Overview of Battery Energy Storage (BESS) commercial and utility product landscape, applications, and installation and safety best practices

Jan Gromadzki
Manager, Product Management at Tesla Energy

TESLA'S MISSION

TESLA EXPERIENCE OVERVIEW

1,500 Supercharger stations
15,000 Superchargers
275 GW Power Electronics

920,000 Vehicles Deployed
6 Billion Miles Driven on Autopilot
65 GWh Li-ion Battery Systems

3 GWh Powerpack/Powerwall/Megapack
3.2 GW Solar

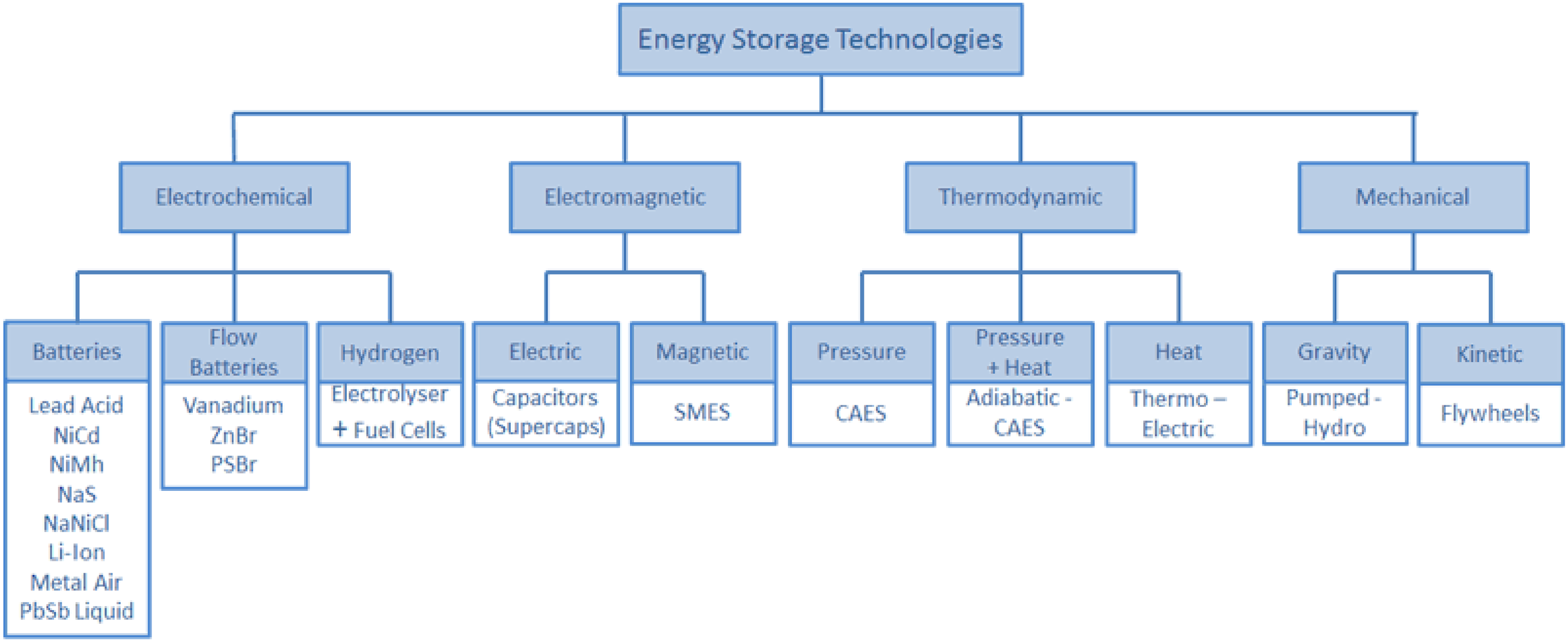
VERTICALLY INTEGRATED WORLD CLASS MANUFACTURING

