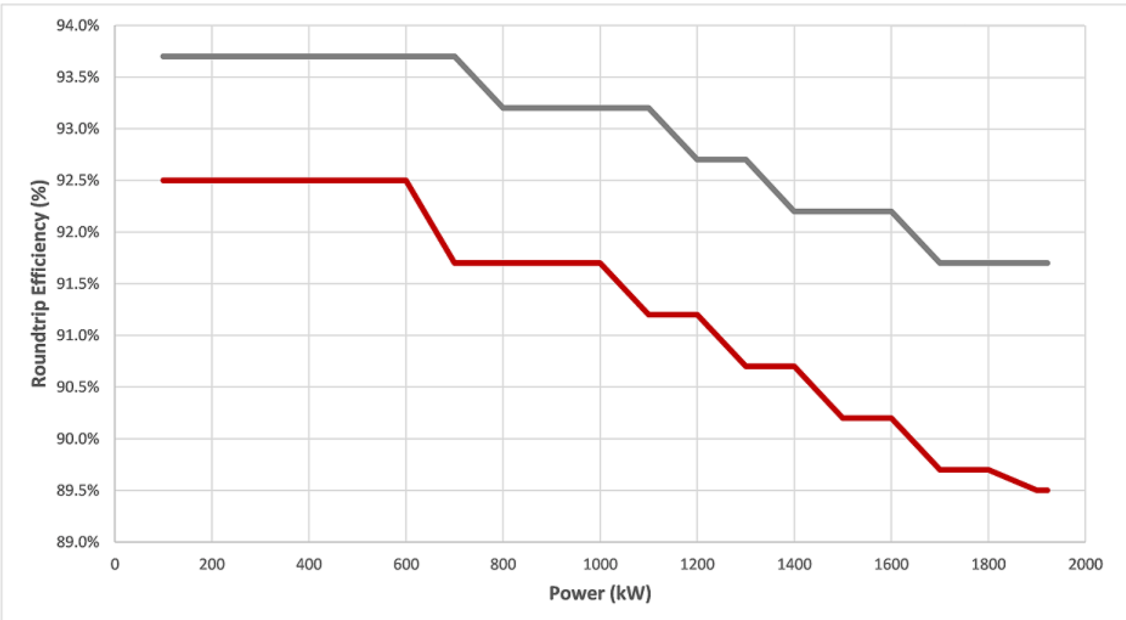
Configuration	Ambient Conditions	Round-Trip Efficiency	
		At Beginning of Life*	At Year 15**
2-Hour C010 / C011 – TC2H	STC	91.7%	89.5%
	$T_{AMBCOLD}$	91.6%	89.4%
	T_{AMBHOT}	88.9%	86.8%
4-Hour C010 / C011 – TC4H	STC	93.7%	92.0%
	$T_{AMBCOLD}$	93.2%	91.5%
	T_{AMBHOT}	90.8%	89.2%
4-Hour C012 – TC2H	STC	91.8%	89.4%
	$T_{AMBCOLD}$	91.7%	89.3%
	T_{AMBHOT}	89.0%	86.7%
2-Hour C010 / C011 – TC2P	STC	91.9%	90.7%
	$T_{AMBCOLD}$	90.2%	89.0%
	T_{AMBHOT}	90.3%	89.1%
4-Hour C010 / C011 – TC4P	STC	93.5%	92.4%
	$T_{AMBCOLD}$	92.9%	91.8%
	T_{AMBHOT}	93.2%	92.1%
4-Hour C012 – TC2P	STC	91.9%	89.8%
	$T_{AMBCOLD}$	91.0%	88.9%
	T_{AMBHOT}	91.6%	89.5%

** Indicative figures.*

*** Indicative figures. Exact value will depend on battery utilization and climate over the 15 years.*

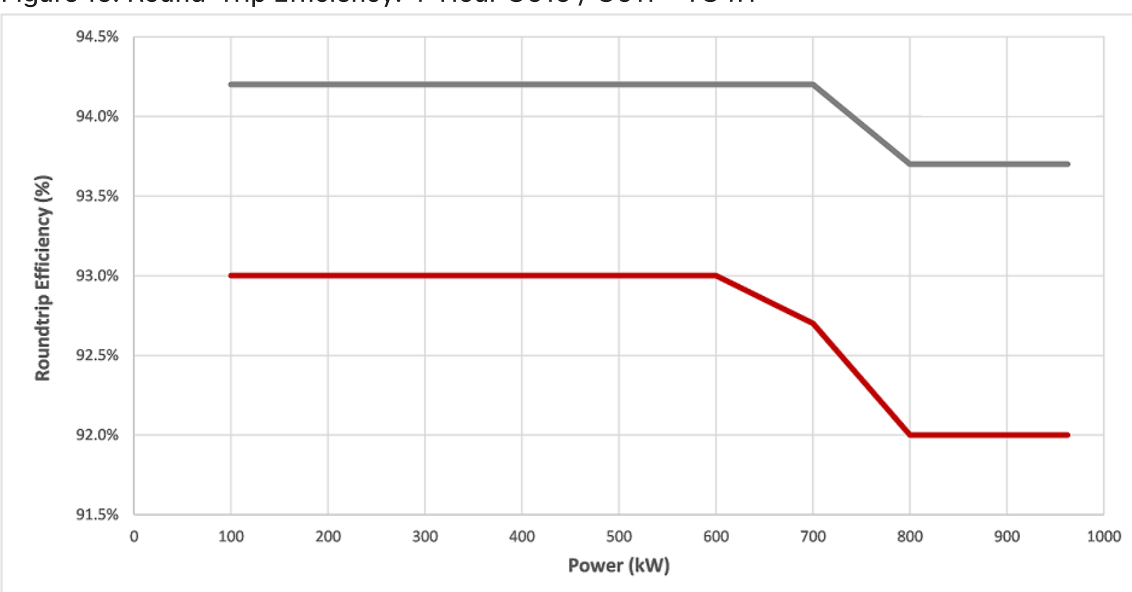
Indicative round-trip efficiency (beginning of life and year 15) under STC for a single Megapack at different power levels is shown in the graphs below.

Figure 9. Round-Trip Efficiency: 2-Hour C010 / C011 – TC2H



Beginning of life
Year 15

Figure 10. Round-Trip Efficiency: 4-Hour C010 / C011 – TC4H



Beginning of life
Year 15

3.3 Megapack Maximum Auxiliary Power, Auxiliary Energy, and Battery Inverter Losses

In addition to power used to charge and discharge the battery modules, Megapack draws some amount of auxiliary power to support its internal controls and thermal management system. Megapack's battery inverter losses also consume some power, which is additional to the Megapack auxiliary power.

Since Megapack's auxiliary power is supplied by its AC output terminals or by the battery modules, it is not possible to measure the auxiliary power separately from the battery inverter losses or any charge/discharge power consumed by the battery modules. Tesla provides a telemetry signal sharing the auxiliary power internally drawn from Megapack on the customer interfaces.

Megapack auxiliary power and battery inverter losses may be drawn from the grid and/or the battery cells depending on the power command and operating state.

Table 8. Source of Auxiliary Power and Battery Inverter Losses

	State Request = OFF	**State Request = ON**		
Control Element	Not applicable	Maintain Energy enabled*	Closed-Loop Control enabled Maintain Energy disabled	
State of Energy	N/A	N/A	0%	>0%
Megapack Auxiliary Power and Battery Inverter Losses Source	Grid	Grid. In addition to auxiliary power and battery inverter losses, a small amount of power will be used to charge Megapacks to maintain its state of energy.		Customer power command is enforced by Closed-Loop Control at the meter. Auxiliary power and battery inverter losses may be fed by the Megapacks (discharging) or the grid (charge greater than auxiliary power and battery inverter losses) depending on the power command.

** Using a Maintain Energy Target equal to the current Remaining Battery Energy.*

For additional details on auxiliary load accounting, refer to *Auxiliary Power* in the *Controls and Communications Manual* on the Tesla Partner Portal.

3.3.1 Megapack Maximum Auxiliary Power

Megapack may draw auxiliary power up to the values indicated in the table below. Each Megapack should be configured with a kVA rating that considers and includes this additional value to ensure that Megapack can supply enough AC current to simultaneously run the thermal system and charge/discharge in accordance with commands.

Table 9. Maximum Auxiliary Power

Configuration	Auxiliary Power (kVA)
2-Hour C010 / C011 – TC2H	40
4-Hour C010 / C011 – TC4H	35
4-Hour C012 – TC2H	40
2-Hour C010 / C011 – TC2P	60
4-Hour C010 / C011 – TC4P	35

Configuration	Auxiliary Power (kVA)
4-Hour C012 – TC2P	60

3.3.2 Megapack Auxiliary Energy over 24 Hours

NOTE: All specifications below assume Heat Mode (*Appendix A: Glossary on page 75*) is not enabled by the user.

Megapack auxiliary power varies over time and is not proportional to the requested charge or discharge power. Auxiliary peak average power is the highest average of the measured power for the specified interval (5-minute or 15-minute) over a standard 24-hour period. The auxiliary energy is shared in kWh over a 24-hour period for example operational scenarios, when Megapack is not actively charging or discharging. Megapack auxiliary energy was evaluated for the following two states:

- **On**: Commands Megapack to go active and enables operation. Megapack will consume additional energy to remain active.
- **Off**: Megapack will not be allowed to operate. In this state, contactors may still close and Megapack may consume a small amount of energy to support vital functionality, but they will not respond to Control Elements.

The following cycles are defined as how Megapack was operated immediately before the 24-hour period during which Megapack auxiliary energy is calculated:

- **No cycle**: Megapack was not charging or discharging power.
- **Post-cycle**: Megapack was charged from 0% SOE to 100% SOE at real power capability (kW) and was immediately discharged from 100% SOE to 0% at real power capability (kW), followed by a charge to 10% SOE to ensure the system is not left at 0% at end of discharge.

NOTE: At 0% SOE, Megapack will draw a small amount of additional power from the grid to prevent hardware damage to its cells.

Auxiliary energy per Megapack over a 24-hour period at the beginning of the battery unit's life is detailed for various scenarios in the tables below. The values provided are exclusive of battery inverter losses, documented in *Battery Inverter Losses on page 21*.

Table 10. Megapack Auxiliary Energy, Off, No Cycle

Configuration	Ambient Conditions	Auxiliary Energy (kWh/24 Hours)	5-Minute Peak Average (kW)	15-Minute Peak Average (kW)
2-Hour C010 / C011 – TC2H	STC	10	1.6	0.8
	$T_{AMBCOLD}$	10	1.5	0.8
	T_{AMBHOT}	35	14.4	13.6
4-Hour C010 / C011 – TC4H	STC	20	5.3	0.7
	$T_{AMBCOLD}$	5	4.3	0.7
	T_{AMBHOT}	25	11.8	0.3
4-Hour C012 – TC2H	STC	25	1.3	0.8
	$T_{AMBCOLD}$	10	1.1	0.7
	T_{AMBHOT}	35	0.8	0.2
2-Hour C010 / C011 – TC2P*	STC	5	1.1	0.2

Configuration	Ambient Conditions	Auxiliary Energy (kWh/24 Hours)	5-Minute Peak Average (kW)	15-Minute Peak Average (kW)
	$T_{AMBCOLD}$	5	1.2	0.7
	T_{AMBHOT}	5	1.1	0.2
4-Hour C010 / C011 – TC4P*	STC	5	0.6	0.2
	$T_{AMBCOLD}$	5	0.9	0.8
	T_{AMBHOT}	5	0.6	0.2
4-Hour C012 – TC2P*	STC	5	0.8	0.2
	$T_{AMBCOLD}$	5	0.8	0.2
	T_{AMBHOT}	5	0.8	0.2

Applicable to Grid-Following mode only. For Grid-Forming mode, contact your Tesla representative.

Table 11. Megapack Auxiliary Energy, Off, Post-Cycle

Configuration	Ambient Conditions	Auxiliary Energy (kWh/24 Hours)	5-Minute Peak Average (kW)	15-Minute Peak Average (kW)
2-Hour C010 / C011 – TC2H	STC	65	8.9	8.1
	$T_{AMBCOLD}$	15	3.3	2.5
	T_{AMBHOT}	155	32.5	39.1
4-Hour C010 / C011 – TC4H	STC	50	9.2	4.6
	$T_{AMBCOLD}$	10	6.1	1.5
	T_{AMBHOT}	95	19.1	18.2
4-Hour C012 – TC2H	STC	70	10.7	10.3
	$T_{AMBCOLD}$	15	7.1	2.9
	T_{AMBHOT}	145	18.5	14.5
2-Hour C010 / C011 – TC2P*	STC	40	8.9	8.2
	$T_{AMBCOLD}$	17	3.9	3.1
	T_{AMBHOT}	119	29.8	29.5
4-Hour C010 / C011 – TC4P*	STC	36	5.2	4.8
	$T_{AMBCOLD}$	14	3.6	2.7
	T_{AMBHOT}	98	15.1	14.9
4-Hour C012 – TC2P*	STC	33	10.3	7.9
	$T_{AMBCOLD}$	12	7.9	3.5
	T_{AMBHOT}	125	30	28.5

Applicable to Grid-Following mode only. For Grid-Forming mode, contact your Tesla representative.

Table 12. Megapack Auxiliary Energy, On, No Cycle

Configuration	Ambient Conditions	Auxiliary Energy (kWh/24 Hours)	5-Minute Peak Average (kW)	15-Minute Peak Average (kW)
2-Hour C010 / C011 – TC2H	STC	30	9.6	1.2
	$T_{AMBCOLD}$	30	10	1.9
	T_{AMBHOT}	60	22.3	14.0
4-Hour C010 / C011 – TC4H	STC	30	2.3	1.1
	$T_{AMBCOLD}$	15	2.3	1.3
	T_{AMBHOT}	40	8.7	7.6
4-Hour C012 – TC2H	STC	45	5.4	1.2
	$T_{AMBCOLD}$	30	5.3	1.4
	T_{AMBHOT}	55	18.1	14.0
2-Hour C010 / C011 – TC2P*	STC	31	10.9	8.7
	$T_{AMBCOLD}$	26	3.4	1.1
	T_{AMBHOT}	88	32.0	30.3
4-Hour C010 / C011 – TC4P*	STC	25	2.3	1.1
	$T_{AMBCOLD}$	25	2.3	1.1
	T_{AMBHOT}	64	16.4	15.3
4-Hour C012 – TC2P*	STC	26	2.3	1.1
	$T_{AMBCOLD}$	26	2.3	1.1
	T_{AMBHOT}	73	29.2	28.6

**Applicable to Grid-Following mode only. For Grid-Forming mode, contact your Tesla representative.*

Table 13. Megapack Auxiliary Energy, On, Post-Cycle

Configuration	Ambient Conditions	Auxiliary Energy (kWh/24 Hours)	5-Minute Peak Average (kW)	15-Minute Peak Average (kW)
2-Hour C010 / C011 – TC2H	STC	95	16.9	8.5
	$T_{AMBCOLD}$	30	11.2	2.9
	T_{AMBHOT}	165	39.7	39.3
4-Hour C010 / C011 – TC4H	STC	55	6.2	5.2
	$T_{AMBCOLD}$	25	3.2	2.0
	T_{AMBHOT}	100	16.0	18.7
4-Hour C012 – TC2H	STC	90	14.8	10.7
	$T_{AMBCOLD}$	40	7.1	2.9
	T_{AMBHOT}	155	18.5	14.5
2-Hour C010 / C011 – TC2P*	STC	64	10.9	8.7

Configuration	Ambient Conditions	Auxiliary Energy (kWh/24 Hours)	5-Minute Peak Average (kW)	15-Minute Peak Average (kW)
	$T_{AMBCOLD}$	35	5.8	3.5
	T_{AMBHOT}	188	32.1	30.4
4-Hour C010 / C011 – TC4P*	STC	58	6.4	5.3
	$T_{AMBCOLD}$	32	4.3	3.1
	T_{AMBHOT}	142	16.4	15.3
4-Hour C012 – TC2P*	STC	56	9.6	8.5
	$T_{AMBCOLD}$	32	4.7	3.5
	T_{AMBHOT}	170	29.2	28.6

**Applicable to Grid-Following mode only. For Grid-Forming mode, contact your Tesla representative.*

3.3.3 Auxiliary Energy during Heat Mode

Megapack's thermal system may be used to maintain its real power capability and maximize Remaining Battery Energy (*Telemetry on page 46*) across its ambient temperature range.

By raising the temperature of the battery modules using Megapack's thermal system, Megapack can be preconditioned from the starting temperatures indicated below to allow charge at real power capability.

The preconditioning duration and energy below are dependent on temperature, product configuration, command, and state of energy and exclude battery inverter losses.

Table 14. Enabling Heat Mode to Charge at Real Power Capability

Configuration	Starting Temperature	Preconditioning Duration (Hours)	Preconditioning Auxiliary Energy (kWh)
TC2H / TC4H	-30°C	18	540
	-20°C	15	445
	-10°C	11.5	350
	0°C	8.5	260
	10°C	6	175
	20°C	3	90
TC2P / TC4P	-30°C	17	500
	-20°C	14	410
	-10°C	14.5	145
	0°C	8.5	95
	10°C	5.5	50
	20°C	3	25

Similarly, Megapack can be preconditioned to allow discharge at real power capability:

Table 15. Enabling Heat Mode to Discharge at Real Power Capability

Configuration	Starting Temperature	Preconditioning Duration (Hours)	Preconditioning Auxiliary Energy (kWh)
TC2H / TC4H	-30°C	3.5	105
	-20°C	0	0
TC2P / TC4P	-30°C	4	100
	-20°C	0	0

Finally, Megapack can be preconditioned from the following starting temperatures to maximize Remaining Battery Energy (*Telemetry on page 46*):

Table 16. Enabling Heat Mode to Maximize Remaining Battery Energy

Configuration	Starting Temperature	Preconditioning Duration (Hours)	Preconditioning Auxiliary Energy (kWh)
TC2H / TC4H	-30°C	18	535
	-20°C	14.5	440
	-10°C	11.5	345
	0°C	8.5	250
	10°C	5.5	160
	20°C	2.5	65
TC2P / TC4P	-30°C	17	500
	-20°C	14	410
	-10°C	14.5	145
	0°C	8.5	95
	10°C	5.5	50
	20°C	2.5	20

3.3.4 Battery Inverter Losses

Battery inverter losses increase with the operating power of the inverter and are accounted for as part of the efficiency. While losses generally decrease with a lower power value, the losses are not equal to zero when the commanded real power is zero.

Battery inverter losses at zero real power include switching losses and quiescent draw from the inverter. Switching losses are present when Megapack is in ON state, even when Megapack is not actively charging or discharging. Quiescent draws are present in both ON and OFF state. Inverter losses do not depend on the ambient temperature.

Table 17. Inverter Losses per Megapack at Zero Power in ON and OFF States

Configuration	Megapack ON (kW)*	Megapack OFF (kW)*
2-Hour**	3.3	1.0
4-Hour**	1.7	0.5

** Indicative figures*

***Applicable to Grid-Following mode only. For Grid-Forming mode, contact your Tesla representative.*

Inverter losses are not measured directly inside of the Megapack and are inherent to the Megapack inverter operation. The values in *Inverter Losses per Megapack at Zero Power in ON and OFF States on page 21* are indicative and provided based on measurements performed on test systems.

