POWERPACK
MICROGRID SYSTEM

TESLA
Microgrids and off-grid power systems consisting of a range of conventional and renewable generation sources, battery storage and grid connections present unique challenges that require robust solutions to maintain stable and sustainable power supply. Tesla's microgrid solution leverages existing unit-level controllers and a robust, frequency-based load sharing scheme to solve these challenges. The end result is a solution that delivers savings and stable, reliable power to a wide range of customers—from remote communities, commercial and industrial facilities to utility substations, military bases and mining operations.

Tesla's microgrid solution revolves around the Tesla Powerpack energy storage technology and includes software, controls and services to effectively manage power and energy flow, while balancing demand needs and maximizing economic benefit over the life of the microgrid. This document details Tesla's comprehensive solution.

> System Overview
> Distributed Energy Resource Management
> Islanding and Grid-Connected Control
> Monitoring and Reporting
> Networking and IT

Tesla offers industry-leading performance, reliability and value to implement microgrids that meet and exceed our customers expectations and requirements. For additional information please visit www.tesla.com/powerpack.
Tesla’s Microgrid Controller manages the various Distributed Energy Resources (DERs), such as the Tesla Powerpack system, diesel generators and solar PV to ensure reliable, low cost supply to the system loads.

The Microgrid Controller hardware is contained within the Tesla Powerpack Controller enclosure and includes a redundant, dual-feed DC power supply fed from within the Tesla Powerpack system. The controller utilizes a cost-based optimization algorithm that considers the priority and schedule of all DERs, dispatching generation and allocating power to loads dynamically. The controller easily allows generation sources to be made unavailable without interruption, and can island the microgrid from the upstream grid, and likewise controls the re-synchronization to the grid without interruption.

**FEATURES**

> User configurable Priority List for all loads and generators
> Cost-based optimization algorithm that utilizes the Priority Lists to dispatch or curtail generators and shed or reconnect loads in order to maintain system operation most cost-effectively
> Management of power buffers (also known as spinning reserves) and energy buffers to account for fluctuations in load and non-dispatchable generation
> System blackstart after a fault and safe system shutdown for maintenance
> Forecasting electric demand and renewable generation in order to optimize schedule decision making*

*Advanced offering
The Microgrid Controller manages DERs, such as Tesla Powerpack systems, generators and PV systems listed on Tesla’s Approved Vendor List (AVL) through interfacing with OEM controllers. DERs may be added to the Approved Vendor List for an additional fee subject to Tesla approval. Generally, the management of DERs include:

- Automatic start and stop of the DER
- Management of real and reactive power sharing between DERs
- DER Priority List and availability and management
- Alarm management and monitoring

The Microgrid Controller manages Tesla Powerpack battery systems by interfacing with the Powerpack Controller. Management of Tesla Powerpack systems includes:

- High State of Energy (SOE) management by curtailing generation
- Low SOE management by increasing dispatchable generation output

POWERPACK SYSTEMS

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DISTRIBUTED ENERGY RESOURCE MANAGEMENT

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- Management of real and reactive power sharing between DERs
- DER Priority List and availability and management
- Alarm management and monitoring
**TRADITIONAL GENERATION**

The Microgrid Controller manages generators by interfacing to the OEM generator controllers listed in the Approved Vendor List. Generator Management includes:

- Maintenance of the minimum run rate during steady-state operation and startup management
- Time-of-use management
- Generator loading optimization
- Minimization of total operating cost*

**SOLAR PV**

The Microgrid Controller manages PV systems by interfacing with the OEM PV controllers listed in the Approved Vendor List. Management of PV systems includes:

- Maximization of renewable consumption
- Curtailment to manage battery SOE, Powerpack inverter loading and non-export
- "Wait for Energy" mode whereby in extreme low-energy situations the system will perform a safe shutdown with an energy buffer in order to wait for the next solar day*

**LOADS**

The Microgrid Controller manages generators by interfacing with the OEM load breakers and controllers listed in the Approved Equipment List. Load Management includes:

- Automatic shedding and Automatic re-connection of load feeders*

*Advanced offering
A single connection to an external grid can be managed by the Microgrid Controller, which seamlessly transitions the microgrid between islanded (off grid) and grid-connected configurations using a power system protection relay to manage the islanding breaker/contactor.

Features:

> Transitions the microgrid between islanded and grid-connected configurations by managing the Microgrid generation
> Automatic islanding in the event that a grid excursion is detected
> Automatic re-synchronization when the grid returns or when initiated by customer
> Intentional islanding may be requested by customer
> When on grid, Tesla’s vast on-grid experience using Opticaster can be used for tariff optimization or providing grid services, such as demand response, frequency response, or non-export
> “Fast Backup” also available, contact Tesla for details*

*Advanced offering
The Microgrid Controller includes monitoring and historian functionalities that allow for system values and parameters to be viewed and exported from the system. The monitoring and historian functionalities are available through the web-based HMI, which is hosted as a HTTP page on the local network.

- Data logged to Tesla servers for remote service and support
- Local control (HTTP based)
- HMI accessible via HTML5 browser to provide control and monitoring flexibility
- Comprehensive HMI offering, includes site specific customization*

*Advanced offering
The Microgrid Controller relies on customer supplied Ethernet networking infrastructure. The Microgrid Controller communicates to the DERs via Ethernet-based communications (e.g. MODBUS TCP/IP). DER’s communicate via OEM communications to the individual components. For components that require non-Ethernet communications (e.g. MODBUS Serial RTU) converters are required to allow these DERs to connect to the Ethernet network.

> Ethernet-based communications
> Redundant ring network recommended
> Internet connection required to allow for, monitoring and historian functionality
> Reporting of the system status and variables to upstream SCADA systems.