Tesla Model S/X/3/Y Production Facility
Fremont, CA

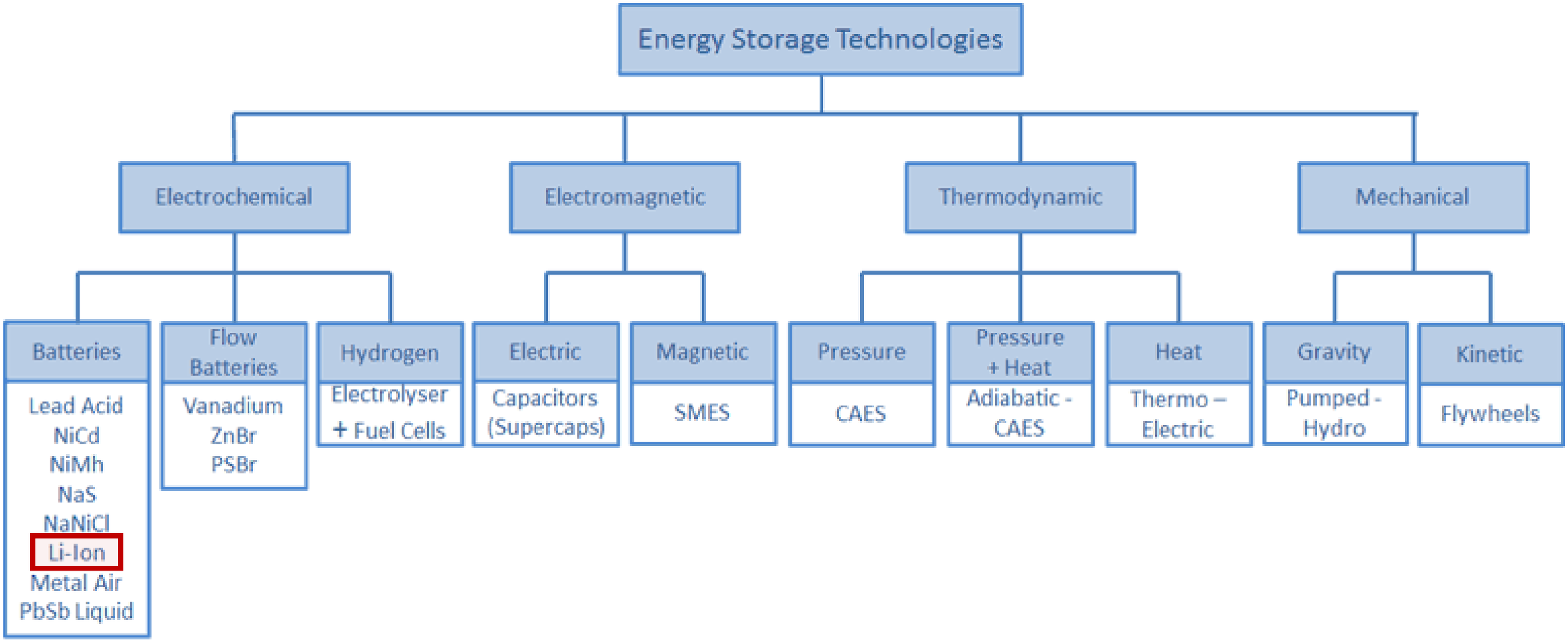
Gigafactory 1
Reno, NV

Gigafactory 2
Buffalo, NY

ESS LANDSCAPE

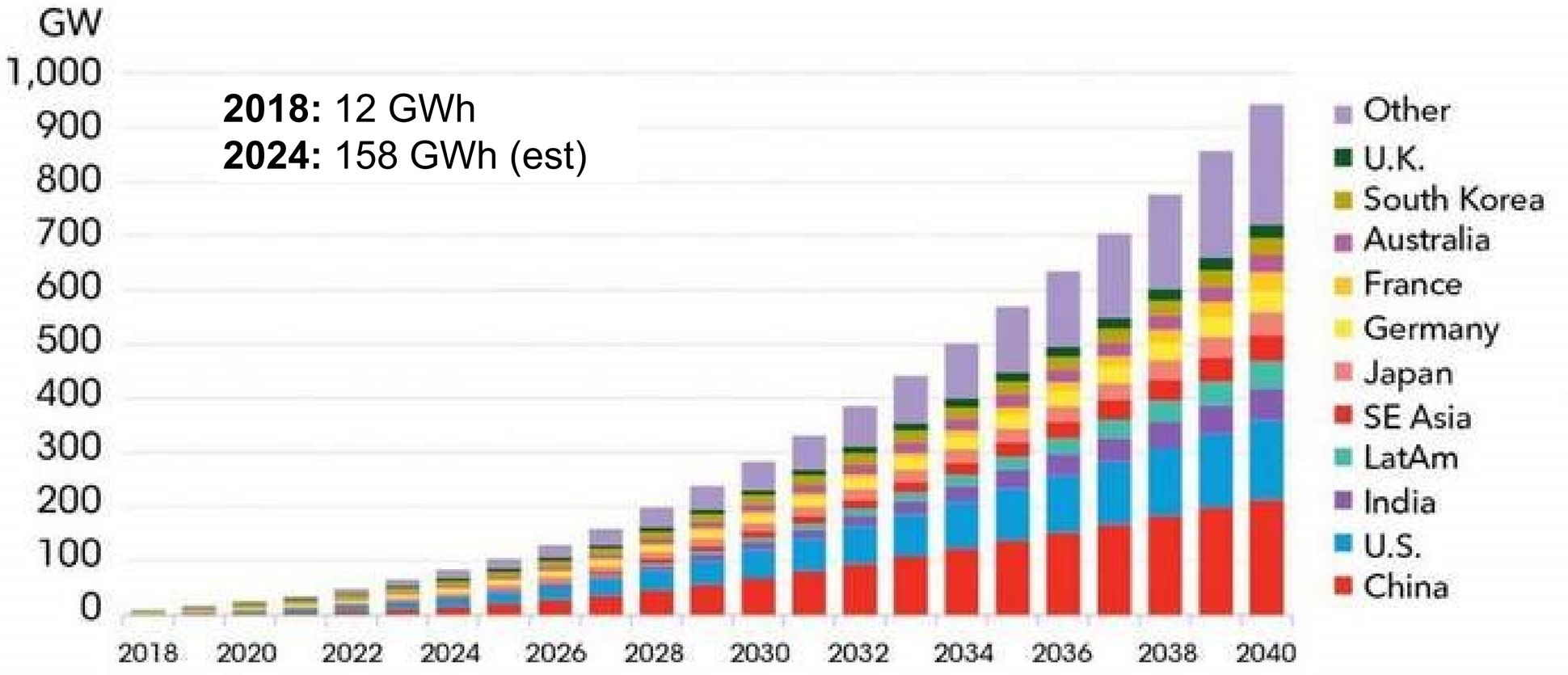


Source: https://www.mpoweruk.com/grid_storage.htm



Source: https://www.mpoweruk.com/grid_storage.htm

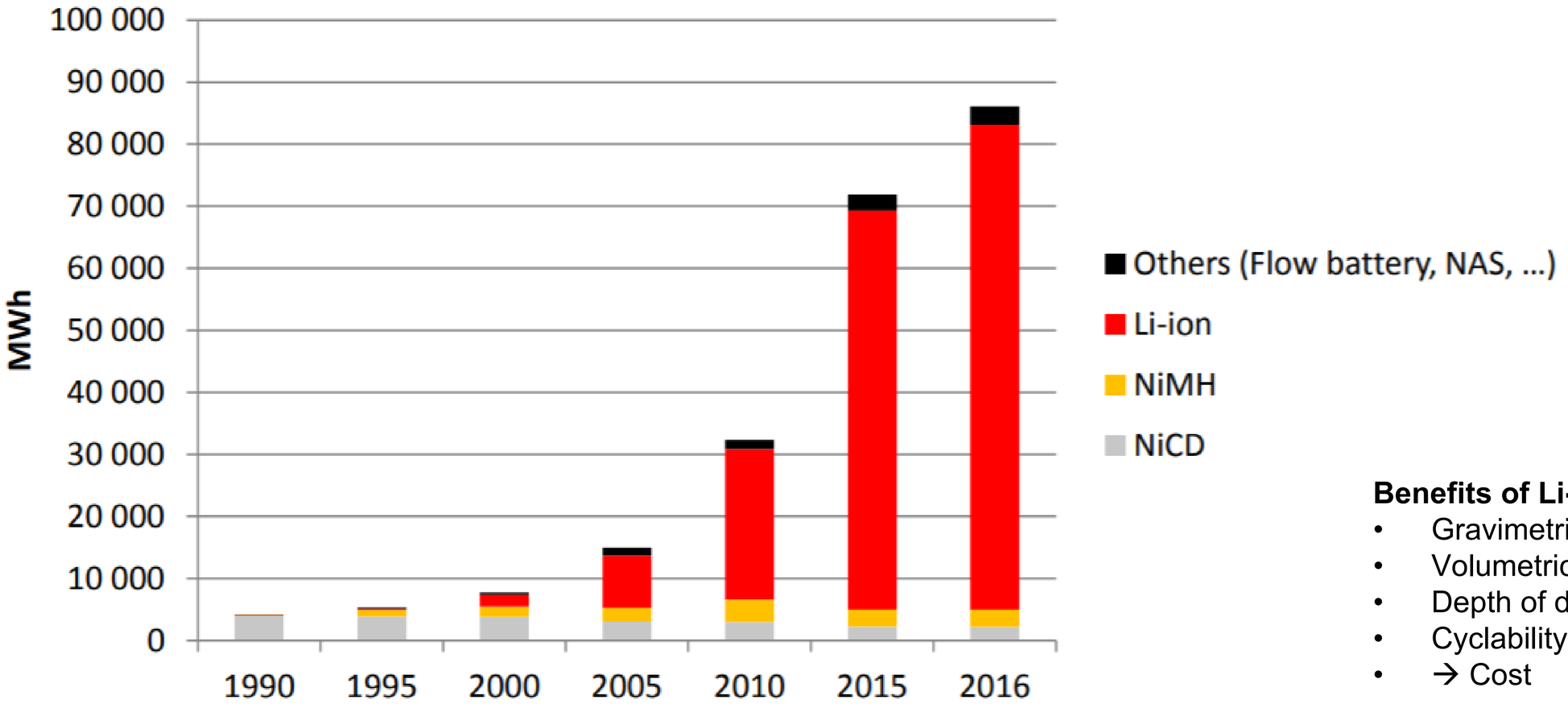
GLOBAL ENERGY STORAGE FORECAST



2018: 12 GWh
2024: 158 GWh (est)