3.4 Interconnection Data

Table 18. Interconnection Data

Specification	Value
Max Continuous Output Current	Factory-configurable (See *Power and Energy on page 13*)
Overload Capability	120% of rated current (10 s max)
Nominal Voltage	480 V AC (configurable)
Output Voltage Range	422-552 V AC
Nominal Frequency	50 or 60 Hz (configurable)
Frequency Range	45-66 Hz
Phases	3
Configuration	3-wire, Wye **Note:** Grounded Wye required at transformer secondary
Power Factor Range	-1 to +1
Total Current Harmonic Distortion (THD)	< 5% (at real power capability)
Power Regulation Accuracy	< 2% (See *Response Time on page 50*)
Overvoltage Category	Category III up to 3000 m
Maximum Supply Fault Current	85 kA_{rms}

3.5 Ride-Through and Anti-Islanding Features

3.5.1 Voltage Ride-Through

Megapack voltage ride-through (VRT) settings – high-voltage ride-through (HVRT) and low-voltage ride-through (LVRT) – are adjustable and programmed during the commissioning process to meet IEEE 1547-2018 or IEEE 2800-2022 requirements, and/or to comply with applicable grid code. The curve in *Megapack Non-Cumulative and RMS-Based HVRT and LVRT Capabilities on page 23* specifies the per-unit HVRT and LVRT non-cumulative capability of Megapack. All per-unit (pu) voltages are defined with respect to 480 V AC L-L.*

Figure 11. Megapack Non-Cumulative and RMS-Based HVRT and LVRT Capabilities

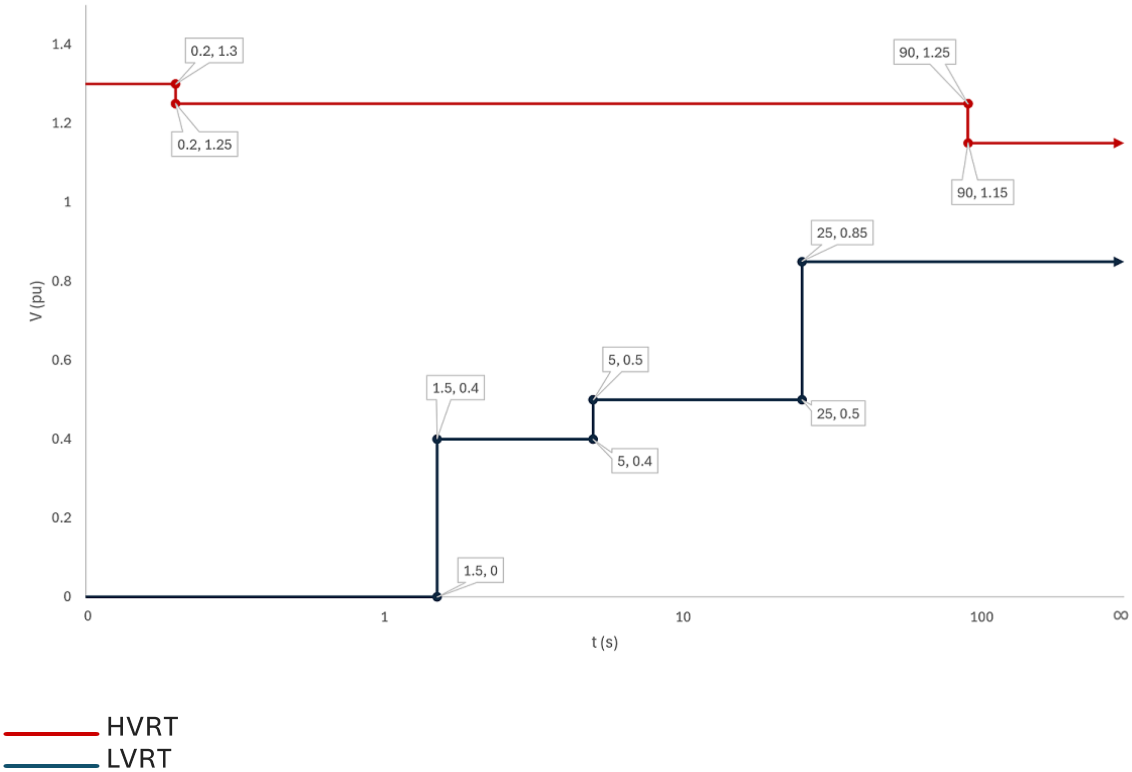


Table 19. Ride-Through Setting Ranges

Parameter	Setting Range	Resolution
Voltage	0.00 – maximum HVRT capability	0.01 pu
Time	0.001 – 60000 s*	0.001 s

* *Time allowed at a specific per-unit voltage depends on the nominal voltage rating. Typically, default settings and acceptable ranges are tested as part of a specific certification. For deviations from certified settings in a region, contact your Tesla representative for more information.*

The table below specifies the maximum per-unit overvoltage (OV) withstand non-cumulative capability of Megapack:

Table 20. Maximum Overvoltage Withstand

Parameter	Per-Unit Maximum Value, Nominal Voltage of 480 V AC, Non-Cumulative and RMS-Based
Maximum OV withstand	130% @ 0.2 s

Megapack has adjustable abnormal voltage settings parameters. For details on configuring Megapack to comply with IEEE 1547, refer to the *Design and Installation Manual* on the Tesla Partner Portal.

In addition to ride-through capability, Megapack is capable of adding or removing VARs during VRT events to help support voltage regulation during a fault event. K-factor (reactive current support coefficient) adjusts the amount of reactive current supplied to support grid voltage during a fault. This coefficient is multiplied by the per-unit voltage sag/swell to determine the amount of reactive current (up to rated current) supplied to support the voltage. There are separate coefficients for sag and swell. Setting a K-factor to 0 disables reactive current support.

As part of the commissioning process, Megapack can be configured to prioritize real or reactive current during VRT (grid fault) events. Megapack can supply negative sequence reactive current (up to rated current per phase) to support voltage imbalance due to grid faults.

3.5.2 Frequency Ride-Through

Megapack frequency ride-through (FRT) settings are adjustable and programmed during the commissioning process to comply with IEEE 1547-2018 or IEEE 2800-2022 Table 15 requirements, and/or to comply with applicable grid code. High-frequency ride-through (HFRT) and low-frequency ride-through (LFRT) parameters are configurable to the limits of the capability curves shown in *Megapack HFRT and LFRT Capabilities (50 Hz) on page 24* and *Megapack HFRT and LFRT Capabilities (60 Hz) on page 25* below.

Figure 12. Megapack HFRT and LFRT Capabilities (50 Hz)

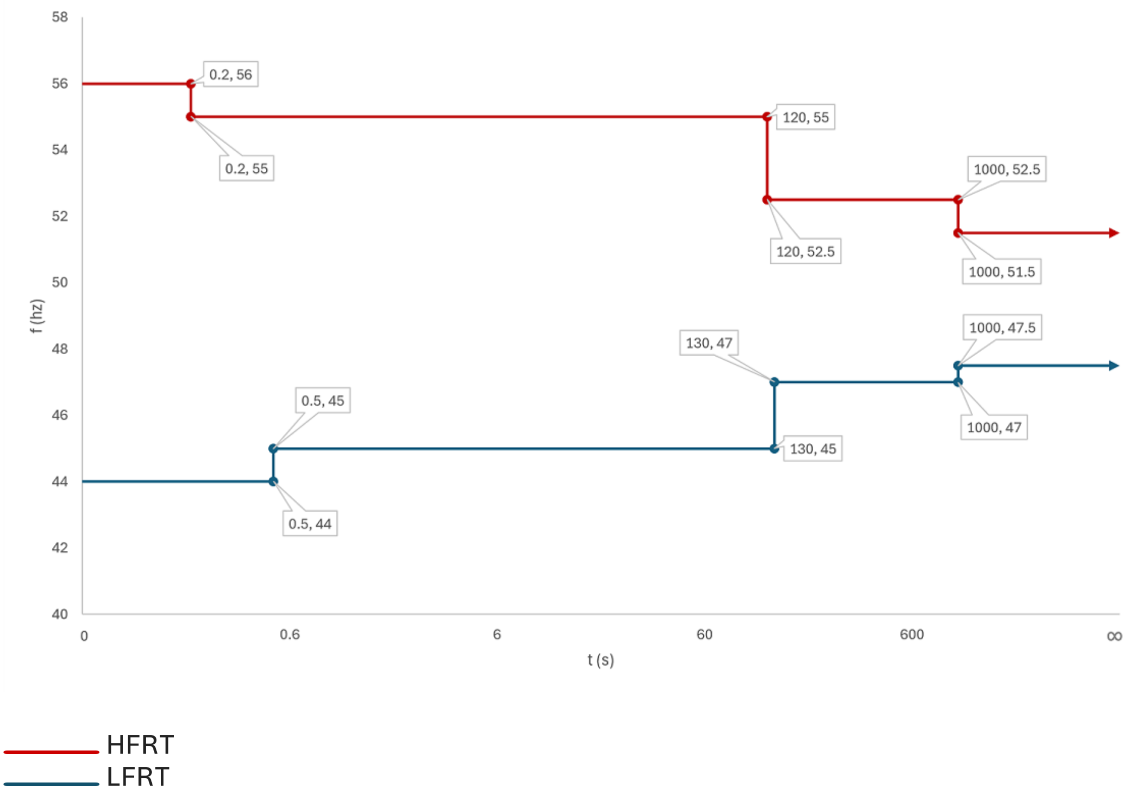
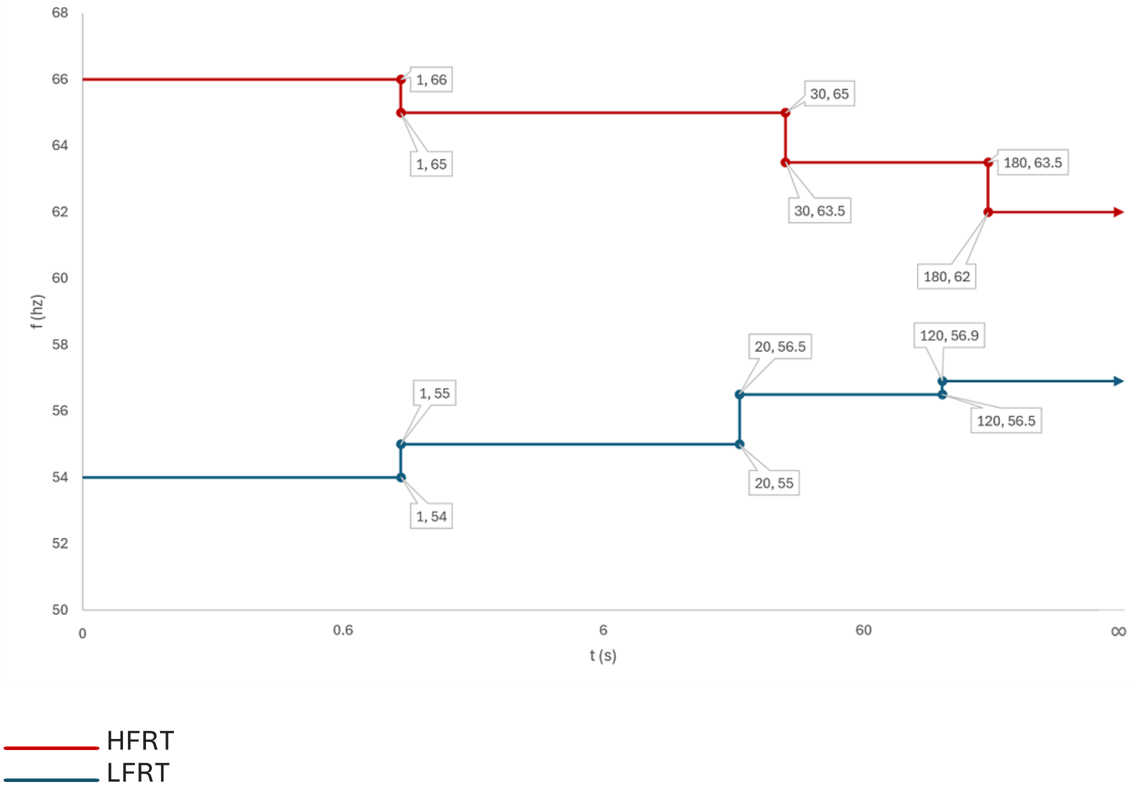


Figure 13. Megapack HFRT and LFRT Capabilities (60 Hz)



Megapack has three underfrequency (UF) and three overfrequency (OF) trip points and times. These are configured during commissioning to comply with the relevant grid code. The limits and resolution of frequency setpoints are enumerated in *Frequency Trip Point Settings on page 25* below.

Table 21. Frequency Trip Point Settings

Trip Point	Frequency Range	Time (s)	Resolution
UF Trip Time 1 - 3	44 – 66 Hz	0.001-60000	0.01 Hz/0.001 s
OF Trip Time 1 - 3			

3.5.3 Ride-Through Operation Alerts

Megapack exposes four ride-through alerts to the customer interface. A Megapack unit will assert an alert that it has entered VRT or FRT mode when any threshold has been crossed that would, if sustained, result in a Megapack trip. For example, if the HVRT settings were set according to the capability curve in *Megapack Non-Cumulative and RMS-Based HVRT and LVRT Capabilities on page 23*, a HVRT alert would be asserted without delay when voltage exceeds 1.15 per-unit. Underfrequency, overfrequency, and undervoltage alerts will be issued when their respective most-stringent thresholds are exceeded.

To reduce the risk of nuisance alerting, the Megapack unit ride-through alert is asserted when at least 50% of its inverters report that they have entered ride-through. The alert will remain asserted until less than 50% of the inverters are in ride-through.

Refer to the *Controls and Communications Manual* on the Tesla Partner Portal for point indices for the ride-through points listed in *System-Level Telemetry and Alerts on page 46*.

3.5.4 Trip Accuracy

Table 22. Trip Accuracy

Trip Setting	Accuracy
Voltage	+/- 1% of nominal voltage
Frequency	+/- 0.01 Hz
Reconnection time	1% of setpoint
Trip time	.16 s for < 5 s 1% of setpoint for > 5 s
Active power	+/- 5% of apparent power capability
Reactive power	+/- 5% of apparent power capability

3.5.5 Anti-Islanding Features

The Megapack inverter includes these anti-islanding features:

- Reconnection delay timer
- Active anti-islanding: Sandia Frequency Shift implemented on all systems
- Passive anti-islanding: Configurable rate of change of frequency (ROCOF) preferences

The reconnection delay timer is configurable with the following settings:

Table 23. Reconnection Delay Timer Default Settings

Feature Name	Effect	Setting Range	Default
Reconnect Time Delay	The amount of time Megapack waits before reconnection, after the grid returns within the frequency and voltage ride-through windows defined above.	0-600 s	300 s
Reconnect Min. Voltage	The minimum voltage at which Megapack interprets the grid is within tolerable conditions.	0-150%	88.33%
Reconnect Max. Voltage	The maximum voltage at which Megapack interprets the grid is within tolerable conditions.	0-150%	105.83%
Reconnect Min. Frequency	The minimum frequency at which Megapack interprets the grid is within tolerable conditions.	44 – 66 Hz	59.3 Hz
Reconnect Max. Frequency	The maximum frequency at which Megapack interprets the grid is within tolerable conditions.	44 – 66 Hz	60.5 Hz

Sandia Frequency Shift is enabled by default, but can be disabled if required for the application. ROCOF is configurable with the following settings:

Table 24. ROCOF Settings

Feature Name	Effect	Setting Range	Default
ROCOF Enable	Turns ROCOF on or off	n/a	Off
ROCOF Fault Limit	Sets the rate of change required for a trip	0.1-100.0 Hz/s	1 Hz/s
ROCOF Time Delay	Sets how long the rate of change has to be present for the inverter to trip	0-1 s	1 s

3.6 Dimensions and Mass

> **NOTE:** Mass as listed is maximum mass. Megapack can be configured for lighter shipping mass based on project-specific requirements.

> **NOTE:** Enclosure dimensions are provided for nominal design guidance only. For precise dimensions, refer to *Megapack 2 XL Drawings*.

Table 25. Megapack Dimensions and Mass (Weight)

Width	Depth	Height	Max. Shipping Mass
8800 mm (346 ½ in)	1650 mm (65 in)	2785 mm (110 in)	38,100 kg (84,000 lb)

3.7 Ambient Temperature and Elevation

Megapack is capable of meeting apparent power capability and real power capability in ambient temperatures between -30°C and 50°C, and in relative humidity of up to 100% condensing.

In high elevation, at low air pressure, the cooling capability of Megapack may be reduced as specified by standard atmosphere conditions as indicated below:

Table 26. Ambient Temperature

Elevation Above Sea Level (M)	Maximum Ambient Temperature During Operation (°C)
0-999	50.0
1000-1999	48.5
2000-2999	42.0
3000	35.5

3.8 Thermal Specifications

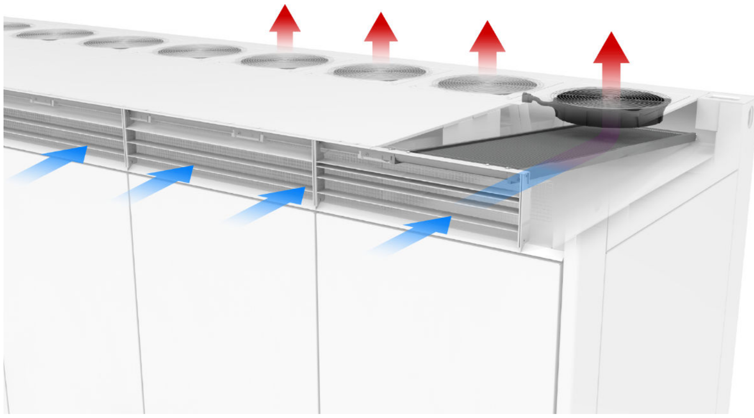
The thermal system includes coolant and refrigerant in a sealed system. Megapack ships with the necessary coolant and refrigerant included as specified below.

Table 27. Thermal Capacities

	Composition	Max Quantity (Approx)	
Coolant	50-50 ethylene glycol-water	380 L / 100 gal	
Refrigerant	R-1234yf (2,3,3,3-Tetrafluoroethane)	4-Hour thermal configuration (TC4P option code)	Up to 2.6 kg / 5.7 lb
		2-Hour thermal configuration (TC2P option code)	Up to 5.2 kg / 11.5 lb
	R-134a (1,1,1,2-Tetrafluoroethane)	4-Hour thermal configuration (TC4H option code)	Up to 1.5 kg / 3.3 lb
		2-Hour thermal configuration (TC2H option code)	Up to 3 kg / 6.6 lb

Air flows through the enclosure as shown below:

Figure 14. Megapack Airflow



The thermal cabinet includes pumps that circulate coolant through the Megapack and a compressor that maintains thermal control, in addition to an in-line heater that can warm the coolant. The thermal cabinet also contains a power conversion system for drawing power from Megapack's internal AC bus. The thermal cabinet is accessible for servicing from ground level.

The thermal roof, or top cabinet of the enclosure, provides ventilation airspace and contains fans and radiators that cool the ethylene glycol-water coolant solution. The thermal roof is accessible for servicing with the help of a ladder or mechanical lift.

Since the thermal subsystem is a fully closed-loop system with a compressor, the refrigerant line includes a pressure relief valve that can activate if incorrect maintenance or operation creates excessive pressure. The system operates autonomously and does not require user feedback.

Megapack is designed to be installed outdoors within the rated operating temperature specifications. Indoor installations are not allowed without consulting Tesla.

CAUTION: Do not install batteries in areas where temperatures routinely approach or exceed 50°C (122°F).

3.9 Enclosure Specifications and Ratings

Table 28. Enclosure Specifications or Capabilities

Corrosion Resistance	Compliant with ISO 12944: C5I (industrial) and C5M (coastal) standards
Impact Rating	IK09
Ingress Rating	IP66/NEMA 3R (Megapack enclosure - including rain and sprinkler test immunity) IP20 (Thermal system)
Roof Live Load	Can support a person of up to 300 lb (136 kg) gross weight in clearly designated areas
Roof Snow Load	732.3 kg/m^2 (150 psf, or 7.18 kN_{Earth}/m^2)
Salt Fog Rating	Able to withstand over 1,000 hours of salt fog application per a C5M system
Seismic, Shock, and Vibration Rating	Qualification Level - IEEE 693-2018 High PL: ZPA=1.0 g 5% damping Certification Level - ICC-ES AC 156-2018 S_{DS}=2.50 g z/h=0 I_p=1.5

Solar Loading	Full apparent power capability and real power capability in all ambient temperature conditions and at maximum elevation up to 1200 W/m^2 solar loading, in any direction (*Ambient Temperature and Elevation on page 27*)
Wind Rating	Able to withstand Category 5 hurricane sustained wind speeds of up to 157 mph (252 km/h)

3.9.1 Noise Specification and Guidance

Each Megapack unit has rooftop fans as part of its thermal system. Megapack's main source of noise comes from these fans, for which there are two related option codes:

- FN## (fan type)
- TC#H (thermal configuration manufacturing option code that represents number of fans)

The maximum audible noise specification is expressed as the sound pressure level (SPL) in decibels, and measured at a 10-meter (33-foot) distance from the enclosure at maximum thermal system operation.