Source: BloombergNEF , GTM

GROWTH OF LITHIUM ION ESS



Benefits of Li-ion:

- Gravimetric density
- Volumetric density
- Depth of discharge
- Cyclability
- → Cost

Source: AVICENNE ENERGY, 2017

PRODUCT LANDSCAPE

Commercial & Industrial (behind the meter)

< 500 – 2000 kWh products

Cabinet Solution:

- Small footprint, easier to transport
- Includes inverter, thermal management
- Indoor/Outdoor
- Not suitable for larger projects due to added EPC costs

SolarEdge
All-In-One

Utility (front of the meter)

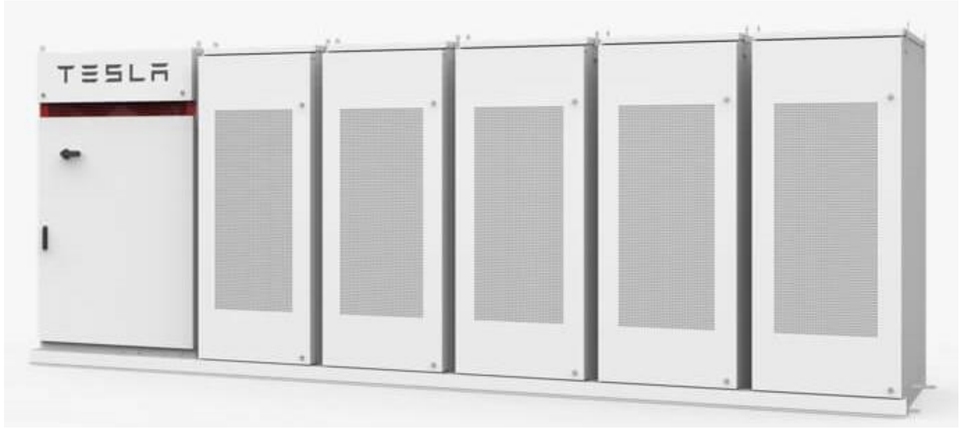
2000 – 6000+ kWh products

Container Solution:

- ISO or similar form factor
- Support module depopulation to customize power/energy ratings
- Can be coupled together for larger project sizes

Samsung Sungrow

COMMERCIAL (C&I) PRODUCT LANDSCAPE



Tesla Powerpack – 232 kWh

SolarEdge – 400kWh

BYD – 210kWh

Sungrow/Samsung – 584kWh

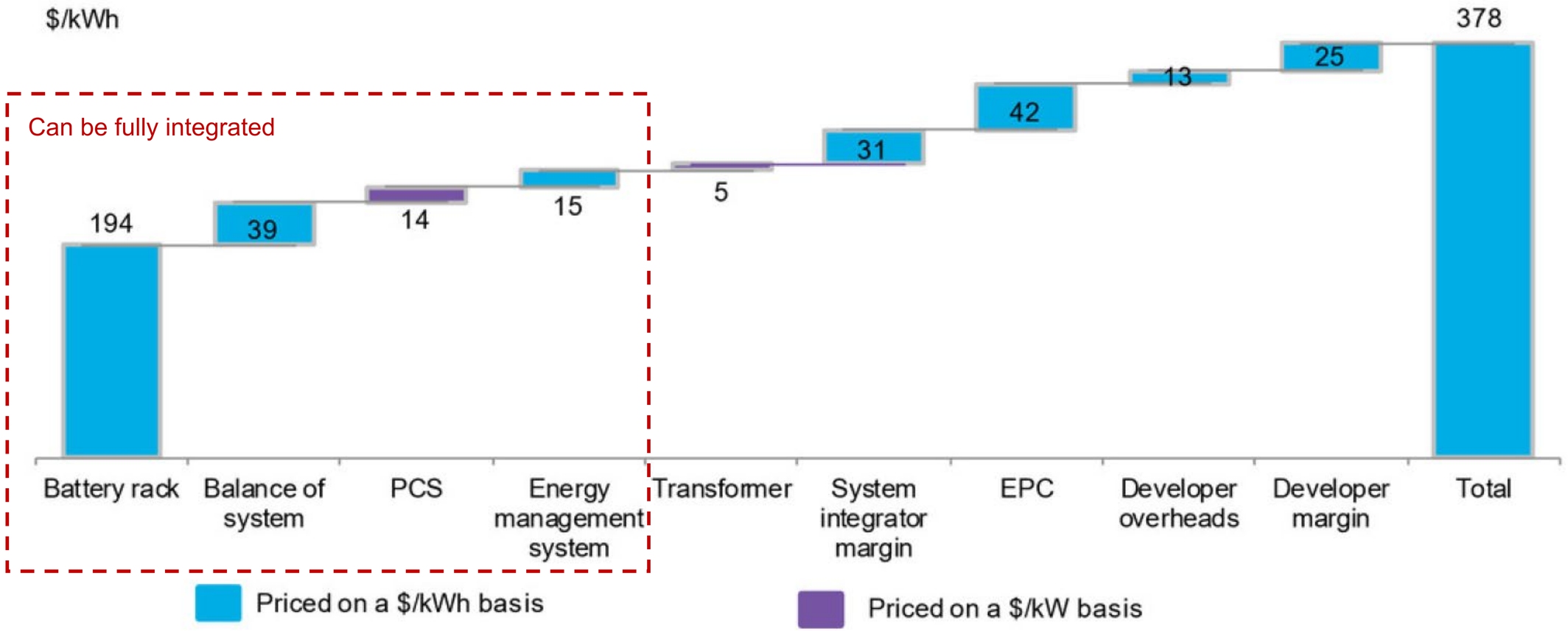
NEC – 510kWh

UTILITY PRODUCT LANDSCAPE

6MWh+ per unit

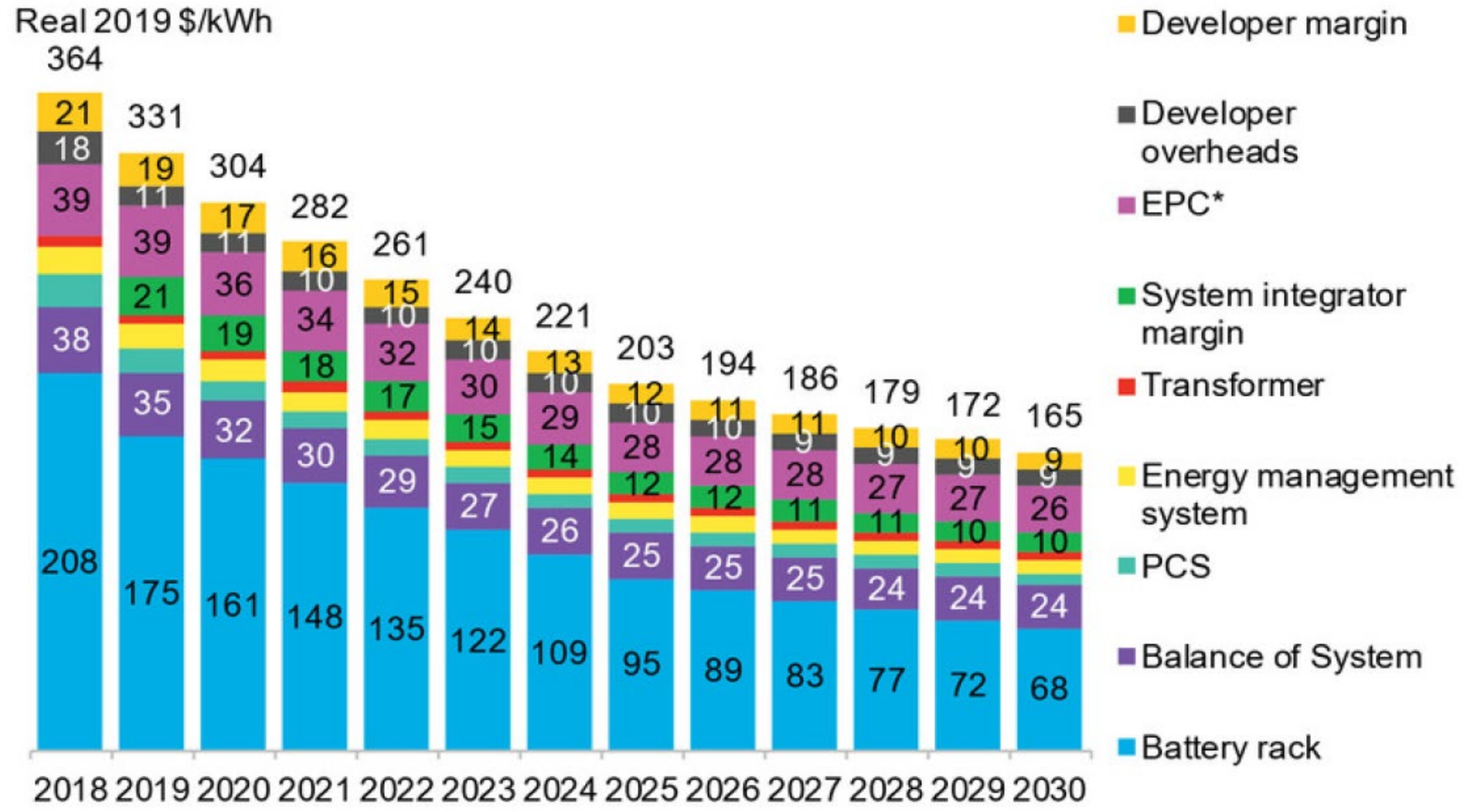
BESS SYSTEM COST STACK

Figure 8: 2019 average survey costs for a utility-scale energy storage system with 4-hour duration



Source: BloombergNEF, survey participants. Note: Delivery year is 2019 Battery rack here is on a $/kWh of usable capacity

BATTERY STORAGE COSTS ARE DROPPING

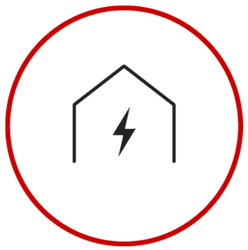


Source: BloombergNEF Note: See Figure 10 for full note.