Refer to the relevant combination of option codes for the Megapack unit's specification:

Table 29. Maximum Audible Noise Specification

FN##	TC2H / TC2P	TC4H / TC4P
FN01 / FN02	71.2 dB(A)	68.9 dB(A)
FN03	66.3 dB(A)	63.8 dB(A)

NOTE: In addition to Megapack unit differences, noise emission is affected by site-specific conditions such as ambient temperature and system dispatch profile. Maximum audible noise may generally only be reached under specific operating conditions. For the majority of the time, noise emitted by Megapack will be much lower.

3.9.2 Enclosure Color

Megapack's exterior paint color code is *RAL 9016 Traffic White*. Touch-up paint ships as a Megapack accessory.

Figure 15. Megapack Enclosure Color

4 Tesla System Controller Specifications

The Tesla System Controller hosts advanced software that provides the single point of interface through which plant operators control and communicate with a Tesla battery storage system. It supports a comprehensive set of telemetry reported at the system- and Megapack-level, and includes a flexible set of controls to manage real power, reactive power, islanding behaviors and more.

The Tesla System Controller requires one or more supported SEL-735 meters to perform control functions. The meter provides frequency, voltage, real power, and reactive power information required for various controls functions and closed-loop control.

This section defines the functional performance capabilities of Megapack that are available via the Tesla System Controller v2 Platform.

NOTE: Megapack is designed to comply with IEEE 1547-2018 communication and controls capabilities.

NOTE: Tesla does not guarantee that the telemetry or controls will be implemented exactly as written in this specification. Communication protocols and control mode APIs are subject to change but will ultimately address the functional behaviors herein.

4.1 Controls

The Tesla System Controller v2 Platform is modular and adaptable to meet project-specific needs, which are primarily driven by site-specific electrical topology, interconnection requirements, and regional regulations.

To satisfy these needs, systems can be operated either as Grid-Forming or Grid-Following. Additionally, the control platform uses a set of **Archetypes** (*Archetypes on page 31*), which serve different segments of the global battery energy storage market based on geographic region and interconnection types. Archetypes decrease project commissioning risk and time by defining, up-front, the required set of individual **Control Elements** (*On-Grid Control Elements on page 42*), their settings, and how they interact and behave as a control system.

Depending on project-specific needs, including those driven by electrical topology, an Archetype will be selected and deployed during commissioning for a given project by Tesla. The overall control configuration of a site, defined by an Archetype and its settings, is called a **Control Profile**.

4.1.1 Archetypes

Standard control Archetypes represent a type of project built with a Tesla battery system and specify metering installation requirements, pre-defined control functions (site- and inverter-level), and system behavior under special conditions based on the project's electrical topology.

An Archetype can consist of one or more Sections, which correspond to portions of a single-line diagram (SLD) associated with specific Control Elements. Intermediate power transformers are supported in all Archetypes to facilitate projects that may include different voltage levels.

Available Archetypes, in addition to summaries of their supported Control Elements, are described by type of project: *Utility Archetypes on page 31* or *C&I Archetypes on page 33*.

4.1.1.1 Utility Archetypes

The following Archetypes are designed for utility-scale projects:

Table 30. Utility-Scale Archetypes

Archetype	Description
Utility Battery Only	The Utility Battery Only Archetype is designed for front-of-the-meter, utility-scale storage projects. This Archetype applies to on-grid projects consisting of a battery meter, a number of generator step-up transformers (GSU transformers), and feeders connecting to medium voltage transformers and Megapacks. The count of GSU transformers, feeders, and Megapacks can change based on project needs.
Utility Co-Located Plant (Battery Only)	The Utility Co-Located Plant (Battery Only) Archetype is designed for projects consisting of both batteries and solar generation assets in which only battery control is within Tesla's scope, or for projects with multiple battery meters instead of a single battery meter at the point of interconnection. Typically, the solar generation assets (PV) and battery will be located on different feeders behind the same generator step-up transformer (GSU transformer). Tesla's control scope ends at the battery meters and will not cover any constraints applying to combined output of the solar assets and batteries. Tesla assumes that a higher-level third-party controller, supplied by the customer, is responsible for managing any constraints of the co-located system.
Utility Hybrid	The Utility Hybrid Archetype is designed for projects consisting of both batteries and solar, where the system is being controlled as a single combined resource (referred to as a hybrid resource) and both solar and battery control is within Tesla's scope. Solar and batteries will usually be located on different feeders behind the same generator step-up transformer (GSU transformer). Tesla's control scope encompasses the entire hybrid resource up to the point of interconnection, and can include one or more GSU transformers. The system will accurately respond to customer-provided real power commands at the hybrid resource's point of interconnection (usually at high voltage). To do so, the Tesla System Controller automatically determines the contribution of solar and battery, prioritizes solar production, and performs closed-loop control at the point of interconnection. If required to meet the customer command, the Tesla System Controller will control solar inverters to curtail production. The Tesla System Controller also ensures GSU transformer nameplate limits are not exceeded by solar production and battery dispatch. Since the battery system is used in conjunction with solar to meet hybrid commands, independent control of the battery is not permitted. Customers are responsible for managing their hybrid commands based on their needs and their solar forecast. **NOTE:** The Utility Hybrid Archetype requires integration with solar inverters or a Renewable Generation Controller, both of which are paid offerings. Refer to the *Renewable Generation Controller Specification* on the Tesla Partner Portal or contact your Tesla representative for more information.

Table 31. Summary of Control Modes by Archetype (Utility-Scale Archetypes)

Control Mode	Utility Battery Only	Utility Co-Located Plant (Battery Only)	Utility Hybrid
Grid-Following	✔	✔	✔
Grid-Forming	✔		✔

Table 32. Summary of Control Elements by Archetype (Utility-Scale Archetypes)

Control Element	Utility Battery Only	Utility Co-Located Plant (Battery Only)	Utility Hybrid
Meters	Single battery meter	One battery meter per battery sub-site	One busway meter at the point of interconnection for the combined hybrid plant. One or more solar meter(s) and battery meter(s).
External Interface	✔	✔	✔
Enable Manager	✔	✔	✔
Maintain Energy	✔	✔	
Ramp Rate	✔	✔	✔ (at the point of interconnection)
Power Factor	✔	✔	✔ (at the point of interconnection)
Voltage Control	✔		✔ (at the point of interconnection)
Frequency Droop	✔		✔ (at the point of interconnection)
Frequency Integral	✔		✔ (at the point of interconnection)
Fast Frequency Response (Low Frequency)	✔		
Fast Frequency Response (High Frequency)	✔		
Closed-Loop Control	✔	✔ (At metered sub-site)	✔ (at the point of interconnection)
Transformer Losses	✔	✔ (At metered sub-site)	✔ (up to the point of interconnection)
Combiner	✔	✔	✔
Battery Group	✔	✔	✔
Re-Engage Monitor	✔	✔	✔
Solar Controls			✔
Solar Battery Split			✔
Asset Power Manager			✔
Inverter Asset Group			✔

4.1.1.2 C&I Archetypes

The following Archetypes are designed for commercial and industrial (C&I) projects:

Table 33. C&I Archetypes

Archetype	Description
Battery Dispatch Only	The Battery Dispatch Only Archetype is used in projects where Tesla provides control capabilities at the battery-level. Site-level control capabilities are outside of Tesla's scope and must be managed by a third-party controller.
Grid-Connected Only	The Grid-Connected Only Archetype is used in projects where the system is grid-connected and Tesla provides both battery-level and site-level control capabilities. These projects consist of a net load meter, Tesla battery, and optional solar generation assets connected to the grid.

Archetype	Description
	Battery and site control can be managed either by Tesla controls such as Opticaster or by a third-party controller. Tesla's controls scope ends at the net load meter and includes control of the battery and solar generation assets (if solar exists). Solar control requires approved solar inverters as specified in the *Tesla Industrial Energy Approved Vendor List* on the Tesla Partner Portal.
Backup	The Backup Archetype is used in projects where the system is normally grid-connected and provides load backup in the event of abnormal grid conditions. Tesla provides battery-level, site-level, and islanding control capabilities. These projects consist of a Tesla battery and an Islanding Controller. Battery and on-grid site control can be managed either by Tesla controls such as Opticaster or by a third-party controller. Islanding transitions are managed by Tesla, whereas a third-party controller must be used for off-grid microgrid control, if needed.
Off-Grid Microgrid	The Off-Grid Microgrid Archetype is used in projects where the system is an isolated grid capable of supporting loads and managing battery operation in coordination with other generation assets. These projects consist of a Tesla battery and approved solar, generator, and/or wind assets while operating off-grid. Tesla manages the entire microgrid operation using its Microgrid Controller software. All third-party devices must be listed in the *Tesla Industrial Energy Approved Vendor List* on the Tesla Partner Portal.
Grid-Connected Microgrid	The Grid-Connected Microgrid Archetype is used in projects in which the system is connected to the grid and is also capable of islanding, and charging or discharging in coordination with generation assets in order to support loads. These projects consist of a Tesla battery and approved solar, generator, or wind assets while operating on-grid and off-grid. Tesla manages the entire site, including islanding transition between on- and off-grid operation. On-grid operation is managed by Tesla controls such as Opticaster. Off-grid operation is managed by Tesla's Microgrid Controller software.

Table 34. Summary of Control Elements by Archetype (C&I Archetypes)

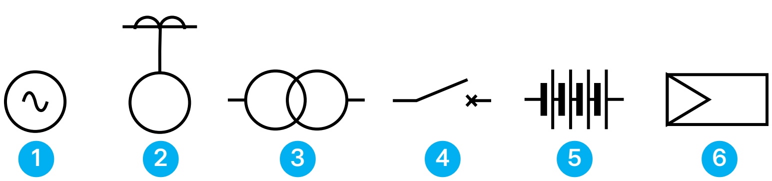
Control Elements	Battery Dispatch Only	Grid-Connected Only	Backup	Off-Grid Microgrid	Grid-Connected Microgrid
External Interface	✔	✔	✔	✔	✔
Direct Real/Reactive (Ramp Rates)	✔	✔	✔		✔
Operator Limits	✔	✔	✔		✔
Active Power Limit	✔	✔	✔		✔
Meters	✔	✔	✔	✔	✔
Closed-Loop Control	✔	✔		✔	✔
Transformer Losses	✔	✔	✔	✔	✔
Maintain Energy	✔	✔	✔		✔
Opticaster		✔	✔		✔
Frequency Droop	✔	✔	✔		✔
Volt-Var	✔	✔	✔		✔

Control Elements	Battery Dispatch Only	Grid-Connected Only	Backup	Off-Grid Microgrid	Grid-Connected Microgrid
Watt-Var	✔	✔	✔		✔
Volt-Watt	✔	✔	✔		✔
Power Factor	✔	✔	✔		✔
Busway Limits		✔	✔		✔
On-Grid Solar Controls		✔			✔
Meter-Based Trips	✔	✔			
Enter Service	✔	✔			
Reference Manager	✔	✔	✔		✔
Enable Manager	✔	✔	✔		✔
Islanding Controls					
Transition Management			✔		✔
Off-Grid Operation			✔	✔	✔
State of Energy Frequency Management			✔	✔	✔
Enable Manager			✔	✔	✔
Microgrid Controls					
Spinning Reserve Controller				✔	✔
Battery Energy Controller				✔	✔
Operator Limits for Generation				✔	✔

4.1.1.3 Archetype Topologies

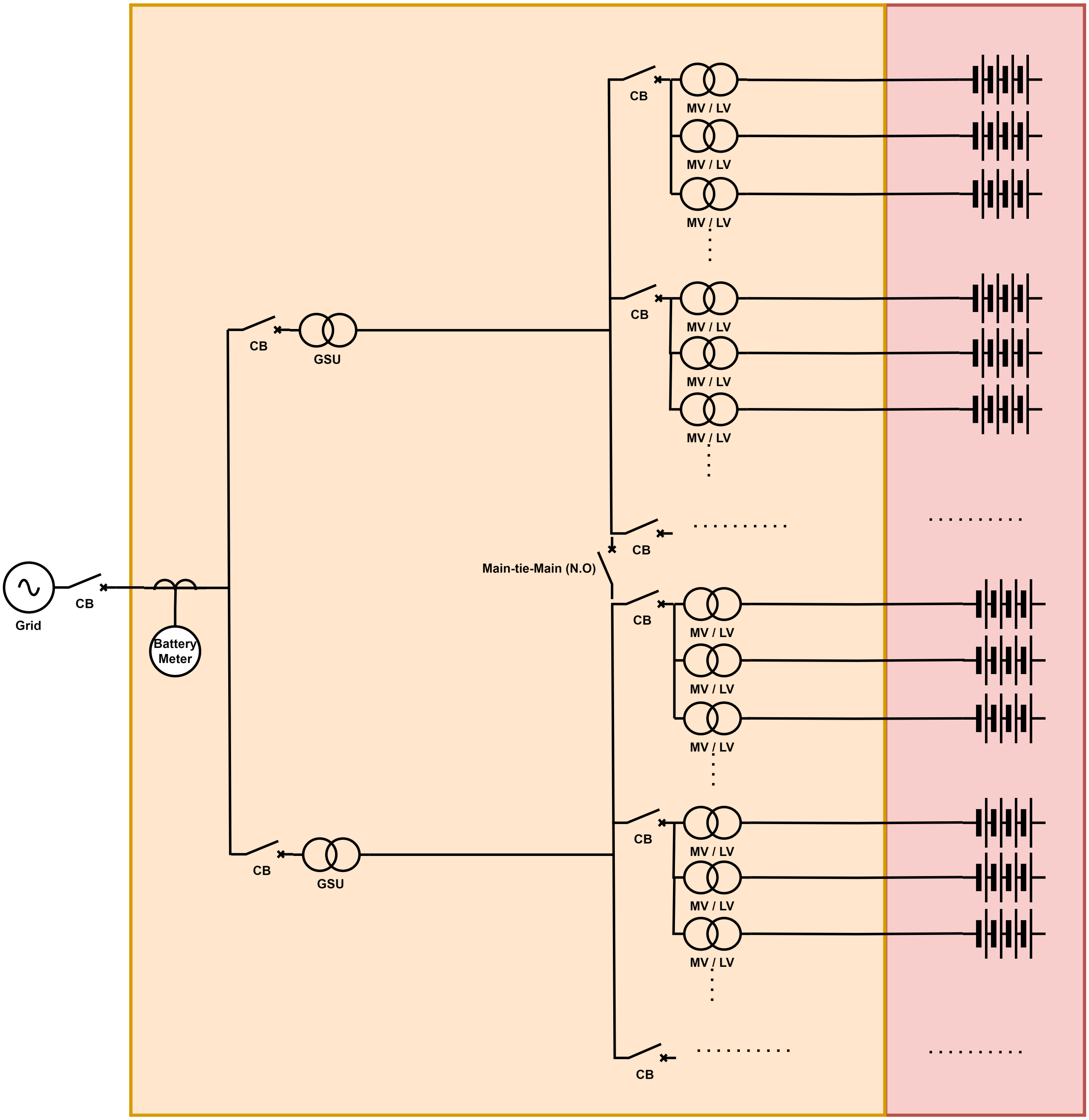
A diagram of the electrical topology for each Archetype is provided below. In the diagrams, shaded areas represent different control sections as indicated in each diagram's legend. Icons in the diagrams generally indicate the following components:

Figure 16. Icon Key



1. Grid
2. Meter: At various locations, as indicated in diagrams
3. Transformer: With types indicated, including generator step-up (GSU), medium voltage (MV), low-voltage (LV)
4. Circuit breaker: Also abbreviated CB
5. Battery assets: Megapack units
6. Solar assets: Also abbreviated PV for photovoltaics

Figure 17. Utility Battery Only Archetype – Electrical Topology & Control Sections