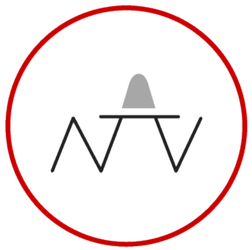
ESS APPLICATIONS

ENERGY STORAGE APPLICATIONS

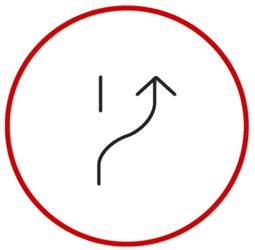
BACK-UP



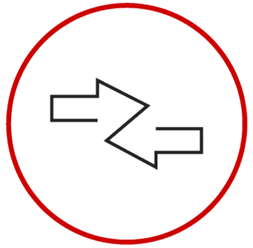
SOLAR SELF-CONSUMPTION



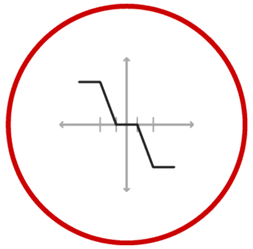
PEAK SHAVING



LOAD SHIFTING

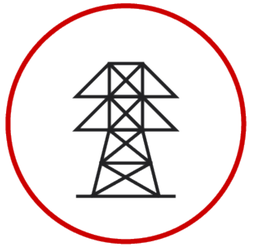


DEMAND RESPONSE



VOLTAGE SUPPORT

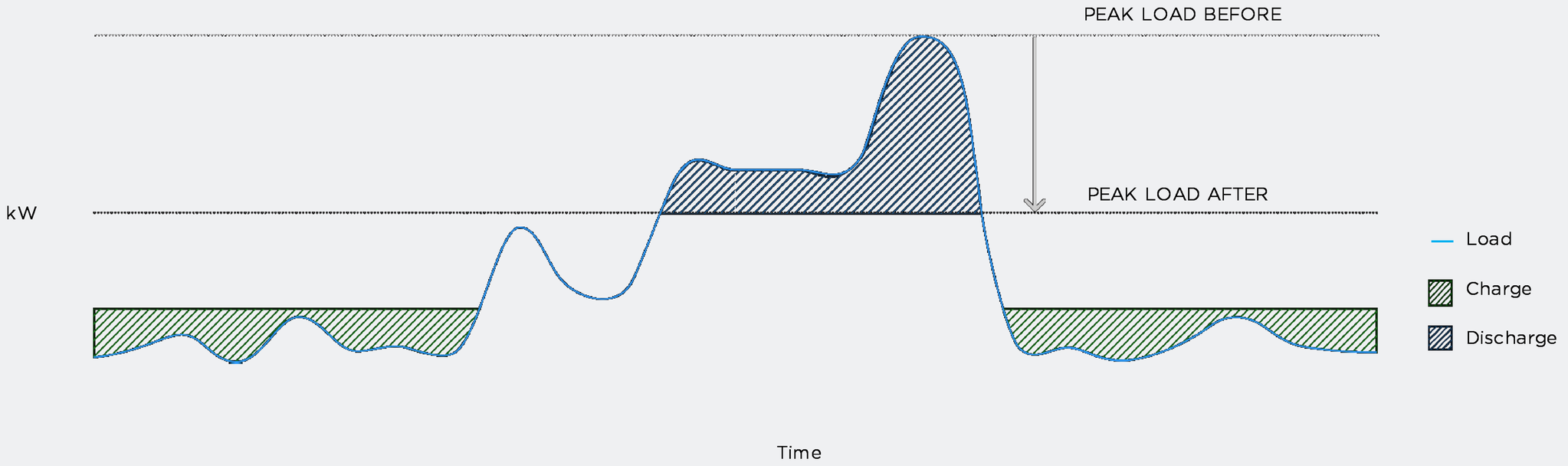
CAPACITY SUPPORT



OTHER GRID SERVICES

PEAK POWER SHAVING

Discharging during peak demand time to avoid or reduce demand charges



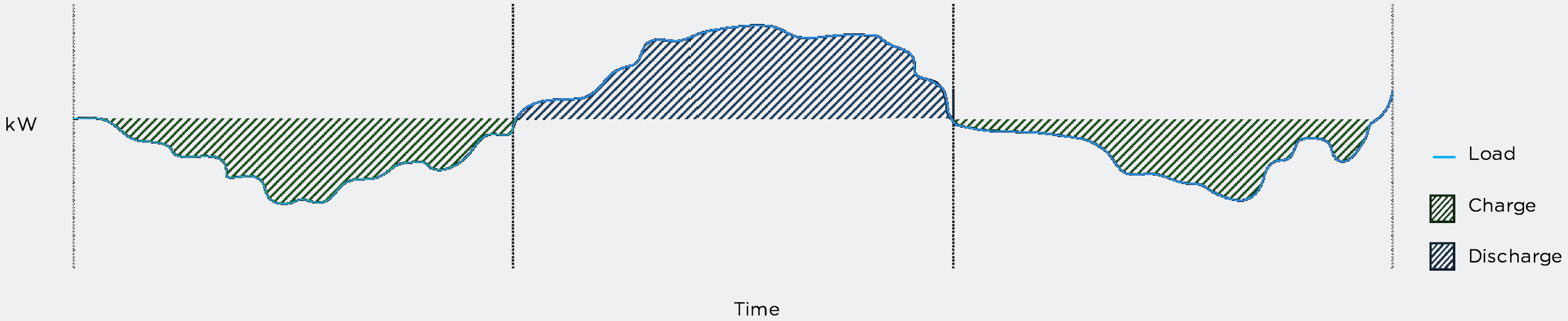
Lower peak demand charges

Reduce grid connection costs

Hedge against rising charges

ENERGY LOAD SHIFTING

Shift energy consumption from one moment to another to avoid paying high energy prices



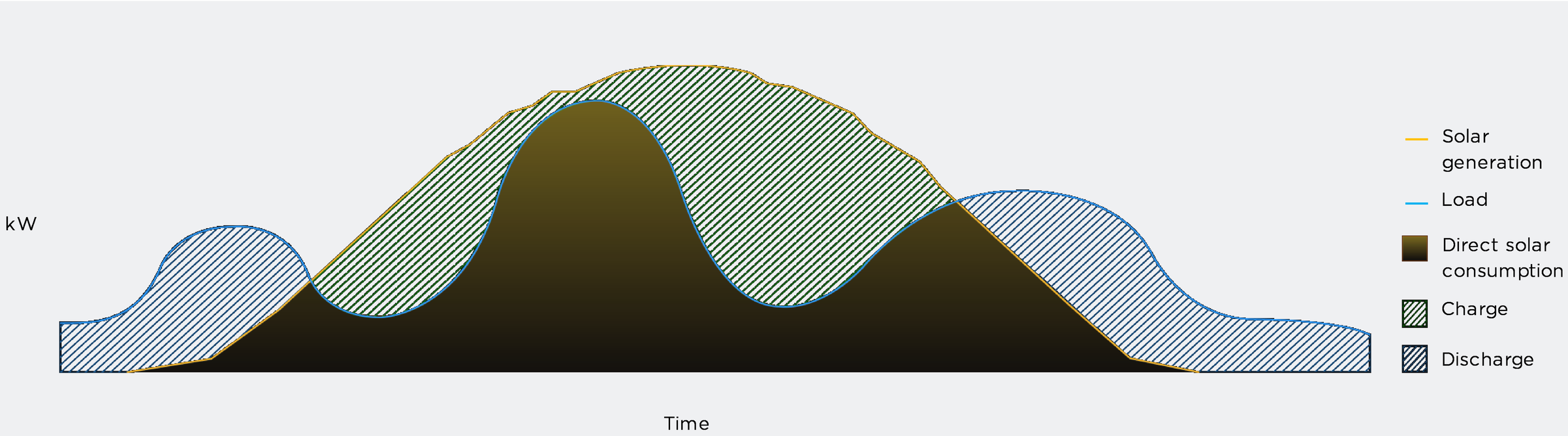
Avoid peak price periods and reduce energy costs

Protect your business from future energy price increases

Maximizes value of energy generated by on-site solar

RENEWABLE ENERGY SELF-CONSUMPTION

Maximize your ability to use your renewable energy generation sources



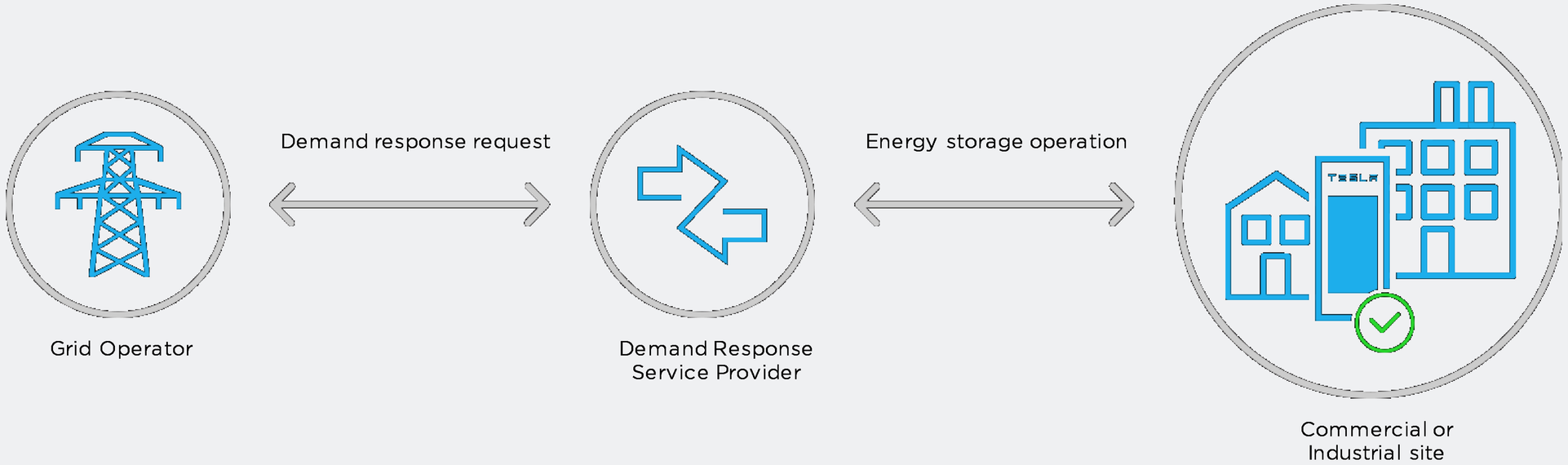
Reduce costs for energy and grid connection

Protect your business from future energy price increases

Drive sustainability and reduce CO_2 emissions

DEMAND RESPONSE PROGRAMS

Maximize revenues by using storage as an asset to help decongest the grid



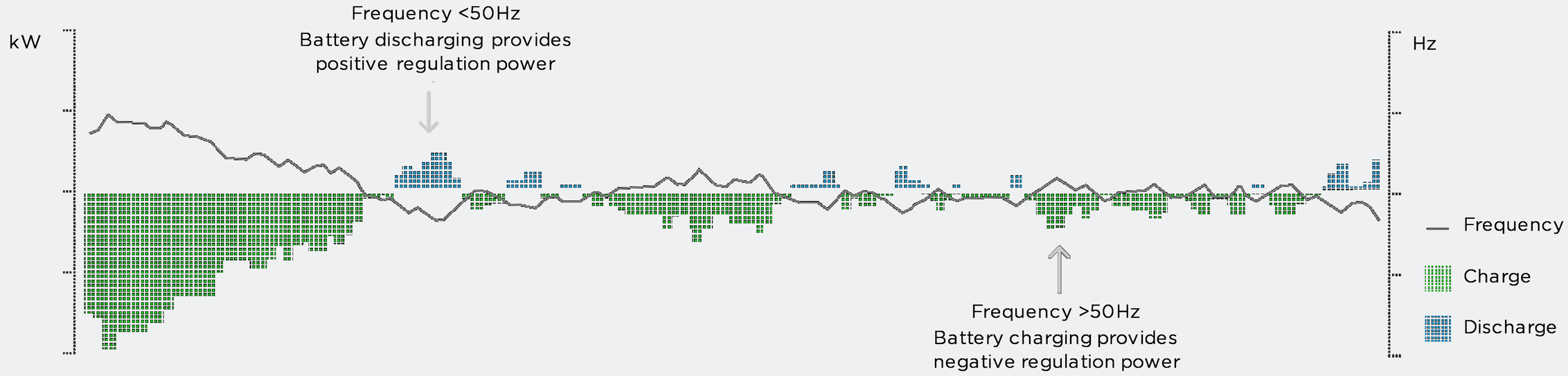
Generate revenue by participating in a demand response program

Support integration of solar on the grid

Improve grid stability

FREQUENCY/VOLTAGE GRID ANCILLARY SERVICES

Provide voltage support and participate in frequency regulation to help maintain a stable grid