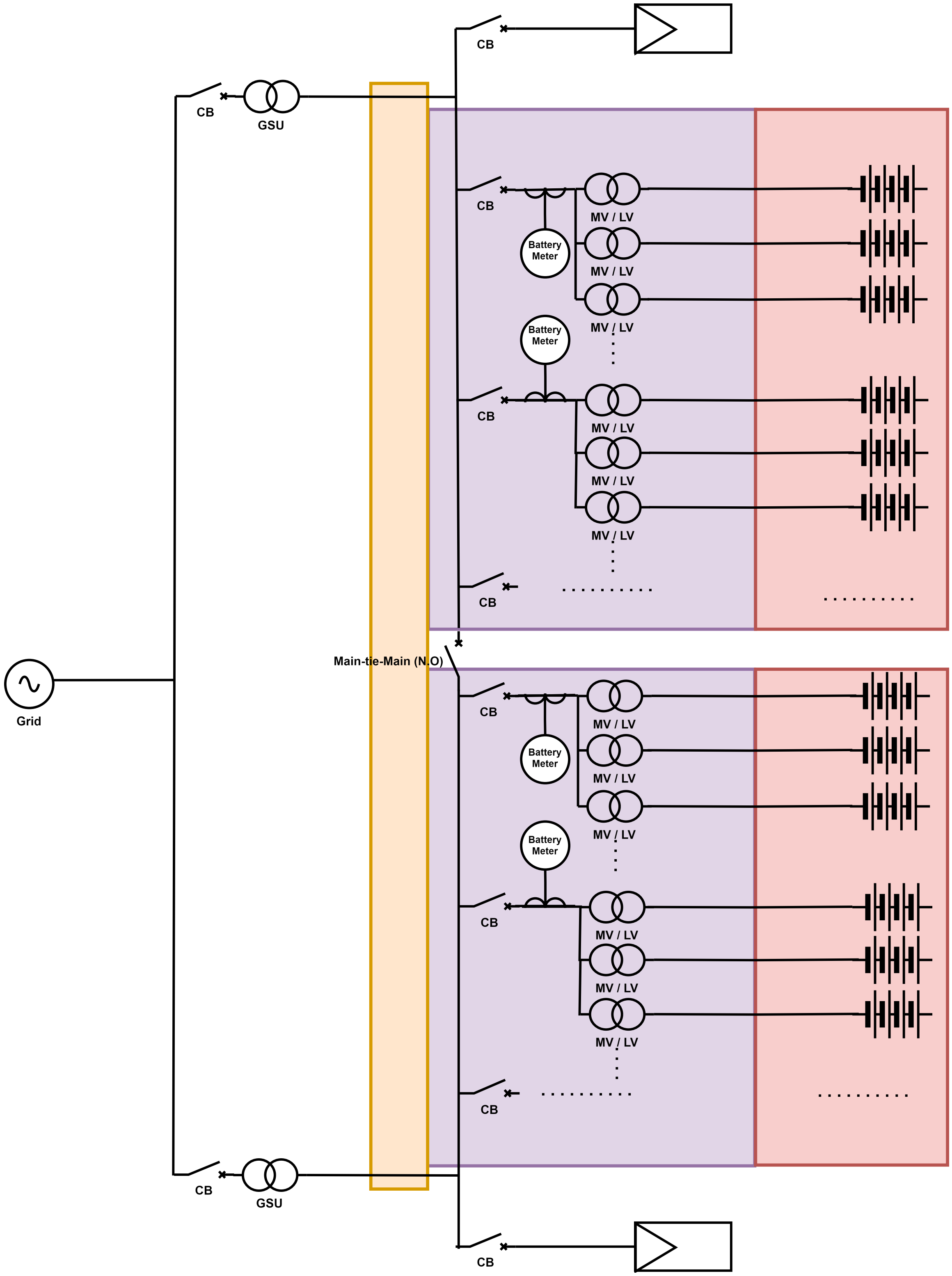


Control Sections

On-Grid

Battery Assets

Figure 18. Utility Co-Located Archetype – Electrical Topology & Control Sections



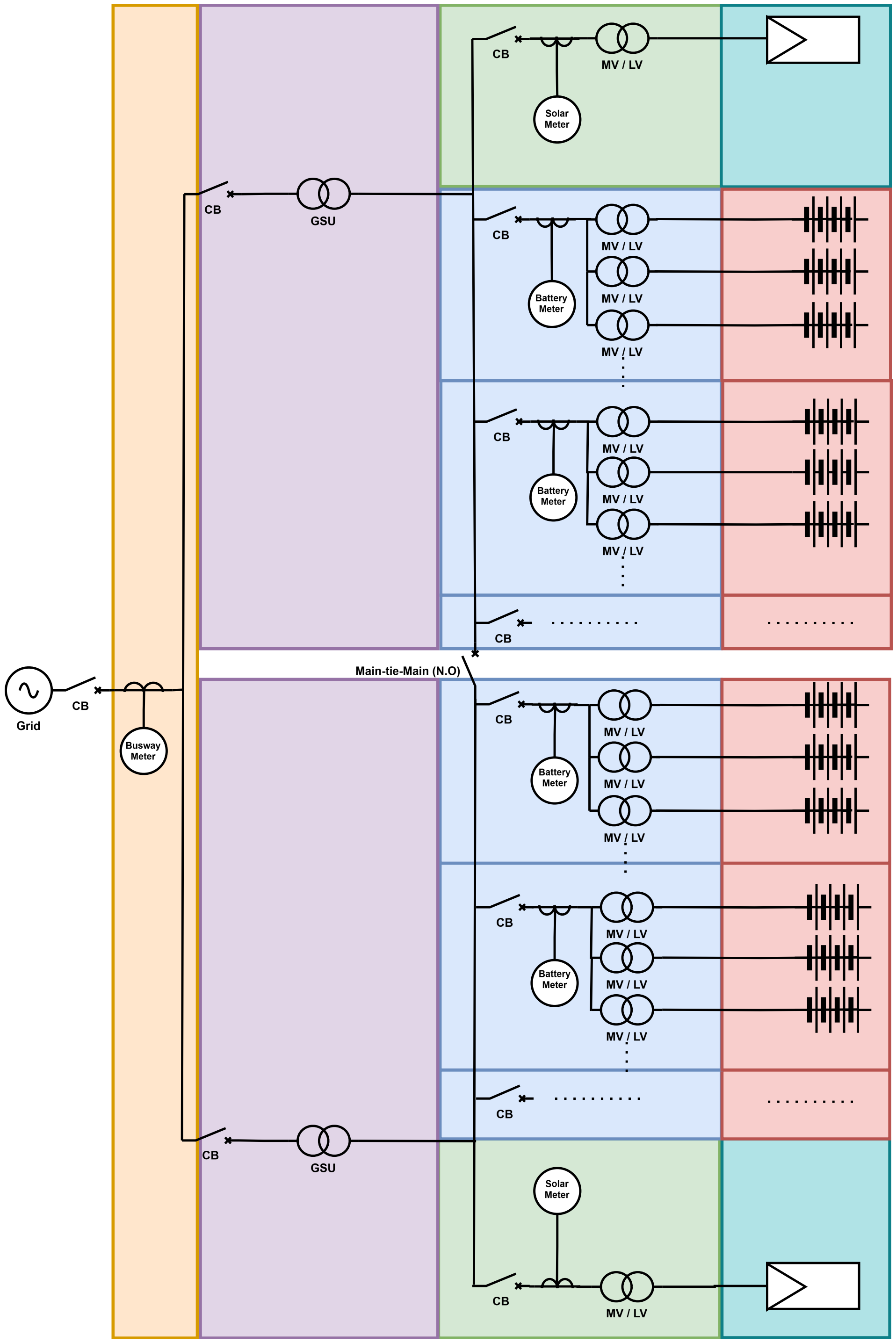
Control Sections

On-Grid

Metered Battery Sub-Site

Battery Assets

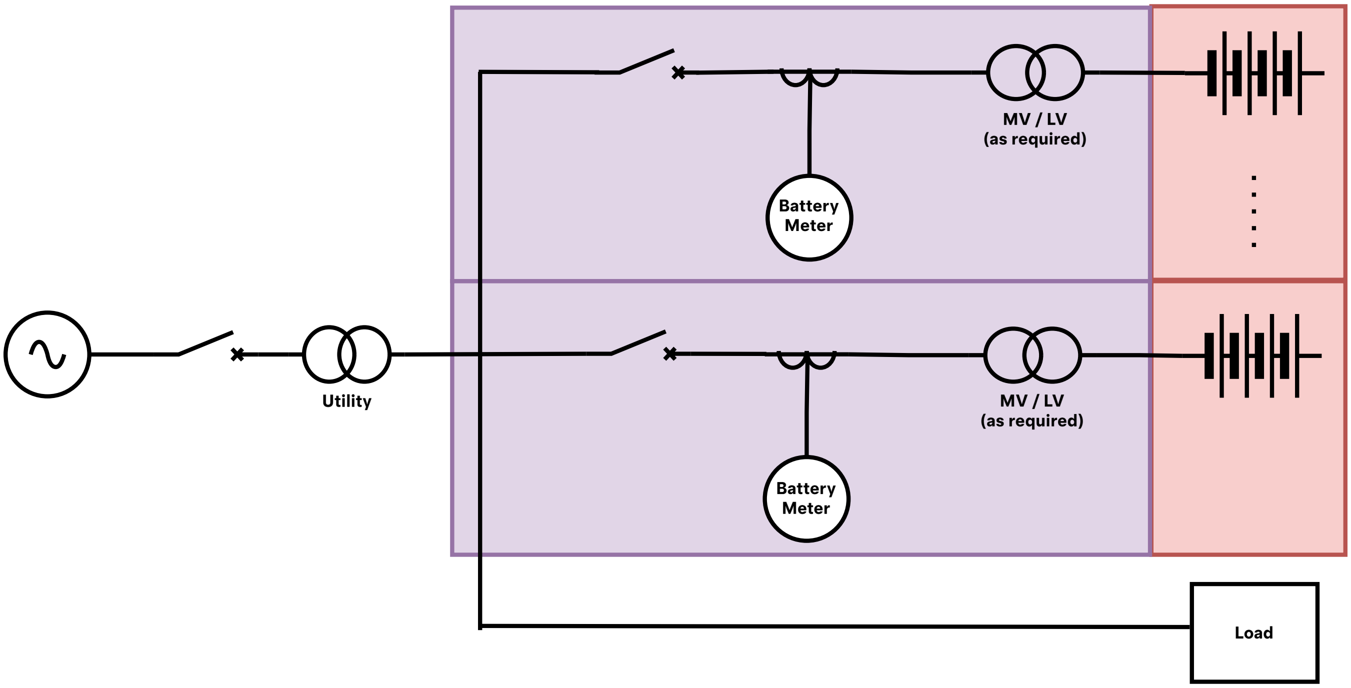
Figure 19. Utility Hybrid Archetype - Electrical Topology & Control Sections



Control Sections

- On-Grid
- Hybrid Sub-Site
- Metered Solar Sub-Site
- Metered Battery Sub-Site
- Solar Assets
- Battery Assets

Figure 20. Battery Dispatch Only Archetype – Electrical Topology & Control Sections

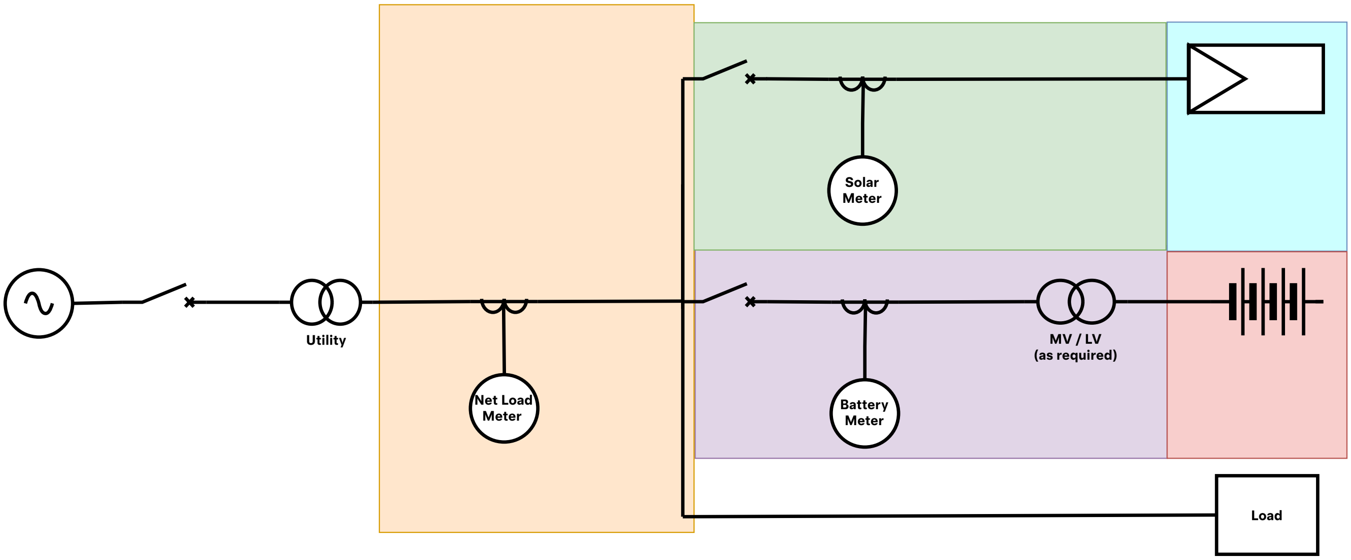


Control Sections

Metered Battery Sub-Site

Battery Assets

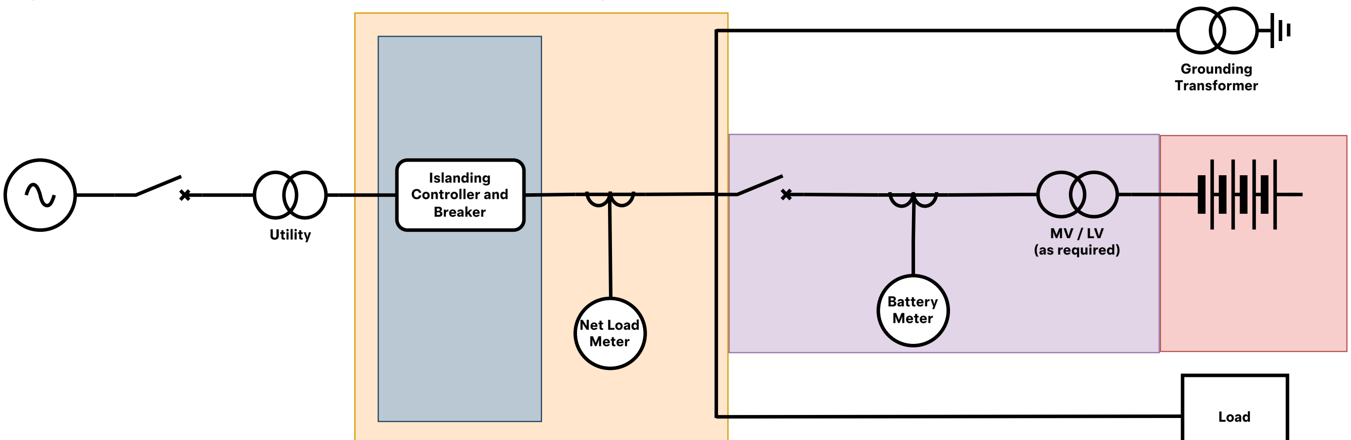
Figure 21. Grid-Connected Only Archetype – Electrical Topology & Control Sections



Control Sections

- On-Grid
- Metered Solar Sub-Site
- Metered Battery Sub-Site
- Solar Assets
- Battery Assets

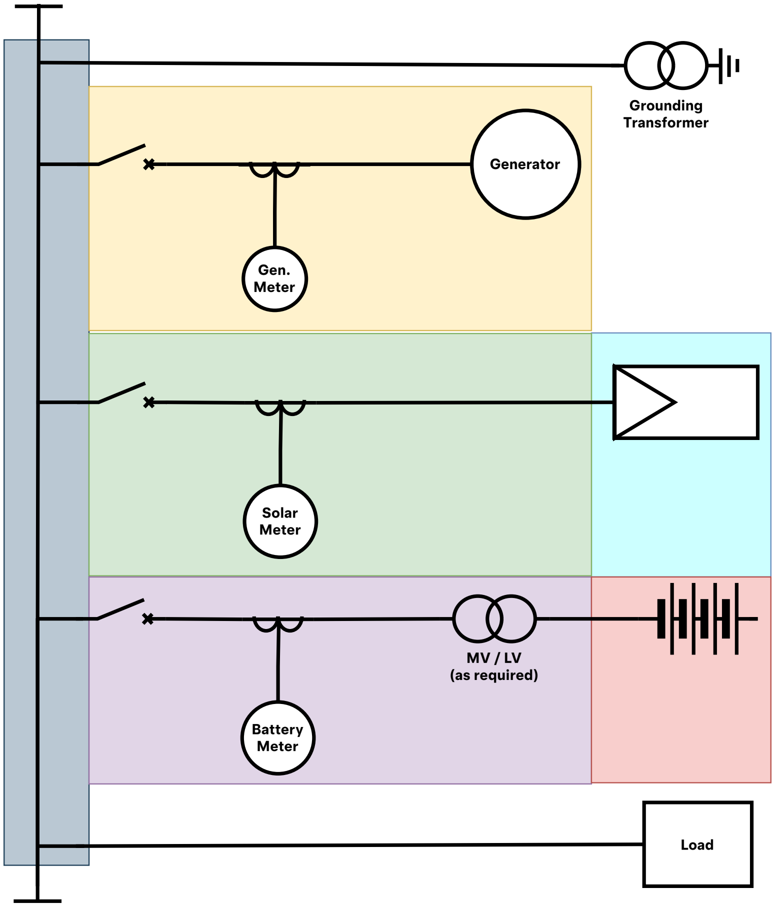
Figure 22. Backup Archetype – Electrical Topology & Control Sections



Control Sections

- On-Grid
- Islanding Control
- Metered Battery Sub-Site
- Battery Assets

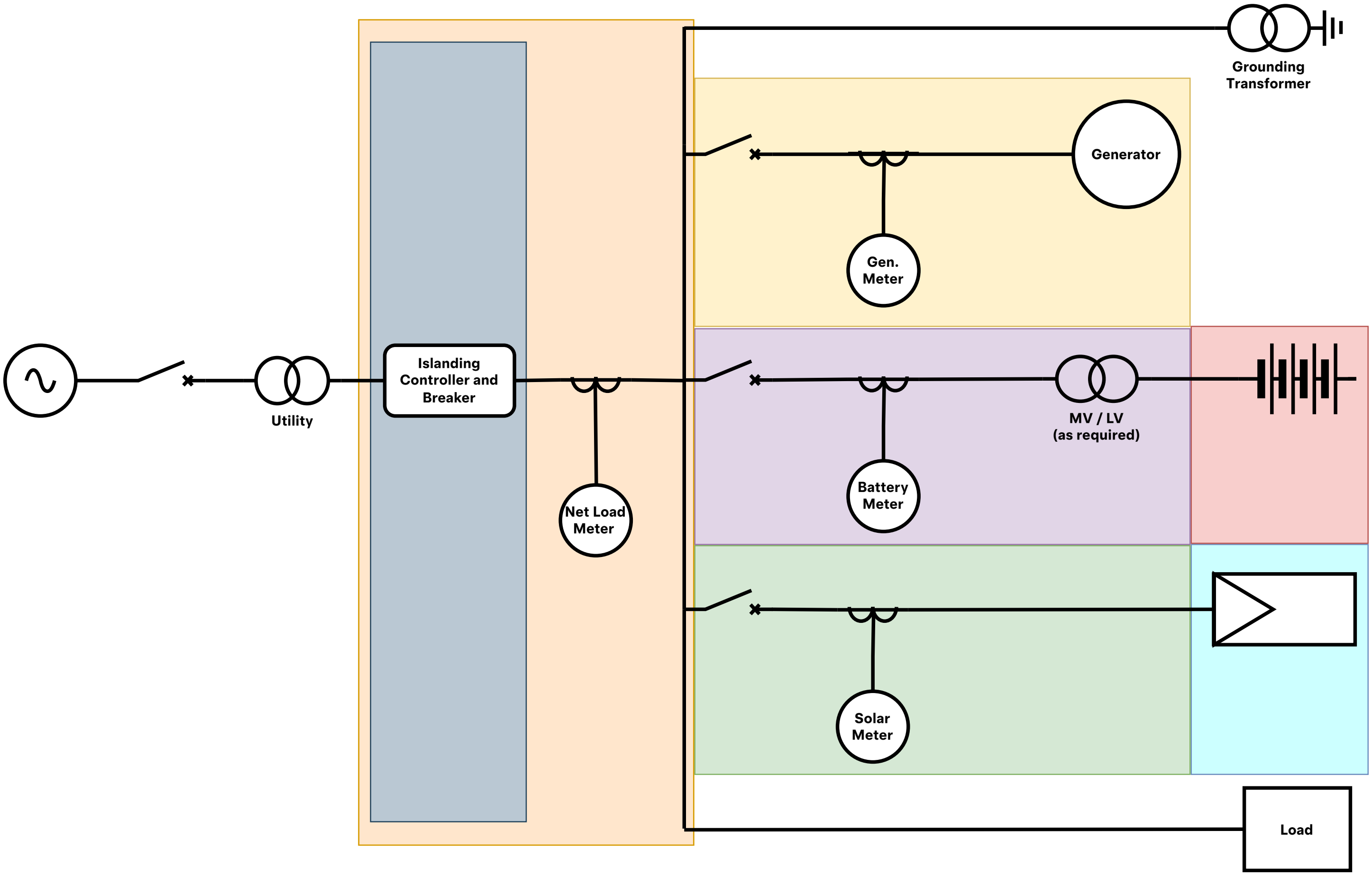
Figure 23. Off-Grid Microgrid Archetype – Electrical Topology & Control Sections



Control Sections

- Microgrid Control
- Metered Generator Sub-Site
- Metered Solar Sub-Site
- Metered Battery Sub-Site
- Solar Assets
- Battery Assets

Figure 24. Grid-Connected Microgrid Archetype – Electrical Topology & Control Sections



Control Sections

- On-Grid
- Islanding and Microgrid Control
- Metered Generator Sub-Site
- Metered Battery Sub-Site
- Metered Solar Sub-Site
- Battery Assets
- Solar Assets

4.1.2 Control Elements

This section details all supported Control Elements. Tesla continues to develop new Control Elements to meet project and market needs.

Control Elements each have a defined logic, settings, inputs, and outputs. Available Control Elements and how they interact are determined by the site's Control Profile.

4.1.2.1 On-Grid Control Elements

The table below provides an overview of on-grid Control Elements.

Table 35. On-Grid Control Elements

Control Element	Description
External Interface	Provides customer-facing Modbus & DNP3 interfaces to interact with the system. Rejects writes that are outside of acceptable values.
Ramp Rate	Includes Direct Real Power and Direct Reactive Power. Limits the rate of change of Direct Real and Direct Reactive power commands.
Closed-Loop Control	Regulates the Real and Reactive power output, as measured at the meter, to accurately meet the total power commands.
Meters	Interfaces with a meter (SEL-735). Meter readings serve as inputs to various Control Elements.
Frequency Droop	Inject or absorbs real power in response to changes in frequency according to a droop curve.
Frequency Integral	Performs integral regulation of the Frequency.
Fast Frequency Response (Low Frequency)	Immediately dispatches real power for a given duration when frequency drops below a threshold.
Fast Frequency Response (High Frequency)	Immediately absorbs real power for a given duration when frequency exceeds a threshold.
Maintain Energy	Commands the system to reach and maintain a specific energy value.
Power Factor	Enforces a specific Power Factor value at the meter.
Voltage Control	Regulates voltage to a Voltage Reference by injecting or absorbing reactive power in response to voltage fluctuations.
Automatic Failover	Allows for an automatic failover for redundant Tesla System Controllers. **Note:** Automatic Failover is a paid SCADA adder which must be selected at contracting to ensure proper SCADA system design. Automatic Failover is currently not part of a standard Archetype.
Enable Manager	Enables or disables behaviors based on specific system conditions.
Transformer Losses	Allows feed-forward compensation of transformer and conductor losses between the battery meter and the Megapacks.
Combiner	Aggregates commands from all Control Elements and enforces operator and nominal limits.
Battery Group	Represents the aggregation of Megapacks. The Battery Group splits the total Real and Reactive commands between individual Megapacks while ensuring the total command is met and balances energy between Megapacks for optimal performance.
Re-Engage Monitor	Handles the system's behavior during an unplanned restart of the Tesla System Controller or its control application, to prevent undesirable control behaviors.
Reference Manager	Provides voltage and frequency references to the inverters for grid forming.
Solar Controls	Solar Controls allow an operator to apply a curtailment command (the User Solar Limit) as an aggregate to solar inverters, regardless of the battery system's behavior, via external interfaces. Solar Controls also report the solar curtailment limit applied to inverters, either as a result of the User Solar Limit or by other control elements (such as Solar Battery Split on hybrid systems).
Solar Battery Split	In a hybrid system, the Solar Battery Split allows to determine the battery and solar real and reactive power contributions.
Asset Power Manager	The Asset Power Manager is used on solar sub-sites and handles the sub-site's power output and reporting in case of inhibit or sub-site meter invalid conditions.

Control Element	Description
Inverter Asset Group	The Inverter Asset Group represents an aggregation of one or more inverters or a solar plant controller and is used on systems interfacing with inverter assets (non-Tesla), such as solar.
Volt-Var	Volt-Var provides a reactive power response from the battery system based on a voltage measurement, according to a voltage-reactive power curve.
Volt-Watt	Volt-Watt limits the real power output of the battery system based on a voltage measurement, according to a voltage-watt power curve.
Watt-Var	Watt-Var provides a reactive power response from the battery system based on a real power measurement, according to a real-reactive power curve.
Busway Limits	Busway Limits use the battery system to limit real power flow at specific meter locations in the system.
Meter-Based Trips	Meter-Based Trips enforces trip and reconnect thresholds on the battery system based on compliance requirements.
Opticaster	Opticaster, Tesla's autonomous site control software, is designed to maximize economic benefits for grid-connected customers. Opticaster forecasts load and solar production, optimizes battery dispatch to reduce electricity bills, maximizes consumption of on-site renewables and enables various types of grid services.

4.1.2.2 Islanding Control Elements

The islanding control elements are only available to sites designed for islanding and which have an approved islanding controller.

> **NOTE:** Islanding controls are offered at an additional price and must be selected at contracting to ensure proper design.

Table 36. Islanding Control Elements

Name	Description
Transition Management	Manages islanding transition preferences, including automatic or user-triggered synchronization.
Off-Grid Operation	
	While operating off-grid, isochronous controls provide automatic frequency control and automatic voltage regulation. Voltage and frequency references are static and set at commissioning.
Black Start	
Black Start Retry	In response to a dead bus, the battery system can be configured to either automatically retry or wait for a user-initiated Black Start.
State of Energy Management	
Frequency Shifting	The battery system can be configured to shift frequency reference as a function of the system's state of energy, which is used to trigger frequency-dependent control functionality of other components of the microgrid (for example, with active power reduction of solar inverters).
Wait for Behaviors	The battery system will operate using specific state of energy thresholds designed to prevent full depletion of batteries while off-grid. Options include: 1) Waiting for Solar, 2) Waiting for User, and 3) Waiting for AC.

Name	Description
Islanding Enable Manager	Enables or disables control features based on user input and system conditions to achieve fail-safe behaviors. Checks are performed on faulted hardware, adequate state of energy, and loss of communications with islanding controller.

4.1.2.3 Microgrid Control Elements

The microgrid control elements are only available to sites designed for islanding and which have an approved islanding controller, or to off-grid only microgrids managed by the Tesla System Controller.

NOTE: Microgrid controls are offered at an additional price and must be selected at contracting to ensure proper design.

Table 37. Microgrid Control Elements

Name	Description
Spinning Reserve Controller	Manages active battery and generation assets in the microgrid with the objective of maintaining sufficient reserve capacity upward and downward to serve sudden changes in net load.
Battery Energy Controller	Operates battery between max and min state of energy (SOE) setpoints to ensure sufficient space is allowed for intended end-of-charge and end-of-discharge behaviors, ensuring stable and reliable operation of the microgrid. At low SOE, available generators are started. At high SOE, excess renewable generation is curtailed.
Operator Limits for Generation	Operators can issue commands to limit renewable resource contribution, specify generator reserve, and directly dispatch generators.

4.1.3 Battery Switches

Battery Switches control the State, Mode, Heating, Peak Power, and Black Start functionality of the Megapacks.

Customer inputs for Battery Switches are described below:

Table 38. Customer Inputs

Parameter Name	Description
State Request	Commands the state of batteries: 0 = Off, 1 = On (required to operate), and 99 = Emergency Off. **Note:** Commanding the system to Off or Emergency Off is not a replacement for performing proper de-energization procedures in order to perform work, as described in the product's *Design and Installation Manual* on the Tesla Partner Portal.
Mode Request	Commands the mode of batteries: 1 = Grid-Following, 2 = Grid-Forming. Grid-Forming may not always be allowed by configuration. **Note:** The battery system can be configured to emulate a virtual synchronous machine and provide grids with inertia, which can help stabilize system frequency and provide system strength.
Black Start Request	Commands the batteries to black start the grid: 0 = No Black Start, 1 = Black Start Now. **Note:** Black start is only available on systems that are designed to grid-form and must be enabled by Tesla at commissioning.
Peak Power Enable	Enable Peak Power with 1, disable with 0. Peak Power should only be used according to the contract and may have warranty implications.
Heat Mode Enable	Enable Heat Mode with 1, disable with 0.

4.2 Telemetry

This section provides a summary of system-level and Megapack-level telemetry points and alerts reported by the Tesla System Controller over supported communications interfaces. Supported interfaces include Modbus and DNP3. System-level monitoring and control is available over DNP3 and Modbus. Megapack-level monitoring is available over DNP3.

NOTE: Accurate time-stamping of Megapack-level alerts requires a GPS clock as NTP server on the Tesla Network and additional configuration to be performed at commissioning. Refer to the *SCADA Design Manual* on the Tesla Partner Portal for additional information.

Table 39. System-Level Telemetry and Alerts

Data Source	Name	Description	SI Units
Tesla System Controller	Tesla System Controller Firmware Version	Tesla System Controller software version number.	N/A
	Dispatchable Charge Power	Negative value. Power that is immediately available to charge the system, taking into account system conditions and excluding power from faulted components. This value applies at the AC output terminals and is not limited by Real Power Charge or Operator Limits.	W
	Dispatchable Discharge Power	Power that is immediately available to discharge the system, taking into account system conditions and excluding the power from faulted components. This value applies at the AC output terminals and is not limited by Real Power Discharge and Operator Limits.	W
	Dispatchable Apparent Power	Immediately available apparent power.	VA
	Full Battery Energy	Energy capacity of the system when fully charged. Excludes the energy of faulted components and of the battery without AC voltage.	Wh
	Remaining Battery Energy	Energy currently available to discharge.	Wh
	Auxiliary Power	Power drawn to support the Megapack internal controls and thermal management loads, not including battery inverter losses. This power may be drawn from the grid and/or battery modules. Aggregated for all Megapacks currently reporting to the Tesla System Controller.	W
	Number of Available Megapacks	Number of batteries available for operation.	N/A
	Not Substantially Available	Will assert when the battery system's dispatchable apparent power is below a threshold (80% by default) of the Nominal Apparent Power. When the site is Not Substantially Available, elements integrators will be disabled.	N/A
	Real Power Available Limited	The battery system is not able to meet the total real power setpoint because the requested power exceeds the Nominal Real Power or the Real Operator Limits.	N/A
	Reactive Power Available Limited	The battery system is not able to meet the total reactive power setpoint because the requested power exceeds the Nominal Reactive Power or the Reactive Operator Limits.	N/A

Data Source	Name	Description	SI Units
	Customer Command Timed Out	The Tesla System Controller has not received any commands from a Modbus client for a duration greater than the command timeout configured, and the last command has timed out. The battery system will stop operating.	N/A
	Meter Invalid	Meter data is currently invalid.	N/A
Meter	Meter Real Power	Total 3-phase Real Power, as read from the Meter.	W
	Meter Reactive Power	Total 3-phase Reactive Power, as read from the Meter.	var
	Meter Voltage	Average line-to-line RMS voltage, as read from the Meter.	V
	Meter Frequency	Frequency, as read from the Meter. Frequency is filtered and can be overwritten by Tesla for specific tests.	Hz
	Meter Energy Import	Energy Accumulator - lifetime energy imported (charged) by the battery, as read from the Meter.	Wh
	Meter Energy Export	Energy Accumulator - lifetime cumulative energy exported (discharged) by the battery, as read from the Meter.	Wh
	Meter Invalid	Meter data is currently invalid: Readings are out of bounds, meter has lost communication, or a PT/CT failure has occurred (if applicable).	

Table 40. Megapack-Level Telemetry and Alerts

Type	Name	Description	SI Units
Analog Inputs	Megapack Real Power Target	Command the Tesla System Controller is sending to the Megapack.	W
	Megapack Real Power	Real power measured by the Megapack.	W
	Megapack Reactive Power Target	Command the Tesla System Controller is sending to the Megapack.	var
	Megapack Reactive Power	Reactive power measured by the Megapack.	var
	Megapack State of Energy	State of energy of the Megapack.	%
	Megapack Energy Remaining	Energy available from Megapack to discharge at nominal operating conditions.	Wh
	Megapack Charge Capacity Remaining	Estimated energy to charge the Megapack until full; subtracts energy to charge faulted components.	Wh
	Full Pack Energy	Usable energy capacity when Megapack is fully charged and at nominal operating conditions.	Wh
	Megapack Frequency		Hz
	Battery AC Voltage	Phase-to-ground RMS voltage, average of all three phases.	V rms
	Megapack Phase (A/B/C) Voltage	Phase-to-ground RMS voltage (A/B/C).	V rms
	Megapack Phase (A/B/C) Current	Phase current (A/B/C).	A rms

Type	Name	Description	SI Units
	Maximum Battery Temperature	Maximum cell temperature in the battery modules.	C
	Ambient Temperature	Ambient temperature measured inside the Megapack enclosure.	C
	Megapack Available Charge Power	Available Charge Power of the Megapack, aggregated from battery modules and inverters; updates based on grid voltage; subtracts faulted components.	W
	Megapack Available Discharge Power	Available Discharge Power of the Megapack, aggregated from battery modules and inverters; updates based on grid voltage; subtracts faulted components.	W
	Megapack Nominal Charge Power	Nominal charge power of the Megapack, aggregated from battery modules and inverters, assuming nominal voltage; includes faulted components. Does not include missing or disconnected components.	W
	Megapack Nominal Discharge Power	Nominal discharge power of the Megapack, aggregated from battery modules and inverters, assuming nominal voltage; includes faulted components. Does not include missing or disconnected components.	W
Binary Inputs	Loss of Megapack Communication	The Tesla System Controller has persistently lost communication with the Megapack, meaning the Tesla System Controller has not received Megapack communications for the timeout duration of 120 seconds, unless otherwise configured. Megapack power output will ramp down over the course of 60 seconds.	N/A
	Megapack Isolation Failure	Megapack has reported an isolation measurement below its acceptable threshold.	N/A
	Megapack Inverter Fault	All inverters in the Megapack are faulted.	N/A
	Enable Circuit Open	Megapack enable circuit is open.	N/A
	Enable Switch Off	Megapack enable switch is in the off position, preventing operation.	N/A
	AC Breaker Status	Megapack AC circuit breaker status (open/closed).	N/A
	Bus Controller Prolonged Fault	Megapack has experienced several consecutive faults and has entered a prolonged fault state, which will stop operation temporarily.	N/A
	Remote Shutdown	Remote shutdown is being commanded via customer external I/O.	N/A
	Coolant Low	Coolant level is low as reported by the coolant sensor.	N/A
	Extreme Temperature Warning	The Megapack has detected a temperature increase above the temperature increase warning threshold.	N/A
	Extreme Temperature Fault	The Megapack has detected a temperature increase above the temperature increase fault threshold.	N/A
	Grid Uncompliant	The Megapack has measured an over/undervoltage, over/underfrequency or zero sequence overvoltage outside of its hardware protection trip thresholds.	N/A

Type	Name	Description	SI Units
	Breaker Irrational	The Megapack AC circuit breaker is reporting open and closed simultaneously.	N/A
	Breaker Ready to Close	The Megapack AC circuit breaker spring is charged, either manually or via motor reclose, and the breaker can close now.	N/A
	Power Electronics Over Temperature	Megapack power electronics are experiencing an over-temperature condition.	N/A
	Low State of Energy	Megapack is at very low state of energy and must be charged as soon as possible to avoid cell damage.	N/A
	Megapack Disabled	The Megapack is disabled, meaning its battery modules and thermal system are commanded to the Off state. **Warning:** This does not replace the need for operators to follow proper de-energization procedures.	N/A
	Sparker Fault	One or more Sparkers are behaving incorrectly. Sparkers are located inside the Megapack and control the levels of combustible gas by providing a spark to combust low levels of these gasses before they accumulate.	N/A
	OV Ride Through Active	The Megapack has detected an overvoltage based on its overvoltage ride-through trip settings and will trip if the overvoltage persists.	N/A
	UV Ride Through Active	The Megapack has detected an undervoltage based on its undervoltage ride-through trip settings and will trip if the undervoltage persists.	N/A
	OF Ride Through Active	The Megapack has detected an overfrequency based on its overfrequency ride-through trip settings and will trip if the overfrequency persists.	N/A
	UF Ride Through Active	The Megapack has detected an underfrequency based on its underfrequency ride-through trip settings and will trip if the underfrequency persists.	N/A
Binary Outputs	Open Megapack Breaker	Write to 1: Opens the Megapack AC circuit breaker. Must be configured by Tesla at commissioning.	N/A
	Close Megapack Breaker	Write to 1: Closes the Megapack AC circuit breaker.	N/A
	Disable Megapack	Write to 1: Brings all battery modules into standby state and brings the thermal HVDC bus down **Warning:** This does not replace the need for operators to follow proper de-energization procedures.	N/A

4.3 Configurable Parameters

This section outlines some of the key configurable parameters supported by the system. Static limits are established during the site commissioning phase and require support from Tesla technical support teams to update. Static limits often represent physical constraints of the site (for example, transformer or conductor sizing) and should not change often. Dynamic limits can be updated in operation by the operator via supported local communications interfaces.

Table 41. Configurable Parameters

Type	Name	Type	Description
Nominal Values	Nominal Real Power Discharge	Static	Nominal discharge power of the site. The maximum power that can be discharged.
	Nominal Real Power Charge	Static	Nominal charge power of the site. The maximum power that can be charged.
	Nominal Reactive Power	Static	Nominal reactive power of the site. The maximum reactive power that can be injected or absorbed.
	Nominal Frequency	Static	Nominal grid frequency (60 Hz or 50 Hz).
	Nominal Energy	Static	Nominal energy capacity. The contractual energy capacity of the system.
References	Reference Frequency	Dynamic	The reference frequency for Frequency Droop, Frequency Integral and Grid-Forming applications.
	Reference Voltage	Dynamic	The reference voltage for Voltage Control and Grid-Forming applications.
Ride-Throughs	Voltage Ride-Through	Static	Site-level voltage ride-through settings.
	Frequency Ride-Through	Static	Site-level frequency ride-through settings.
Limits	Export Limits	Static	Set allowed grid export limits (none, solar only, battery and solar).
	Charge from Solar	Static	Limit battery system to only charge from solar generation.
	Bus Export Limit	Static	Limit combined solar and storage dispatch on a shared bus to remain below ampacity limits. **NOTE:** Requires a supported meter on the bus to regulate.
Operator Limits	Real Operator Limit Maximum	Dynamic	The maximum real power limit allowed at the specified measurement point.
	Real Operator Limit Minimum	Dynamic	The minimum real power limit allowed at the specified measurement point.
	Reactive Operator Limit Maximum	Dynamic	The maximum reactive power limit allowed at the specified measurement point.
	Reactive Operator Limit Minimum	Dynamic	The minimum reactive power limit allowed at the specified measurement point.

4.4 Response Time

This section documents the transition time between states and rise time in response to a power command or a change in frequency. This section also provides an example of the step response behavior given specific assumptions.

4.4.1 Transition Time

The table below shows the transition time of the Megapack System.

Table 42. Transition Time

State Request	Transition Time
Off to On	90 s
On to Off	180 s

4.4.2 Rise Time and Reaction Time

The tables below show the rise time and reaction time of the Megapack System. These characteristics are measured at the meter using meter event recording capabilities and assume the following conditions:

- The Tesla System Controller and the meter are synchronized to a common time source
- The State Request is set to On
- The Ramp Rate is set to a large W/s value (in other words, there are no limitations on ramp rate)
- The short circuit ratio at the inverter-level is at least 2.6 (for example, an inverter-level short circuit ratio of 2.6 with an impedance of 0.015+j0.14, in per unit for 33 kV and a 100 MVA base, corresponds to a grid short circuit ratio of 4.2)

Table 43. Rise Time

Control Element	Start Condition	Rise Time to 95% of Command measured at the Meter	Rise Time to 98% of Command measured at the Meter
Direct Real Power Command	When the Tesla System Controller receives the command	≤ 200 ms	≤ 250 ms
Direct Reactive Power Command	When the Tesla System Controller receives the command	≤ 200 ms	≤ 250 ms
Frequency Droop	When Reference Frequency exceeds the Lower Deadband or the Upper Deadband	≤ 200 ms	≤ 250 ms

Table 44. Reaction Time

Control Element	Start Condition	Reaction Time (10% of Command measured at the Meter)
Direct Real Power Command	When the Tesla System Controller receives the command	65 ms
Direct Reactive Power Command	When the Tesla System Controller receives the command	65 ms

4.4.3 Step Response Example

NOTE: The step response behavior of the Megapack System varies depending on Megapack System configuration, site design, and grid conditions. For example, a lower short circuit ratio or a lower grid voltage may result in higher overshoot, longer settling time, and longer time to steady state, particularly for reactive power.

The example below shows the indicative step response behavior of the Megapack System. These characteristics are measured at the meter using meter event recording capabilities and assume the following conditions:

- The grid has a short circuit ratio of 40
- The Mode Request is set to Grid-Following

- The Megapack System is operating as a battery-only project
- The Megapack System is designed to operate within +/- 0.95 power factor
- The Megapack System is operating at the nominal grid voltage
- For the real power step response behavior, the command is equal to the Nominal Real Power Discharge or Nominal Real Power Charge of the Megapack System
- For the reactive power step response behavior, the command is equal to the Nominal Reactive Power of the Megapack System
- Voltage Control is disabled
- Closed Loop Control is enabled

Figure 25. Step Response Example

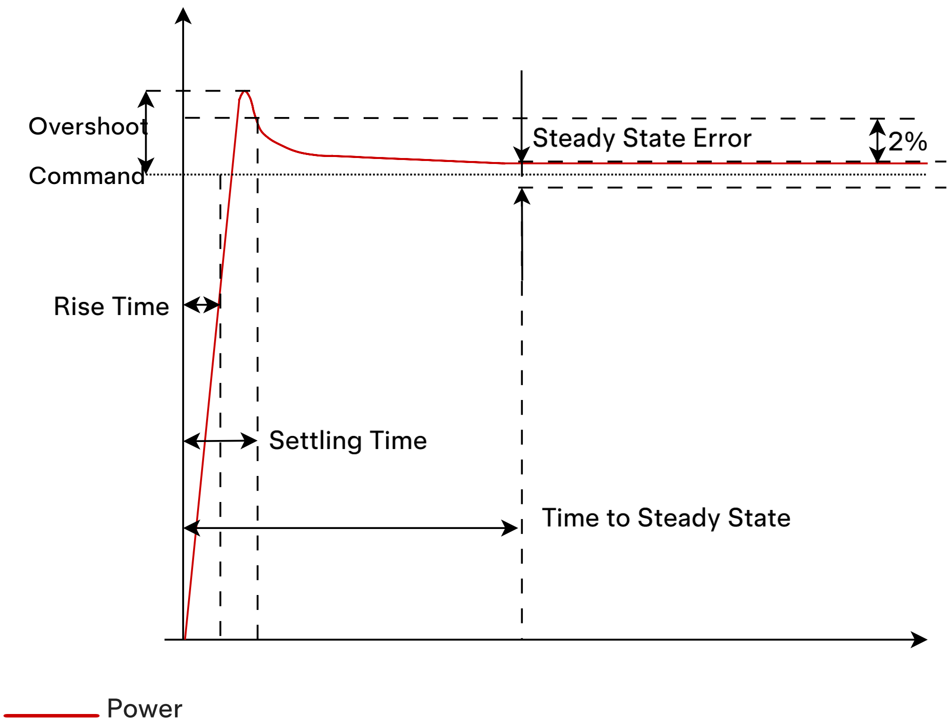


Table 45. Step Response Example

Characteristic	Description	Real Power	Reactive Power
Overshoot	Difference between the maximum Meter Real Power or Meter Reactive Power and the command, divided by the command	≤ 3%	≤ 3%
Settling Time	Duration between when the Tesla System Controller receives the command and when the Meter Real Power or Meter Reactive Power settles within 2% of the final steady state value after overshoot	≤ 5 s	≤ 5 s
Time to Steady State	Duration between when the Tesla System Controller receives the command and when the Meter Real Power or Meter Reactive Power settles within an error band equal to the steady state error around the final value	≤ 45 s	≤ 45 s
Steady State Error	Error remaining between the Meter Real Power or Meter Reactive Power and the command, in steady state, divided by the command	≤ 0.2%	≤ 0.2%

Characteristic	Description	Real Power	Reactive Power
		NOTE: On sites with energy overbuild or long system duration (6+ hours), the steady state error can increase up to 0.4% due to the increased number of battery units and inverters on the site.	