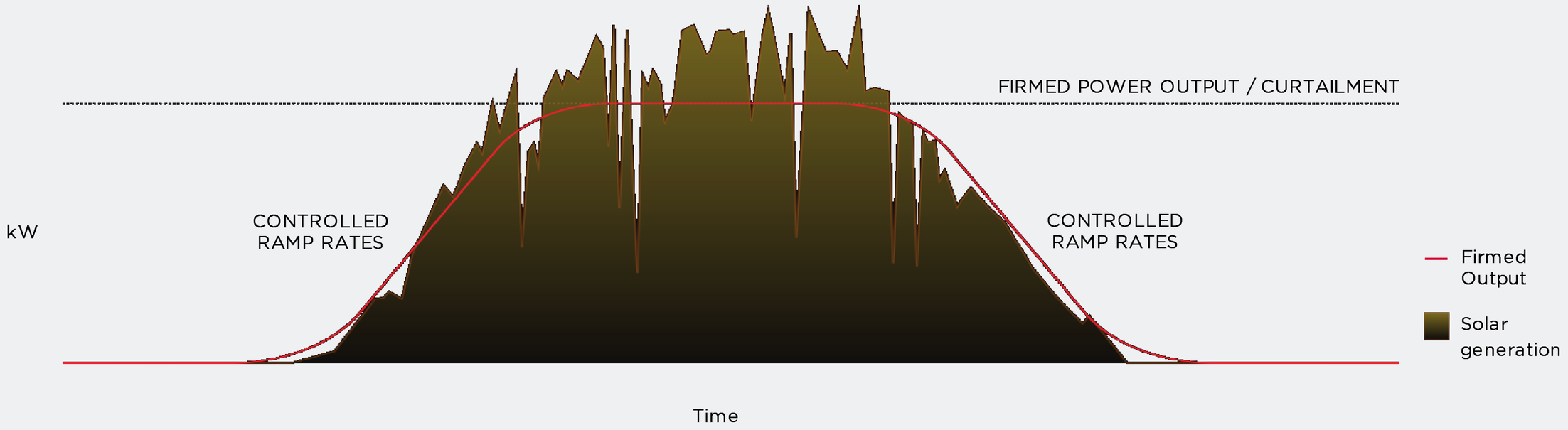
Provides reactive power control

Lowers risk of grid outage

Provides additional revenue stream

RENEWABLE POWER PRODUCTION FIRMING

Smooth out variability and increase certainty in renewable energy production

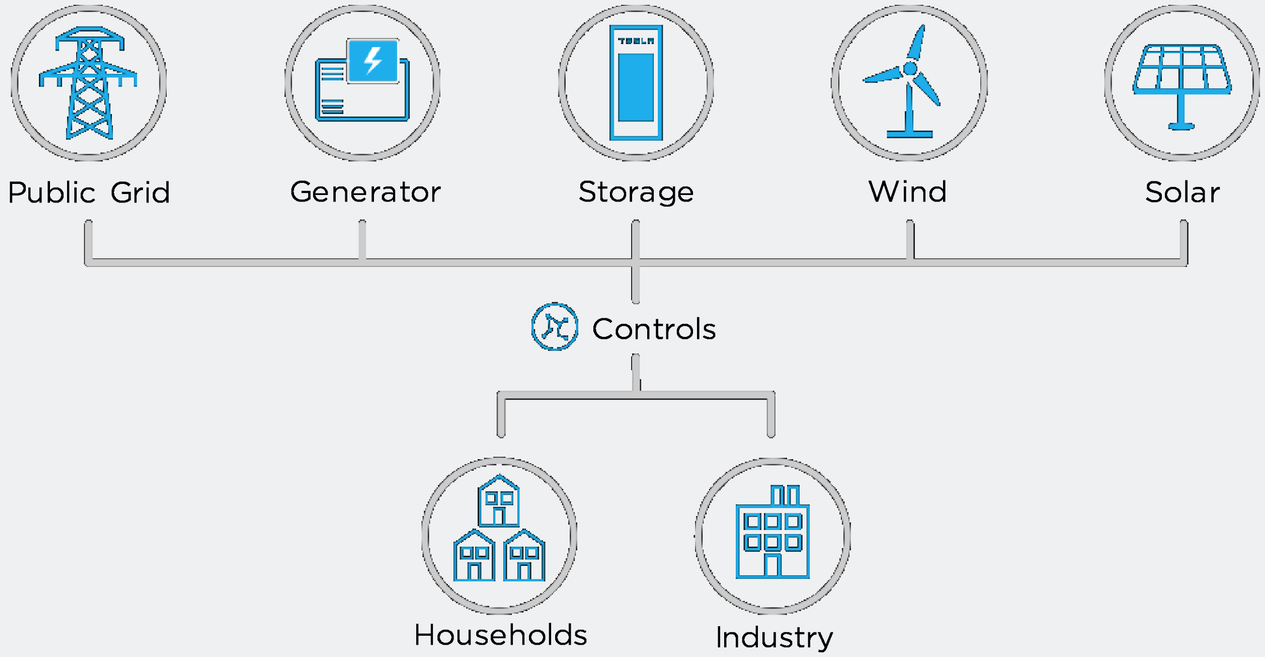


Controls ramp rates and smoothes generation profile

Enables continuous power despite fluctuations in power supply

Avoids renewable curtailment and increases energy output

MICROGRIDS
ENABLING FACILITIES TO ISLAND



Reduce energy costs and use of diesel for generation

Lower maintenance costs by reducing generator run hours

Protect against diesel supply constraints and price changes

ESS PRODUCT FEATURES, INSTALLATION, AND SAFETY

MEGAPACK

An all-in-one AC energy storage system for utility market optimized for cost and performance

MEGAPACK SPECIFICATIONS

	2 Hour	4 Hour
Rated AC Energy [kWh]	2,529	2,964.8
Rated AC Power [kW]	1,264.5	741.2
Round Trip Efficiency (at STC)	87.5%	90%
AC Power (kVA @ 480V) [Max]	Scalable up to 1540	Scalable up to 910
Maximum Mass (kgs / lbs)	21,500 / 47,400	23,500 / 51,800
Dimensions W x D x H (m / ft)	7.12m x 1.6m x 2.52m / 23’-5” x 5’-3” x 8’-3”	

MEGAPACK FEATURES

Each unit is fully assembled and tested at the Tesla Gigafactory and ships ready to install

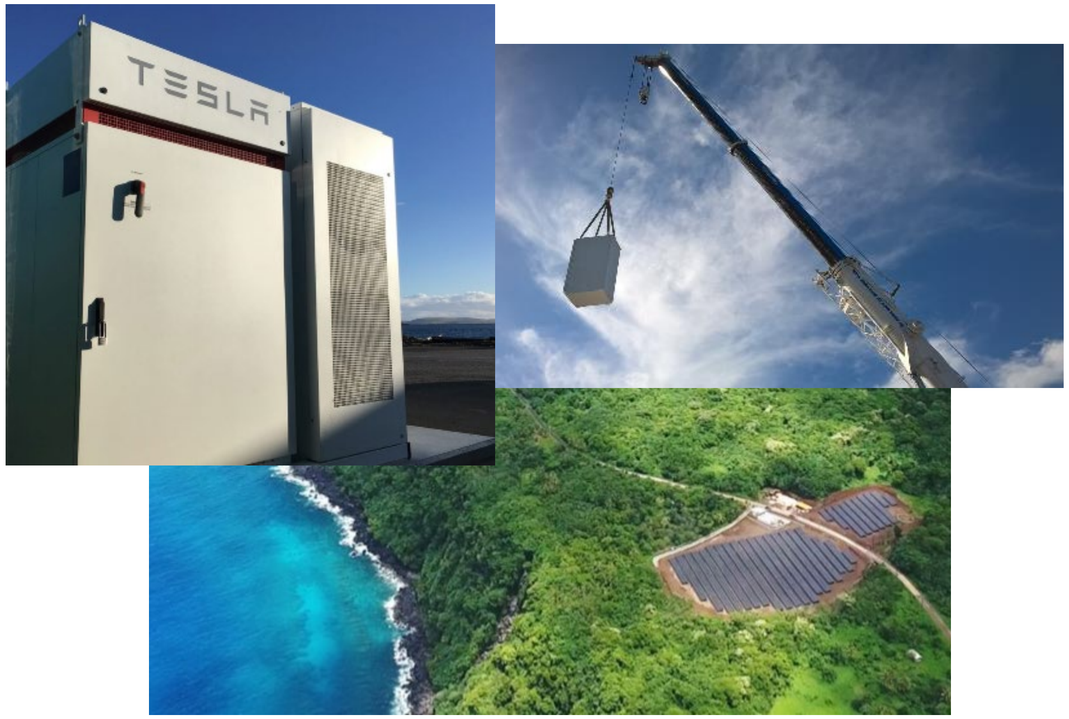
WHAT TO INSTALL WHERE

Utility-specific ESS products enable the lowest cost, highest density utility-scale projects.

- Megapack is cost optimized for projects sized >2MWh
- Megapack requires more space and bigger crane to install

C&I-sized ESS products are versatile and best suited for a whole range of locations and applications

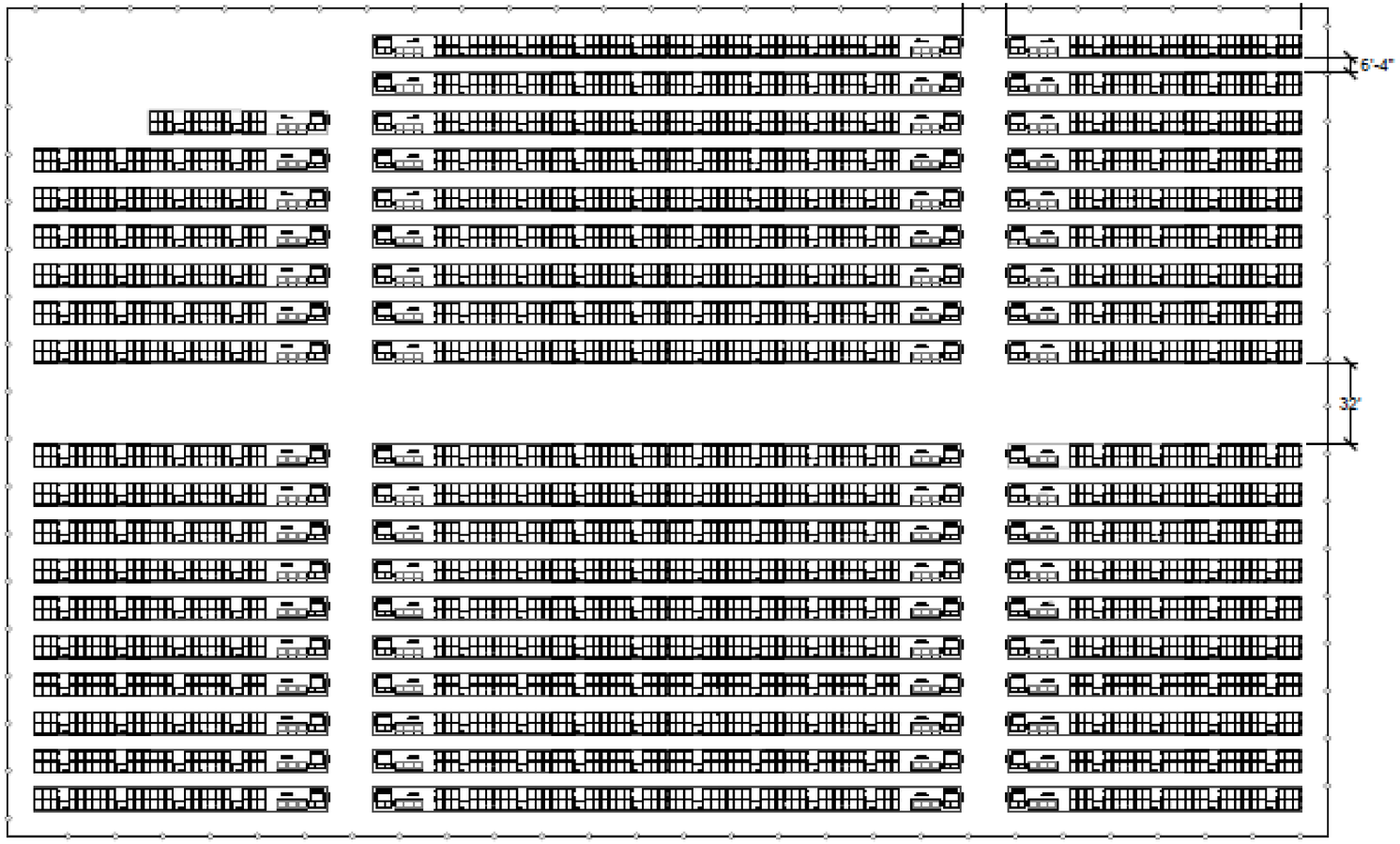
- Powerpack is generally less expensive than Megapack on an installed basis for projects <2MWh
- Powerpack's modularity makes it easier to transport and install in locations with difficult access