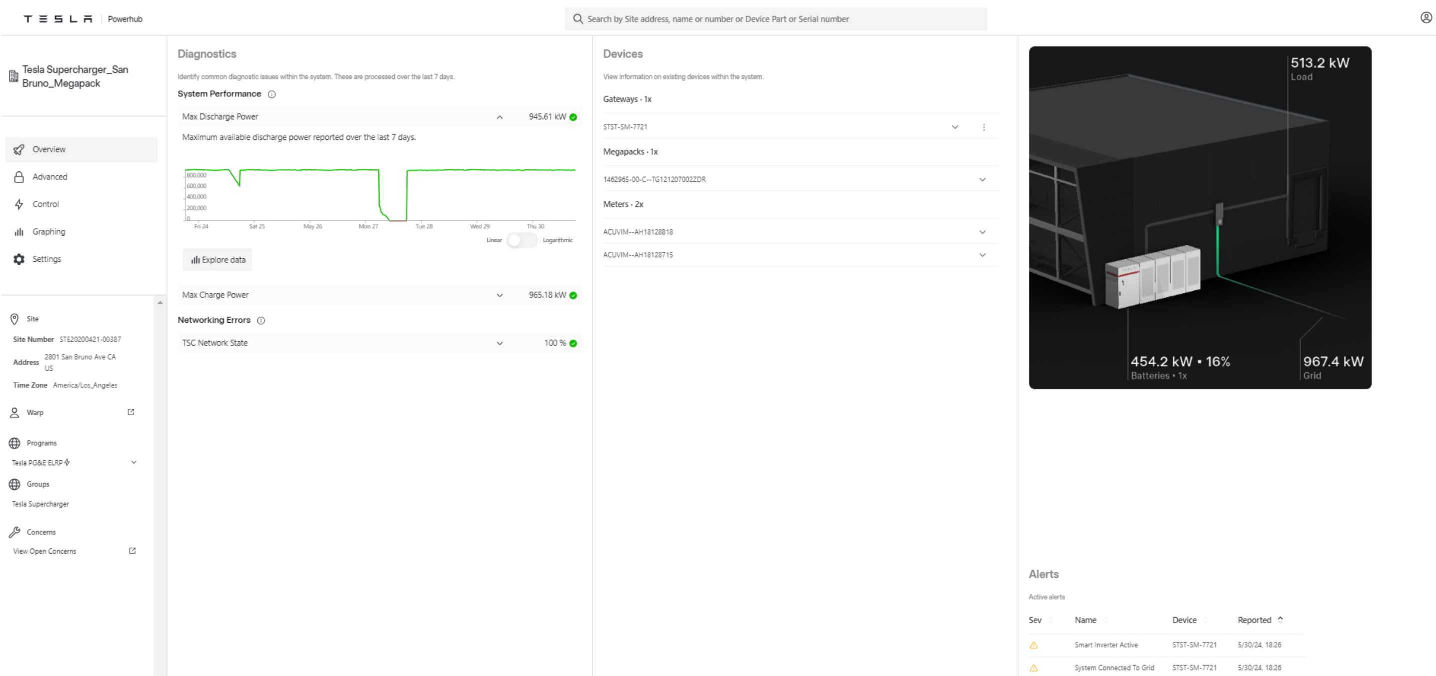
NOTE: If the Mode Request is set to Grid-Forming, the step response behavior will depend on project-specific modeling and configuration. These characteristics will not only include the response to the Direct Real Power Command and the Direct Reactive Power Command but also the inertial response, meaning the response will not be a step. Contact your Tesla representative for more information.

5 Powerhub

Powerhub is a cloud-based monitoring and diagnostics platform that provides data for single sites or aggregated across portfolios of sites. Devices, alerts, health checks, and real-time power flows are available in site view. Historical data can be reviewed in a graphing interface, providing visibility into site-level behavior and allowing data to be exported to a CSV file format.

Access to Powerhub is included by default for all Megapack customers. For more information, see the *Application Note: Powerhub for Megapack and Powerpack* on the Tesla Partner Portal.

Figure 26. Powerhub Site View



6 Standards and Regulations

Refer to the *Megapack 2 XL Compliance Packet* on the Tesla Partner Portal for a full compliance packet of completed certifications in all regions.

6.1 Safety Certification and Hazard Mitigation

Megapack is designed to comply with major market grid codes, including the following standards, by OSHA-recognized Nationally Recognized Testing Laboratories:

- UL 1642 (cell-level certification)
- UL 1973 and IEC 62619 (battery module-level certification)
- UL 9540, IEC 62933-5-2, IEC 62109-1 (system-level certification)
- UL 1741, CSA C22.2 #107.1 (power electronics)
- UL 1998 and IEC 60730 Annex H (functional safety of software)
- IEC 61000-6-2, and EN 55011 (EMC)
- UN 38.3 (transportation, self-certified)
- IEEE 693 (seismic safety)
- UL 9540A (large-scale fire testing): Tested at the cell, module, and unit level

Megapack is designed to comply with major installation codes for energy storage systems, including NFPA 855, IFC 2018 and 2021, and NEC 2020.

In addition to providing product safety features (*Hazard Mitigation Features on page 11*), Tesla conducts extensive analysis and testing to assess hazardous conditions related to Tesla products. Megapack includes multiple layers of protection to mitigate hazardous electrical and fire conditions. Megapack has been reviewed and validated by an Independent Engineer, both at the product level and for the results of large-scale fire testing.

Megapack neither contains nor needs built-in smoke, gas, or fire detection or suppression devices. When required by the AHJ, third-party multi-spectrum IR heat or flame detectors can be installed externally at the site-level.

Refer to the *Industrial Lithium-Ion Battery Emergency Response Guide* on the Tesla First Responders Information page at *https://www.tesla.com/firstresponders* for detailed hazard and response information.

6.2 Environmental Compliance

Each Megapack contains coolant and refrigerant in its thermal system. These substances are built into the Megapack and do not need to be added at the time of installation at site. Depending on the number of Megapacks installed on a site, storage, use and handling of these substances during maintenance events may require reporting, hazard management plans, or containment procedures as required by local codes.

Megapack's enclosure is designed with an integrated 900 L gravity-fed secondary coolant containment basin in its enclosure base in accordance with Title 40 CFR 264.175.

Should an internal coolant leak occur, a gutter system directs coolant away from the batteries to the base of the enclosure to a central location in the AC bus bar area of the Customer Interface Bay. In addition, Megapack has a coolant reservoir level indicator that will alert Service Providers to be dispatched for investigation.

6.3 Cybersecurity

Tesla is continually assessing Megapack System security and its compliance with various cybersecurity standards applicable to battery energy storage systems. Tesla has programs, policies, and processes that cover critical cybersecurity items, including the following:

- Personnel risk assessment, training, background checks, awareness
- Access management and control
- Electronic security perimeters and electronic access methods
- Incident response
- Continuity of operations (recovery and business continuity)
- Configuration change management
- Vulnerability assessments and patching process
- Transient cyber assets and removable media

In addition, Tesla provides a list of cybersecurity mandates and recommendations to ensure vulnerabilities within the overall SCADA network are mitigated. Mandatory items include changing default passwords, disabling unused wireless interfaces, access control and review, and system change management.

Recommended items include network scanning, password strengthening, disabling unused ports and services, timely patch implementation, and multifactor authentication.

7 Site Design Considerations

This section provides key information about how to design and install a Megapack site. Unless otherwise specified, Tesla shall not be responsible for the scope described in this section.

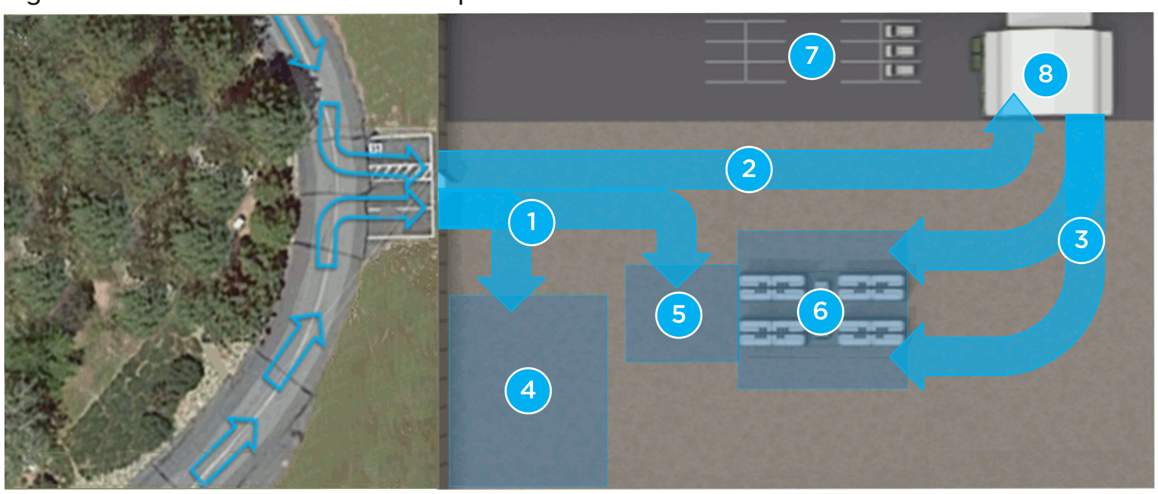
> **NOTE:** For comprehensive site design and installation guidance, refer to the *Megapack 2 XL Design and Installation Manual* on the Tesla Partner Portal.

7.1 Routes and Zones

A site generally consists of routes and zones as indicated below. A **route** is defined as the full path between two or more locations and includes the surface being traveled upon. A **zone** is a defined area of the site that is typically distinguished by function. A zone can be in multiple locations on a site and is dependent on the site layout. Routes and zones are generally allowed to overlap as needed.

> **NOTE:** Route and zone requirements are for non-emergency operations only. Follow local codes and standards as appropriate for emergency vehicle access.

Figure 27. Routes and Zones -- Example



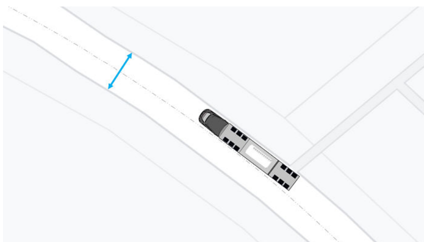
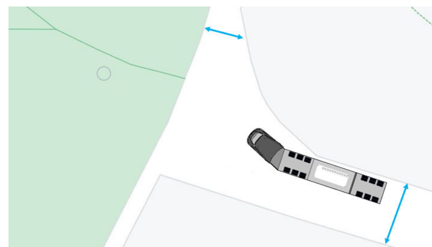
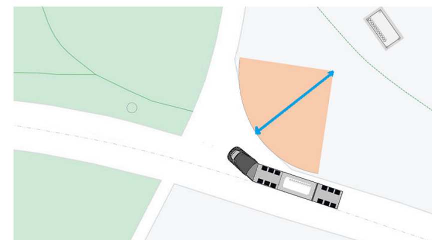
1. Delivery Route
2. Service Access Route
3. Battery Service Route
4. Construction Staging Zone
5. Crane Zone
6. Battery Zone:
    - Foundation Zone
    - Battery Service Zone
7. Parking Zone
8. Service Staging Zone

7.1.1 General Requirements

The design of routes and zones must abide by the requirements described in this section. Due care must be taken to engineer and install appropriate surfaces in all routes and zones for the full duration of the project's life.

All routes must be wide enough to support the wheel swept-path of designated vehicle types and strong enough to support the designated vehicle axle loads. Other infrastructure crossing routes at or below grade (water, electrical, or drainage) should be reviewed in detail to make sure there are no conflicts. It is recommended to include geotechnical engineering stakeholders and craning and logistics providers early in the site design process to ensure all other considerations (such as crane type or delivery vehicle needs) are incorporated. Refer to the *Megapack 2 XL Sample Engineered Template* on the Tesla Partner Portal for assistance with calculations and vehicle blocks to support swept-path analysis. Contact your Tesla representative with any deviations.

Table 46. Example Route Design Considerations

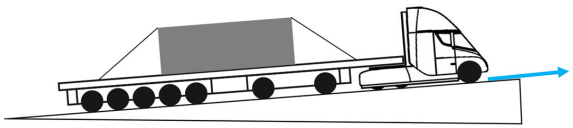
 Minimum Route Width: Linear Driving	 Minimum Route Width: Around Turns	 Minimum Intersection Turn Radius

CAUTION: Standing water in any routes or zones may impact serviceability or structural integrity and should be mitigated as much as possible.

NOTE: The requirements for routes and zones generally apply at any site regardless of whether it is a single- or multiple-battery site. Contact your Tesla representative for more information.

Table 47. General Requirements for All Routes and Zones

Slope	Vehicle Requirements	Surface Conditions
Battery Service Zone: • Maximum 5% in any direction Foundation Zone: • Refer to *Foundation on page 65* All other routes and zones: • Maximum 5% cross slope	• Support for axle loads for designated vehicle types. • Support for adequate width for designated vehicle travel. • Support for minimum turning radii of designated vehicle types.	Required: • No potholes, ruts, or standing water. • Adequately compacted and safe for people to work on and for designated vehicle types to operate on. • Engineered with sufficient grip to provide tire traction.

Slope	Vehicle Requirements	Surface Conditions
• Maximum 10% slope (grade) 		Recommended: • All-weather surfaces that will not require major upkeep and resurfacing after significant weather events. • A material that has been specified by the local or regional Department of Transportation. • Graded or crowned surface to shed water and prevent ponding.

7.1.2 Route Requirements

Uses and additional requirements and recommendations specific to each route are described below.

Table 48. Route Uses and Requirements

Route or Zone	Use	Designated Vehicle Types	Requirements and Recommendations
Delivery Route	Transport between the public right-of-way, the designated project entrance, and the vehicle unloading point (Crane Zone or Construction Staging Zone).	• Megapack delivery vehicle • Crane • Utility vehicle • Telescopic forklift • Fixed-mast forklift • Service delivery vehicle	Required: • Delivery vehicles and cranes must have a valid route to all designated Crane Zones and/or Construction Staging Zones for installation.
			Recommended: • Looped route or cul-de-sac to avoid needing to reverse the delivery vehicle for long distances. • Ability for delivery vehicle to back into or pull alongside the Crane Zone for greatest efficiency.
Service Access Route	Transport between the public right-of-way and the Service Staging Zone.	• Megapack delivery vehicle • Crane • Utility vehicle • Telescopic forklift • Fixed-mast forklift • Service delivery vehicle	No additional requirements.
Battery Service Route	Transport between the Service Staging Zone and each Battery Service Zone.	• Fixed-mast forklift • Utility vehicle	Required: • Designated vehicle types must have a valid route from the public right of way to the Service Staging Zone to **every** Battery Service Zone.

7.1.3 Zone Requirements

Descriptions and additional requirements and recommendations specific to each zone are described below.

Table 49. Zone Descriptions and Requirements

Route or Zone	Description	Designated Vehicle Types	Requirements and Recommendations
Construction Staging Zone	Portions of the site set aside for construction activities. Typical uses include material handling and temporary stockpiling, equipment and contractor parking, and occasionally the storage of battery units.	• Megapack delivery vehicle • Crane • Utility vehicle • Telescopic forklift • Fixed-mast forklift	Recommended: • Consider that it is common for the construction staging zone to overlap with the service staging zone.
Crane Zone	Portions of the site that have been allocated for the set up or operation of a crane.	• Crane	Required: • Depending on the delivery logistics plan, additional clearances or surface load considerations may be required if delivery vehicles need to be within close proximity of the crane.
Battery Zone – Foundation Zone	The area upon which the battery unit is installed. Figure 28. Megapack Foundation Zone - Side View 	• None	Refer to *Foundation on page 65*. **CAUTION:** The Foundation Zone must be protected from flooding. If more than 15 cm (6 in) of water are standing in the zone for longer than 30 minutes, the system must be shut down and a Service Provider must be contacted.
Battery Zone – Battery Service Zone	The area in which service actions take place, as defined in *Clearance - Battery Service Zone on page 67*.	• Utility vehicle • Fixed-mast forklift	Required:

Route or Zone	Description	Designated Vehicle Types	Requirements and Recommendations
			• Supporting at least two egress routes, one in each direction, for people to vacate the zone on foot in the event of an emergency.
Parking Zone	Vehicle parking, required at all stages of the project life, but the quantity and usage of the parking will vary.	• Utility vehicle	Required: • Cannot overlap with listed equipment clearances on site. • Does not obstruct any of the delivery or service routes. • Parking stalls no smaller than 5.5 m x 2.75 m (18 ft x 9 ft).
			Recommended: • Temporary parking may be a good option for the surge in parking need during the construction of the project.
Service Staging Zone	Portions of the site set aside for service preparation activities. Typical uses include material handling and temporary stockpiling, and occasionally the storage of supplies. **NOTE:** Details of this zone are provided in the *Application Note: On-Site Maintenance Infrastructure Requirements* on the Tesla Partner Portal.	• Utility vehicle • Telescopic forklift • Fixed-mast forklift • Service delivery vehicle	Required: • Must be able to support a service delivery vehicle being unloaded by a forklift with sufficient room for the forklift and load to maneuver around the delivery vehicle.

7.1.4 Typical Vehicles

Various vehicles are required to access routes and zones at the site as designed by the engineer of record.

The figure below shows the relative scale of typical vehicles compared to the Megapack:

Figure 29. Typical Vehicle Scale Compared to Megapack (Examples)

7.2 Site Components

In addition to the Megapack System components provided by Tesla (*Megapack System Components on page 4*), a Megapack site may require other equipment as outlined below.

Table 50. Overview of Site Components

Component	Details
Meters	The Tesla System Controller uses various meter inputs for different control functions. The Tesla System Controller only supports the SEL-735 Power Quality and Revenue Meter.
Transformers	Any transformer connected to a Megapack requires a solidly grounded circuit to operate. The Megapack terminals shall be connected to the wye side of a transformer. The transformer may be a step-up/step-down transformer, a grounding transformer, or an isolation transformer. Megapacks do not require galvanic isolation from each other and may be connected in parallel on a single secondary (low-voltage side) transformer winding.
Line reactors	Megapack may require the use of line reactors to mitigate resonance in certain circumstances where other loads are connected to the Megapack at the Megapack nominal voltage.
Substations, switchgear, and other electrical protection devices	A Megapack site requires protection and isolation for life safety, equipment safety, and maintenance purposes. Substations, switchgear, circuit breakers, protective relays, and disconnect switches may be used to control, protect, and isolate electrical equipment at various voltage levels on a site.
Networking	A Megapack site requires communication between the Tesla System Controller, Megapacks, and all meters over TCP/IP. The communication network is recommended to be resilient and fully redundant, use a single logical architecture that can scale, and be secure by applicable cybersecurity standards. The Tesla System Controller also requires an internet connection.
Supervisory control and data acquisition	The Tesla System Controller can be integrated with a supervisory control and data acquisition (SCADA) system to expand its functionality. SCADA components may include other controllers, computers, network clocks, and uninterruptible power supplies.
Maintenance infrastructure	A Megapack site may require on-site maintenance infrastructure for rapid and effective maintenance. The maintenance infrastructure generally consists of dedicated areas, storage containers, and office trailers designed to support Tesla Energy Service.
Access, security, and lighting	A Megapack site needs to be accessible to authorized personnel and shall be installed in a manner that restricts access by persons who are not qualified. When restricting access, fences, screens, walls, or barriers are suggested. A Megapack site may require security and lighting.

7.3 Transportation Considerations

Megapack is designed for easy and convenient shipping through a consolidated design with simple, accessible lifting points. Megapack can be transported by land and sea.

Megapack has six compliant ISO 1161-type lifting points called ISO fittings for effective rigging and to aid transportation and logistics. Megapack, fitted with a protective shipping cover, arrives at the delivery point on a trailer pulled by a truck and can be offloaded by lifting from these six ISO fittings. Depending on site constraints and lifting equipment, additional rigging (such as spreader bars and shackles) may be required.

Because of its pre-assembled and pre-tested nature, Megapack is considered a non-divisible entity, which means it cannot and should not be disassembled during any portion of its transportation. Doors should not be opened and parts should not be removed under any circumstance.

Megapack is a large, overweight load. In order to prepare for successful delivery, access roads must be capable of supporting loaded delivery vehicles such as cranes and forklifts. The site shall provide and maintain a clear access route from the public right-of-way to the on-site maintenance infrastructure, and from the on-site maintenance infrastructure to the front of each Megapack for delivery, installation, replacement, and removal of Megapack and its components.

7.3.1 Ocean Shipping Guidance

Megapack cannot be shipped using standard (ISO-668 40-ft High Cube dry) container types due the height of the overall product. Megapack is capable of being transported on a transient ocean vessel. Tesla's recommendation for ocean transit is via flat rack or a trailer on roll-on/roll-off (ro-ro) vessels. Based on the applicable Incoterms® Rules, should a flat rack or ro-ro vessel option not be available, Tesla can work with customers to determine what specialized equipment will be necessary on a case-by-case basis.

7.4 Storage Considerations

Megapacks may be stored for a maximum of 12 months (365 days) from the shipping date without needing to be charged. Charge power must be made available to the system at the end of the storage duration. The following conditions must be met to ensure system integrity during storage:

Table 51. Storage Conditions

Duration	Temperature Range During Storage	Maximum Humidity
Up to 12 months (365 days) from delivery	-30°C to 50°C (-22°F to 122°F)	Up to 100% relative humidity, condensing

Table 52. Storage Clearance

Front	Back-to-Back	Side-to-Side
1060 mm (42 in)	150 mm (6 in)	150 mm (6 in)

7.5 Installation Considerations

NOTE: For comprehensive installation guidance, refer to the *Megapack 2 XL Design and Installation Manual* on the Tesla Partner Portal.

7.5.1 Anchoring

Megapacks may be anchored to their foundations using their anchor brackets, which are steel flanges welded to the base of Megapack. Megapack's anchor brackets are to be structurally affixed to a foundation as required based on the type of foundation used. Each anchor bracket supports a total of three anchoring points.

7.5.2 Foundation

Megapacks must be installed on a non-combustible foundation or base, such as concrete pad or steel beams, that is strong enough to support the weight of the equipment and to resist all anchor loads. Proper clearances must be observed. The Megapack unit must be installed on a single planar surface. If using non-concrete pad designs, review with Tesla.

7.5.3 Megapack Clearance

The clearances listed in this section are as required by the product. Additional clearances to non-Megapack equipment may be required per local codes and regulations.

Equipment clearances must be maintained throughout the operating life of the system. See the *Equipment Clearance Requirements on page 66* table below for dimensions. Shaded areas indicate the Battery Service Zone.

Figure 30. Equipment Clearance Requirements - Side View

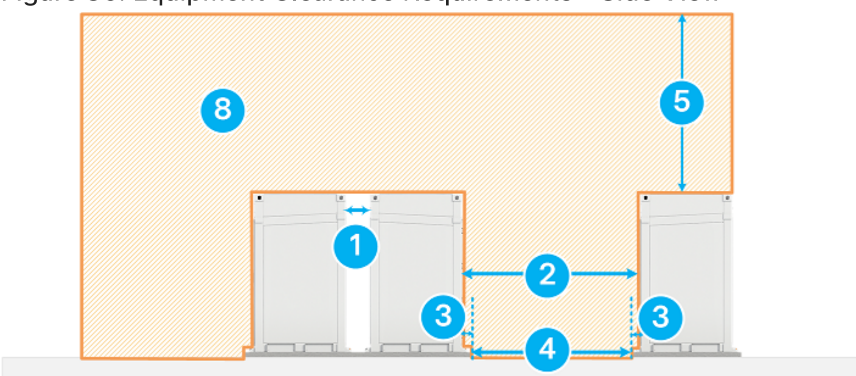


Figure 31. Equipment Clearance Requirements - Front View

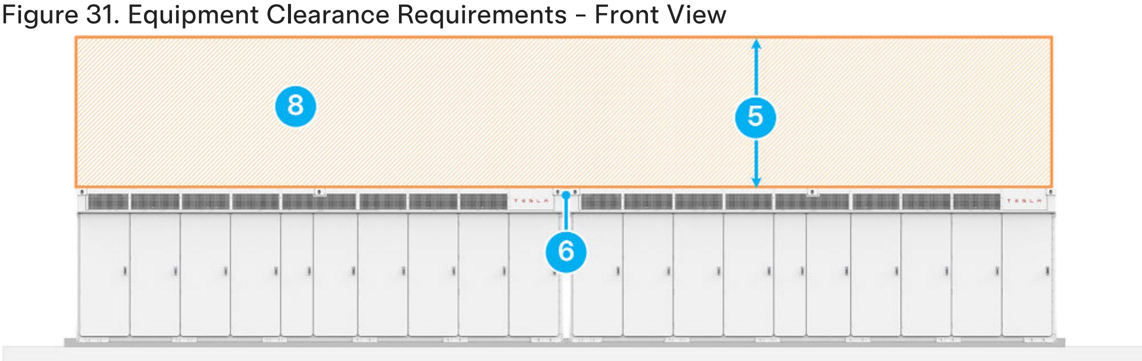
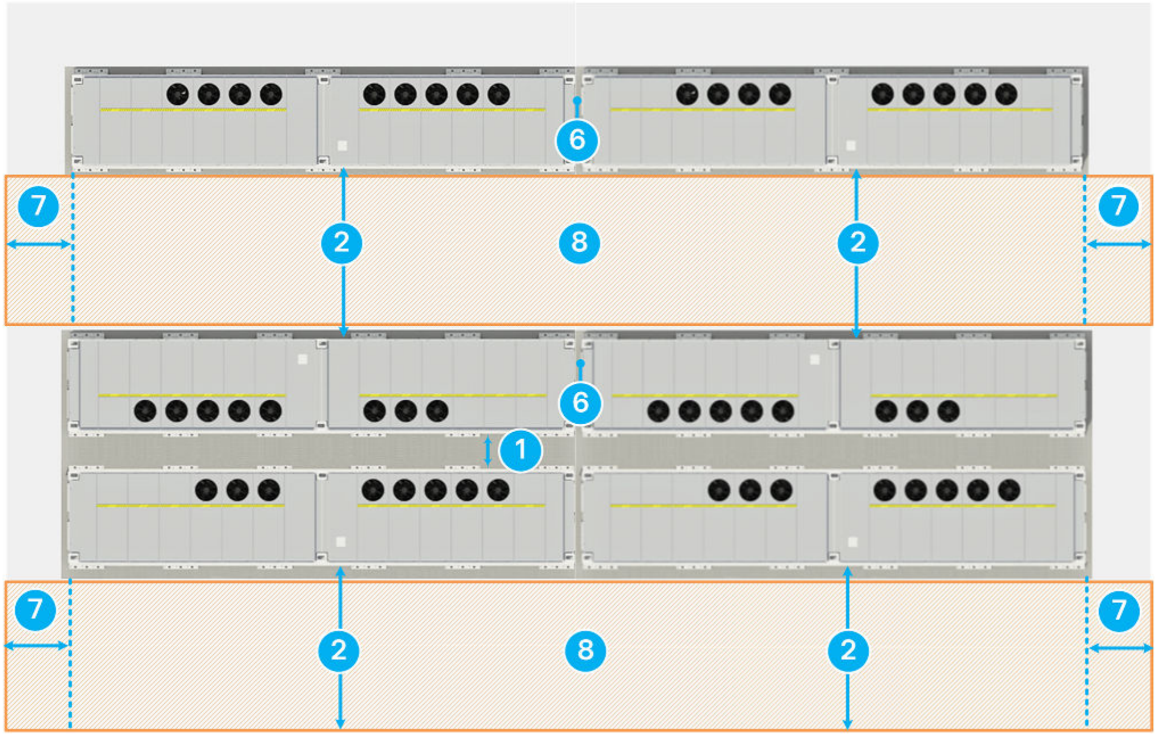


Figure 32. Equipment Clearance Requirements - Plan View



NOTE: All clearances listed must be observed from Megapack to any obstruction, including customer equipment or structures as well as other Tesla-provided components such as the Standard Tesla System Controller Enclosure.

Table 53. Equipment Clearance Requirements

Callout	Type	Minimum	Maximum	Notes
1	Back-to-back clearance	460 mm (18 in) *recommended* for access purposes. 230 mm (9 in) with prior Tesla review.	None	Measured from the back faces of the Megapacks.
2	Front clearance	2440 mm (96 in)	None	Measured from the face of the door(s). Tesla-required clearance for maintenance access. **NOTE:** Removable bollards may be installed within this area with prior Tesla approval. No permanent obstructions are allowed.
3	Foundation overhang	100 mm (4 in)	305 mm (12 in)	Varies depending on anchor and site design but must fall within this range.
4	Drive aisle clearance	1960 mm (77 in)	None	Measured from foundation. Tesla-required clearance for maintenance access.
5	Vertical clearance	2440 mm (96 in)	None	Must extend across the Battery Service Zone, as some service equipment extends beyond the roof of the enclosure.

Callout	Type	Minimum	Maximum	Notes
				Megapack may only be installed by a crane, thus actual clearance during installation will be greater.
6	Side-to-side clearance	150 mm (6 in)	None	Measured from the side faces of each Megapack.
7	Service side clearance	915 mm (36 in)	None	Measured from the face of each side of the Megapack, except where side-by-side with another Megapack.
8	Battery Service Zone	--	--	The Battery Service Zone, shown shaded above, consists of the *Front* **(2)**, *Vertical* **(5)**, and *Service side* **(7)** clearances. **NOTE:** Small inclusions for foundations are allowed as long as the foundation does not infringe on the *Foundation overhang* **(3)** and *Drive aisle* **(4)** clearances.

7.5.4 Exposures and Fire Clearances

The dimensions and requirements as specified below are the product minimums and persist throughout the design, installation, and operating life of the system. Many jurisdictions have guidelines or restrictions about how close potentially combustible objects can be located to battery systems. Designers, owners, and operators are responsible for ensuring that the site meets the requirements of the local jurisdictions.

Figure 33. Exposure Clearances - Isometric View / Side View

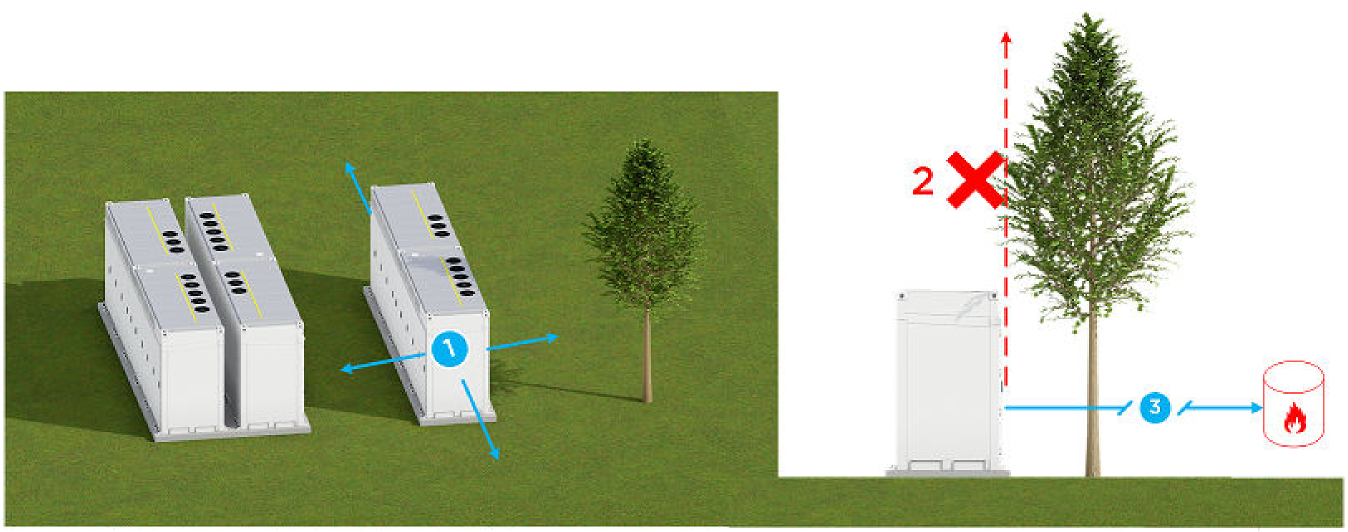


Table 54. Exposure Clearance Requirements

Callout	Type	Minimum	Maximum	Notes
1	Ordinary combustibles	1530 mm (60 in)	None	Minimum clearance as noted is required on all sides to ordinary combustible objects including trees, wooden fences, and other combustible structures.
2	Vertical combustible or ignitable	NA	NA	**Do not install Megapack under combustible or ignitable objects, at any distance.**

Callout	Type	Minimum	Maximum	Notes
3	Ignitable liquids	6096 mm (240 in)	None	Minimum clearance as noted is required on all sides to ignitable liquids sources.

NOTE:

- Megapack is not intended to be installed within 3050 mm (120 in) from accessible means of egress and exposures (such as buildings, public ways, and hazards not associated with electrical grid infrastructure as defined by the clearance requirements in the International Fire Code and NFPA 855).
- Any installation that requires clearances of less than 3050 mm (120 in) to accessible means of egress or exposures may require a freestanding fire barrier per requirements in the International Fire Code and NFPA 855.

7.6 Remote Connection

To warranty and maintain the Megapack System, Tesla requires remote connections for the purposes of:

- Data logging for periodic collection of operational data and low-level sensor data from the Megapack System for maintenance and warranty purposes
- Diagnostics and dispatch support for monitoring and responding to issues
- Firmware and configuration updates for maintaining the Megapack System

Unless otherwise specified, the Tesla System Controller requires access to the Tesla servers either via the integrated cellular modem or an unrestricted hardline internet connection provided by the customer over the Customer Network and the Tesla System Controller's LAN 1 Ethernet port.

7.7 Wiring Interfaces

Megapack requires power and communications wiring between system components and to the site's main AC panel. The table below summarizes the wiring interfaces needed. All materials are supplied by the contractor.

Table 55. System Wiring Interface Summary

From Equipment	To Equipment	Wiring Interface	Minimum Conduit Size
Megapack	Controller or field network enclosure	Communications cable	N/A
		DC power conductors (for communication control power or microgrid applications)	N/A
	Grid interconnection	AC power conductors (3-phase and ground)	N/A
Controller	AC power supply	AC power conductors (2-phase and ground)	25 mm (1 in)
	Meters	Communications cable	25 mm (1 in)

Each Megapack requires a 3-wire circuit (3 phases, ground) connection.

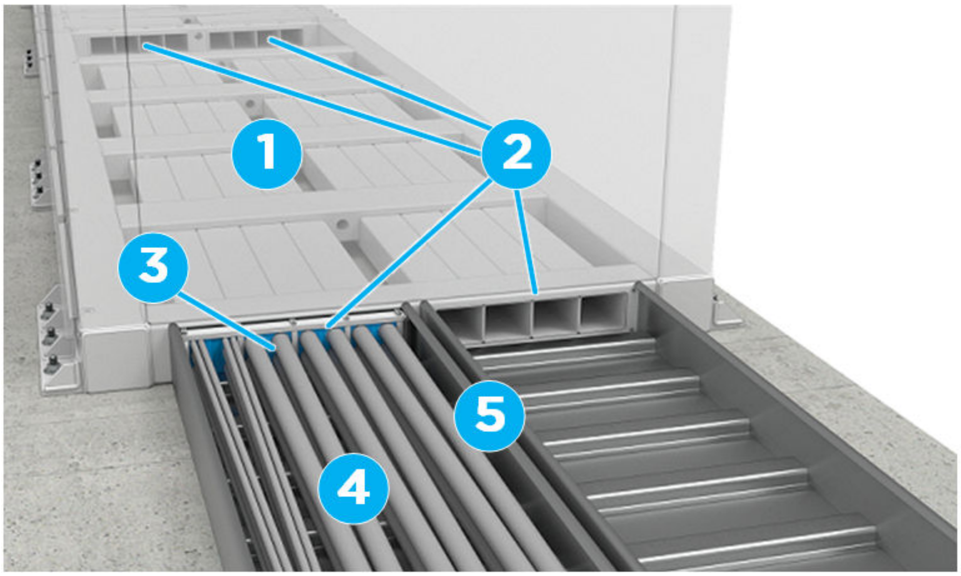
Conductors enter Megapack via the above-ground wireway, and terminate on the AC bus bars in the Customer Interface Bay.

Megapack is designed with two above-ground wireways through which to route AC cabling to LV transformer termination and communications cabling. The wireways do not require any site trenching construction. Each wireway runs from each side of the Megapack into the AC bus bar area in the Customer Interface Bay. Circuits using wireways must be designed and installed in accordance with local code.

Table 56. Wireway Opening Dimensions

Enclosure Variant	Width	Height	Channel Width
-C variant	410 mm (16 ¼ in)	96 mm (3 ¾ in)	NA
-D variant	502 mm (19 ¾ in)	96 mm (3 ¾ in)	4 channels, 121 mm (4 ¾ in)

Figure 34. Megapack Integrated Wireway (-D Enclosure)



1. Two four-channel (single-channel in the -C enclosure) wireways, integrated into the Megapack base
2. Wireway openings
3. Roxtec seal in the wireway opening
4. AC power conductors or other cables such as communications cables
5. Two cable trays

Dedicate a separate 3-phase circuit for each Megapack. Tesla requires copper or aluminum conductors with a minimum insulation temperature rating of 90°C.

Provide an equipment grounding connection for each power circuit. The grounding conductor size depends on local requirements and the Megapack breaker rating.

Auxiliary power is not required. Megapack pulls auxiliary power for the control power and thermal management from the local AC, and therefore requires no field work.

The Standard Tesla System Controller Enclosure must be powered from a dedicated 120-480 V circuit. Its internal transformer adjusts voltage as required.

Communications wiring for the Megapack System requires special attention to network cabling.

8 Operation, Maintenance, and Service

This section discusses responsibilities for system owners and Service Providers while the Megapack System is in an operational state and throughout the productive lifetime of the system.

Responsibilities of system owners include:

- Designating site operators as needed
- Monitoring and operating the site as required (*Tesla System Controller Specifications on page 31*)
- Providing for site access for Service Providers (*Maintaining Access, Routes, and Zones on page 70*)
- Providing a safe work environment for Service Providers (*Safe Work Environment Requirements on page 71*)
- If requested by a local authority, providing total material quantities as indicated in the *Application Note: Considerations for Hazardous Materials Business Plans (HMBP)*
- Arranging for decommissioning (*Decommissioning on page 74*)

A Service Provider is defined as one of the following:

- Tesla Energy Service
- Certified Service Provider:
  - System owner certified by Tesla
  - Third party certified by Tesla

Responsibilities of Service Providers include providing preventative and corrective maintenance to the Megapack System (*Maintenance and Service Considerations on page 71*).

CAUTION: If you are making changes to the site that may affect its design, you must ensure that the site continues to abide by all requirements in the *Megapack 2 XL Design and Installation Manual* on the Tesla Partner Portal.

NOTE: Tesla's standard service offering does not include maintenance scope beyond the Megapack System.

8.1 Maintaining Access, Routes, and Zones

To service Megapack, Service Providers will require frequent access to the site and to the Megapacks themselves, over the full duration of the project's life. Routes and zones at the site must allow for year-round access, including for support of all vehicles as designated by the site's engineer of record. Refer to *Routes and Zones on page 57* for more information.

8.1.1 Megapack Access

- The Service Provider must be allowed to have the ability to remove any locks preventing access.
- Clearance must be maintained such that the Battery Service Zone remains free of obstruction (including, for example, snow, sand, and blown debris) during system operation to avoid restricting airflow through the ventilation openings. Restricted airflow can affect system performance.

8.1.2 Lift Plan

The original lift plan used to install Megapack at commissioning must be provided to Service Providers. This provides background information that can be used to plan for Megapack removal or replacement during the operations phase.

8.2 Safe Work Environment Requirements

Over the operating life of your Megapack System, you may need to isolate and de-energize the Megapack for various reasons:

- For Tesla to perform service on the Megapack System
- For providers other than Tesla to perform work upstream or around the Megapack
- To put the Megapack in an idle state by de-energizing the equipment due to an upstream fault or other reason

If a Service Provider needs to perform maintenance, you will need to provide both access to the Megapack System and a safe work environment. Providing a safe work environment will typically require the Megapack to be isolated and de-energized.

Depending on the scope of service and the site design, the Megapack will either need to be de-energized at the Megapack AC circuit breaker or at an upstream AC disconnect.

Provided that the Megapack does not exceed the maximum allowable arc flash incident energy as specified below, most Megapack service can be completed safely by de-energizing at the Megapack AC circuit breaker.

If the Megapack exceeds the maximum allowable arc flash incident energy, all Megapack service will require upstream AC disconnect.

Table 57. Maximum Allowable Arc Flash Incident Energy

All Regions
14 cal/cm^2

8.3 Maintenance and Service Considerations

8.3.1 On-Site Maintenance Infrastructure

If Tesla Energy Service is the service provider, on-site maintenance infrastructure is required. On-site maintenance infrastructure (OMI) is essential to the rapid and effective maintenance of Megapack sites. The table below summarizes the minimum design requirements for on-site maintenance infrastructure. Most on-site maintenance infrastructure is contained within the Service Staging Zone.

> **NOTE:** Regional differences may apply. Australia and New Zealand have distinct requirements that must be followed. Contact Tesla for more information.

Table 58. On-Site Maintenance Infrastructure

Level	Applicability	Minimum On-Site Maintenance Infrastructure Requirements	Minimum Critical Services Requirements
1	Projects with 1 or more Megapacks require Level 1 or higher	• Service Staging Zone • Parking Zone	• Portable Restroom • Cellular service • Electricity
2	Projects with 15 or more Megapacks require Level 2 or higher	• One 20-foot storage container • Service Staging Zone • Parking Zone • Storage Clearance Area	• Portable Restroom • Cellular service • Electricity • Waste disposal

Level	Applicability	Minimum On-Site Maintenance Infrastructure Requirements	Minimum Critical Services Requirements
3	Projects with 36 or more Megapacks require Level 3 or higher	• One 40-foot storage container • Service Staging Zone • Parking Zone • Storage Clearance Area	• Portable Restroom • Cellular service • Electricity • Waste disposal
4	Projects with 75 or more Megapacks require Level 4 or higher	• Two 40-foot storage containers • Service Staging Zone • Parking Zone • Storage Clearance Area	• Portable Restroom • Cellular service • Electricity • Waste disposal
5	Projects with 146 or more Megapacks require Level 5 or higher	• Three 40-foot storage containers • Service Staging Zone • Parking Zone • Storage Clearance Area	• Portable Restroom • Cellular service • Electricity • Waste disposal
6	Projects with 261 or more Megapacks require Level 6 or higher	• Four 40-foot storage containers • One 60 x 12-foot office trailer • Service Staging Zone • Parking Zone • Storage Clearance Area	• Restroom • Electricity • Internet and cellular service • Waste disposal • Water
7	Projects with 376 or more Megapacks require Level 7	• Five 40-foot storage containers • One 60 x 12-foot office trailer • Service Staging Zone • Parking Zone • Storage Clearance Area	• Restroom • Electricity • Internet and cellular service • Waste disposal • Water
8	Projects with 501 or more Megapacks require Level 8	• Six 40-foot storage containers • One 60 × 24-foot double-wide office trailer • Service Staging Zone • Parking Zone • Storage Clearance Area	• Restroom • Electricity • Internet and cellular service • Waste disposal • Water
9	Projects with 651 or more Megapacks require Level 9	• Eight 40-foot storage containers • One 60 × 24-foot double-wide office trailer • Service Staging Zone • Parking Zone • Storage Clearance Area	• Restroom • Electricity • Internet and cellular service • Waste disposal • Water

Level	Applicability	Minimum On-Site Maintenance Infrastructure Requirements	Minimum Critical Services Requirements
10	Projects with 800 or more Megapacks require Level 10	• Ten 40-foot storage containers • One 60 × 36-foot triple-wide office trailer • Service Staging Zone • Parking Zone • Storage Clearance Area	• Restroom • Electricity • Internet and cellular service • Waste disposal • Water
11	Projects with 1000 or more Megapacks require Level 11	• Contact Tesla for infrastructure requirements	• Contact Tesla for infrastructure requirements

NOTE:

- This table provides general guidance on the minimum requirements for the preliminary development of a site
- Project-specific requirements may vary based on site-specific factors as detailed in the *Application Note: On-Site Maintenance Infrastructure Requirements* on the Tesla Partner Portal
- The applicable category of maintenance and project-specific requirements are defined in the contract
- Always follow all local codes and regulations

8.3.2 Maintaining the Perimeter

- Fencing may be locked and posted with a placard stating "Authorized Users Only" or similar. Refer to local code for fencing placard requirements.
- Any fencing must follow clearance requirements.

8.3.3 Maintaining the Enclosure

- Enclosures must be regularly visually inspected for any areas of damage, which shall be reported to a Service Provider.
- Enclosures must be regularly visually inspected to ensure they remain free of debris or rodents.

8.3.4 Environmental Considerations

Each Megapack contains coolant and refrigerant in its thermal system (*Thermal System on page 9*). Depending on the number of Megapacks installed on a site, storage, use and handling of these substances may require reporting, hazard management plans, or containment procedures as required by local codes and regulations. All local codes and regulations related to this matter must be followed. Refer to the *Megapack 2 XL Design and Installation Manual* on the Tesla Partner Portal for more information.

8.3.5 Energy Meters

The Tesla System Controller uses various meter inputs for different control functions. The meters are expected to be installed during the installation phase of the project and are the operator's responsibility to maintain.

For additional information and for a list of supported meters, refer to the *Megapack 2 XL Design and Installation Manual* on the Tesla Partner Portal.

NOTE: When communication to any of the meters is lost during on-grid normal operation, the system ceases to operate until communication is resumed. If communication is lost, the values reported are the last values read from the meter until communication is resumed.

8.4 Decommissioning and Disposal

8.4.1 Safety

Refer to the *Industrial Lithium-Ion Battery Emergency Response Guide* (ERG) on the Tesla First Responders Information Page at *https://www.tesla.com/firstresponders* for detailed hazard information specific to Megapack's lithium-ion batteries. The *Transportation* section of the ERG provides guidance and cites example regulations for shipment of dangerous goods. All logistics and transportation companies in the supply chain are responsible for knowing and following all applicable regulations pertaining to the storage, handling, and transportation of dangerous goods. The ERG is periodically updated. Download the latest revision of the ERG from *https://www.tesla.com/firstresponders*.

Tesla recommends that a physical copy of the ERG is transported along with Megapack, and subsequently remains on site and accessible at all times, for the life of the product.

Safety Data Sheets (SDS) are available for materials in Tesla Energy products. Refer to the Tesla Partner Portal for more information.

8.4.2 Decommissioning

Prior to shutting down and decommissioning Megapack, Megapack must be discharged accordingly as required by applicable regulations.

Megapack contains recyclable materials. Tesla strongly encourages recycling and recommends that when a Megapack must be decommissioned, it be returned to a Tesla facility for disassembly and further processing or to an alternate recycling facility.

Megapacks should be disposed of or recycled in accordance with local, state, and federal regulations. Note that regulations regarding disposal of batteries vary by jurisdiction.

Appendix A: Glossary

Only selected terms appear in this glossary. For a complete glossary, refer to the *Tesla Energy Glossary* on the Tesla Partner Portal.

AC output terminals – The point on the AC bus bars at which the external AC connections to the Megapack are terminated. Megapack's apparent power capability (kVA), real power capability (kW), and energy capacity (kWh) are specified at this point.

apparent power capability – Rated AC apparent power capability of Megapack in kVA, factory-configurable by Tesla. Displayed as Maximum Continuous Power on the product nameplate.

battery cell – The smallest non-divisible energy component of the Megapack, assembled into a battery module in series and parallel arrays.

battery inverter losses – Power consumed by inverter switching losses and quiescent draw from the battery module's inverter.

battery module – A field-replaceable unit that integrates battery cells, fusing, and battery management system functions. The battery module interfaces are output electrical connections, thermal interface, and communication connections.

beginning of life – The start date of the Megapack System warranty.

Customer Network – The network that provides the customer's interface to the Tesla system. This network is accessed via the Tesla System Controller's LAN 1 port, and is often the broader local SCADA network for the site.

energy capacity – Rated AC energy capacity of Megapack in kWh. Displayed as Nominal Battery Energy (AC) on the product nameplate.

frequency ride-through (FRT) – The capability of grid-connected devices to stay connected over short periods of time when local frequency differs from the grid's nominal frequency. Megapack Systems support both high-frequency ride-through (HFRT) and low-frequency ride-through (LFRT) settings.

fully operational – The operating condition in which the Megapack is capable of discharging or charging at real power capability.

Heat Mode – A Megapack control mode that is used to precondition the battery cell temperature in order to maintain the real power capability and/or to maximize the discharge energy capacity of Megapack at low ambient temperatures.

inverter – Bi-directional power conversion system that couples each Megapack with the power grid (AC power).

Megapack – Modular AC-coupled energy storage system, including an enclosure, battery modules, inverters, and a thermal system.

Megapack auxiliary energy – Energy consumed to support the Megapack internal controls and thermal management loads over the course of 24 hours. This energy may be consumed from the grid and/or battery modules.

Megapack auxiliary power – Power drawn to support the Megapack internal controls and thermal management loads, not including battery inverter losses. This power may be drawn from the grid and/or battery modules.

Megapack maximum auxiliary power – Maximum power that can be drawn to support Megapack internal controls and thermal management loads, not including battery inverter losses. This power may be drawn from the grid and/or battery modules.

Megapack System – A Tesla System that consists of one or more Megapacks and the Tesla System Controller.

Megapack site – The Megapack System plus additional equipment required by the site and supplied by the customer.

nameplate label – Label attached to a Megapack that indicates its electrical and mechanical specifications.

nominal – Standard value, as used for example in nominal voltage or nominal frequency, to which the Megapack is designed to operate under normal conditions.

overvoltage (OV) withstand – The capability of Megapack to stay connected over short periods of time despite local voltage exceeding the grid's nominal voltage.

peak apparent power capability – Rated peak AC apparent power capability of Megapack in kVA. Only available if Megapack is configured with Peak Power Mode by Tesla.

peak real power capability – Rated peak AC real power capability of Megapack in kW. Only available if Megapack is configured with Peak Power Mode by Tesla.

ratings – Energy capacity or power capability that the Megapack is designed to meet given certain nominal conditions. Nominal ratings are displayed on the product nameplate.

real power capability – Rated AC real power capability of Megapack in kW. Throughout Megapack documentation, the term *real power* may be used synonymously with the term *active power*.

round-trip efficiency (RTE, %) – The quotient of total energy discharged over the total energy charged. The energy charged and discharged are measured during a cycle of 0%-100%-0% SOE, where the Megapack is charged from 0% to 100% at real power capability, then discharged to 0% at real power capability. The round-trip AC-AC energy efficiency shall be measured at the AC output terminals of the Megapack and shall include Megapack auxiliary energy and energy resulting from battery inverter losses, but exclude site auxiliary energy expended during the cycle as defined above.

site auxiliary energy – Energy consumed to support site devices other than the Megapack auxiliary energy. This energy may be consumed from the grid and/or battery modules.

site auxiliary power – Power drawn to support site devices other than the Megapack auxiliary power. This power may be drawn from the grid and/or battery modules.

Standard Test Conditions (STC) – Defined as the Megapack maintained at 25°C and 1 atmosphere (101.3 kPa) of pressure.

state of energy (SOE) – The amount of energy left in the Megapack or Megapack System measured as a percentage of Full Battery Energy.

supervisory control and data acquisition (SCADA) – Additional hardware and software that may be required to control and monitor a Megapack site.

$T_{AMBCOLD}$ – The ambient temperature for cold weather performance is defined as the Megapack soaked at -20°C. This temperature definition is used to define performance in a nominally cold temperature climate, and does not define the operating limitation or temperature rating of the Megapack.

T_{AMBHOT} – The ambient temperature for hot weather performance is defined as the Megapack soaked at 45°C. This temperature definition is used to define performance in a nominally hot temperature climate, and does not define the operating limitation or temperature rating of the Megapack.

Tesla Network – The Tesla-controlled network that includes the individual battery units (Megapacks) of the battery system. This network is accessed via the Tesla System Controller's LAN 2 port, and often includes additional components such as field network devices.

Tesla System – One or more Tesla Energy products and the Tesla System Controller.

Tesla System Controller – The single point of interface with which to monitor and control the entire Tesla System and approved third-party generation sources. There are two physical variations of the Tesla System Controller: The Standard Tesla System Controller (deployed in the Standard Tesla System Controller Enclosure), and the Large Tesla System Controller.

voltage ride-through (VRT) – The capability of grid-connected devices to stay connected over short periods of time when local voltage differs from the grid's nominal voltage. Megapack Systems support both high-voltage ride-through (HVRT) and low-voltage ride-through (LVRT) settings.

Revision History

Revision	Date	Details
2.0	February 25, 2026	• Changed unit from kW to kVA for clarity (*Megapack Maximum Auxiliary Power on page 16*) • Updated battery inverter losses for TC2H and TC4H (*Battery Inverter Losses on page 21*)
1.9.1	November 19, 2025	• Clarified that the values for certain configurations apply for Grid-Following mode only (*Battery Inverter Losses on page 21*)
1.9	November 13, 2025	• Added configurations to auxiliary energy during Heat Mode (*Auxiliary Energy during Heat Mode on page 20*) • Added peak average power (*Megapack Auxiliary Energy over 24 Hours on page 17*) • Added new configurations for auxiliary energy, maximum auxiliary power, round-trip efficiency, battery inverter losses, and noise specification (*Megapack Auxiliary Energy over 24 Hours on page 17*, *Round-Trip Efficiency on page 14*, *Megapack Maximum Auxiliary Power on page 16*, *Battery Inverter Losses on page 21*, *Noise Specification and Guidance on page 29*) • Updated “following one full cycle” to “post-cycle” to account for a charge to 10% SOE after the cycle to ensure the system is not left at 0% at end of discharge (*Megapack Auxiliary Energy over 24 Hours on page 17*) • Improved ratings for C012 cell option (*Power and Energy on page 13*) • Added information about non-standard configurations, such as the 8-Hour non-standard configuration (*Power and Energy on page 13*) • Removed Peak Power Mode as an offering • Provided information about manufacturing options, including additional thermal system manufacturing option information (*Product Configurations on page 6*, *Thermal Specifications on page 27*) • Updated state of energy for accuracy and clarity in the table in *Megapack Maximum Auxiliary Power, Auxiliary Energy, and Battery Inverter Losses on page 16* • Provided a summary of supported control modes (Grid-Forming/Grid-Following) per Archetype (*Utility Archetypes on page 31*) • Clarified that system-level monitoring and control is available over both Modbus and DNP3 (*Telemetry on page 46*) • Added reaction time; added minimum short circuit ratio condition required to meet the rise time specification (*Rise Time and Reaction Time on page 51*)
1.8	May 29, 2025	• Restructured and clarified auxiliary power content (*Megapack Maximum Auxiliary Power, Auxiliary Energy, and Battery Inverter Losses on page 16*) • Separated battery inverter losses from auxiliary energy (*Battery Inverter Losses on page 21*) • Clarified preconditioning applicability to Heat Mode and that this specification excludes battery inverter losses (*Auxiliary Energy during Heat Mode on page 20*)

Revision	Date	Details
		• Updated the maximum allowable arc flash incident energy from 8 to 14 cal/cm^2 for all regions (*Safe Work Environment Requirements on page 71*) • Provided additional cell option details (*Product Options on page 6*) • Added ride-through alert details (*Telemetry on page 46*) • Clarified ride-through behavior and included applicability for IEEE 2800-2022 (*Ride-Through and Anti-Islanding Features on page 22*) • Updated reconnection delay timer setting ranges (*Anti-Islanding Features on page 26*) • Updated *Tesla System Controller on page 10* and *Megapack System Components on page 4* to include additional Large Tesla System Controller • Added note on Megapack-level alerting timestamp accuracy (*Telemetry on page 46*)
1.7	February 12, 2025	• Introduced the C011 cell option (*Battery Modules on page 8*, *Power and Energy on page 13*, *Round-Trip Efficiency on page 14*, *Megapack Maximum Auxiliary Power, Auxiliary Energy, and Battery Inverter Losses on page 16*) • Introduced fan type options (*Product Options on page 6*) • Modified the maximum audible noise specification (*Noise Specification and Guidance on page 29*) • Updated auxiliary consumption specifications for the C010 cell option (*Megapack Auxiliary Energy over 24 Hours on page 17*) • Updated round-trip efficiency specifications for the C010 cell option (*Round-Trip Efficiency on page 14*) • Clarified that the step response example assumes that Closed Loop Control is enabled (*Step Response Example on page 51*)
1.6	December 2, 2024	• Provided product configuration, option, and variant descriptions (*Product Configurations on page 6*) • Introduced the C012 cell option (*Battery Modules on page 8*, *Power and Energy on page 13*, *Round-Trip Efficiency on page 14*, *Megapack Maximum Auxiliary Power, Auxiliary Energy, and Battery Inverter Losses on page 16*) • Clarified thermal capacity configuration descriptions (*Thermal Specifications on page 27*)
1.5	October 23, 2024	• Provided electrical topology diagrams for each Archetype (*Archetype Topologies on page 35*) • Provided service side clearance (superseding door swing clearance) and updated diagrams with Battery Service Zone highlight (*Megapack Clearance on page 65*) • Clarified *state of energy* and removed the obsolete term *state of charge* (*Appendix A: Glossary on page 75*) • Updated safety features section and improved context (*Hazard Mitigation Features on page 11*) • Changed control element name from Redundancy to Automatic Failover (*On-Grid Control Elements on page 42*) • Added detail about steady state error in overbuilt or longer-duration systems (*Note on page 53*)

Revision	Date	Details
1.4	July 24, 2024	• Provided clarification on power transition states, rise time, and step response behavior (*Response Time on page 50*) • Clarified introductory definitions of C&I Archetypes for improved understanding and consistency (*C&I Archetypes on page 33*) • Updated telemetry to include hardware-capable signals (*Telemetry on page 46*) • Updated runaway gas igniters term to Sparker System (*Hazard Mitigation Features on page 11*)
1.3	May 31, 2024	• Added Utility Hybrid Archetype (*Archetypes on page 31*) • Added site-level monitoring and control over DNP3 (*Tesla System Controller Specifications on page 31*) • Added C&I Archetypes (*Archetypes on page 31*) • Updated islanding and microgrid controls (*Islanding Control Elements on page 44*, *Microgrid Control Elements on page 45*) • Added a topic describing routes and zones to aggregate and better clarify site civil design requirements and considerations (*Routes and Zones on page 57*) • Clarified that THD is at real power capability (*Interconnection Data on page 22*) • Clarified that each Megapack unit must be installed on a single planar surface (original language: "Equipment must all be installed on a single level surface.") (*Foundation on page 65*)
1.2	March 6, 2024	• Clarified previous updates to on-site maintenance infrastructure Levels 1-5 (*On-Site Maintenance Infrastructure on page 71*) • Updated (decreased) coolant volume (*Thermal Specifications on page 27*)
1.1	January 30, 2024	• Introduced standard Archetypes to replace the previous concept of Templates (*Archetypes on page 31*) • Added the Co-Located Archetype (*Archetypes on page 31*) • Updated on-site maintenance infrastructure levels (*On-Site Maintenance Infrastructure on page 71*) • Clarified supply fault current rating (*Interconnection Data on page 22*) • Corrected clearance legends (*Megapack Clearance on page 65*)
1.0	November 8, 2023	Initial revision, based on *Megapack 2 XL Specification v2.5* and enhanced with Megapack-System-wide information.

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