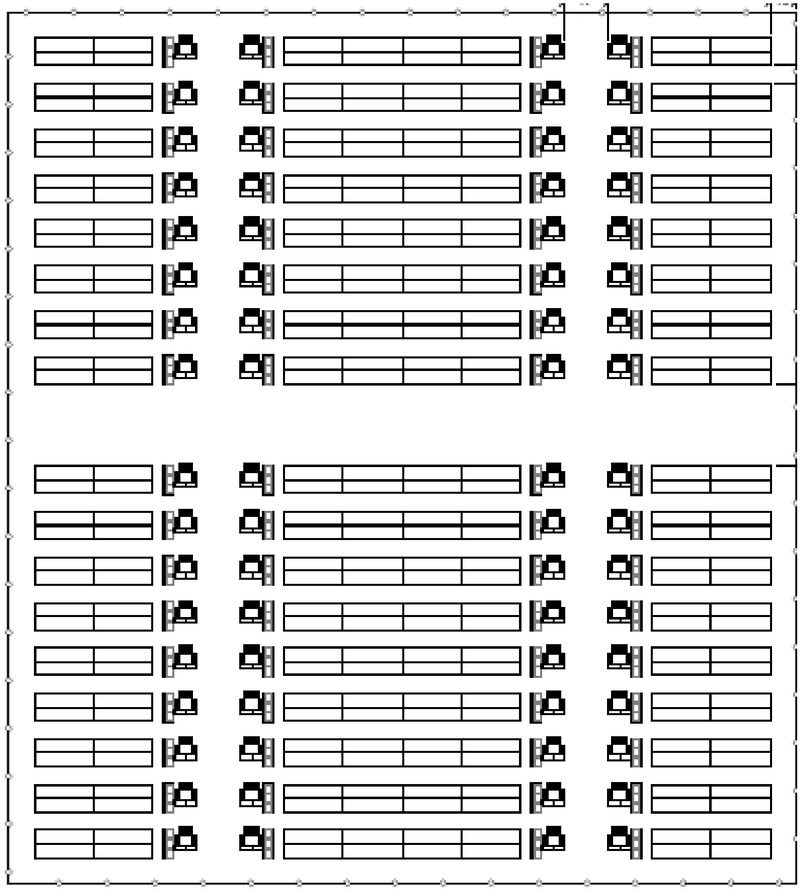
MEGAPACK VS POWERPACK ENERGY DENSITY

Megapack yields a 63% more energy density and requires >10x fewer enclosures vs Powerpack

Powerpack | 51 kWh/m^2

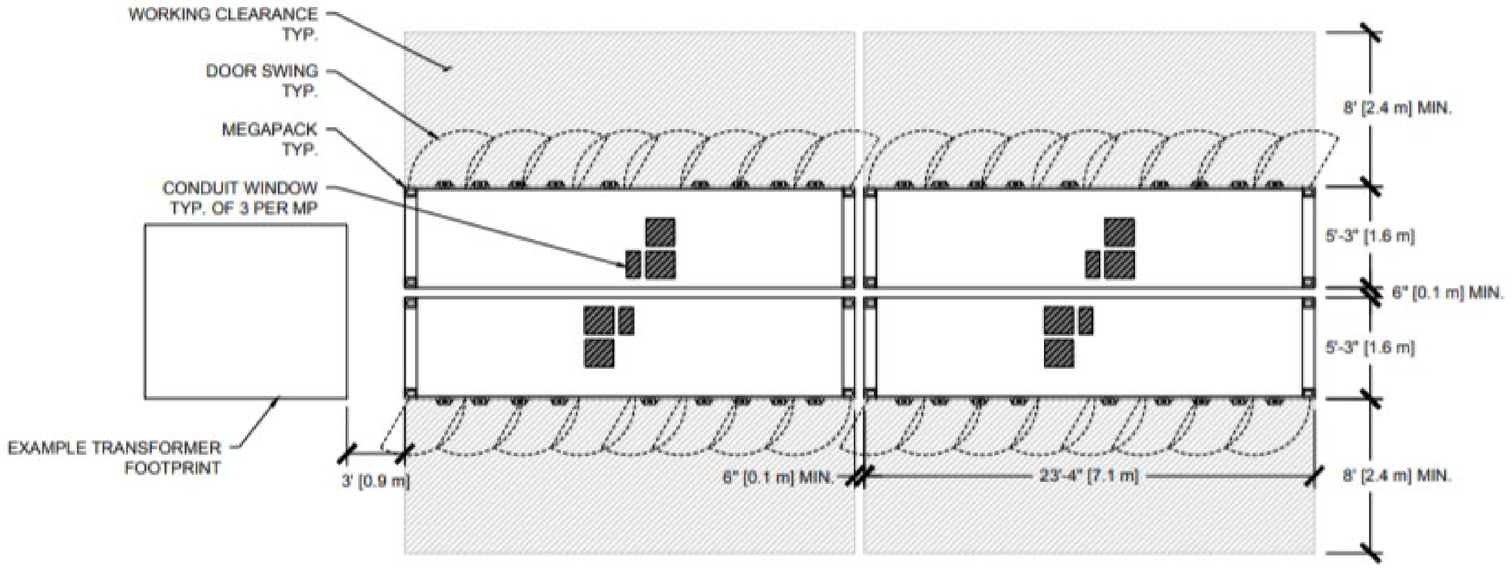


Megapack | 83 kWh/m^2



ESS INSTALLATION

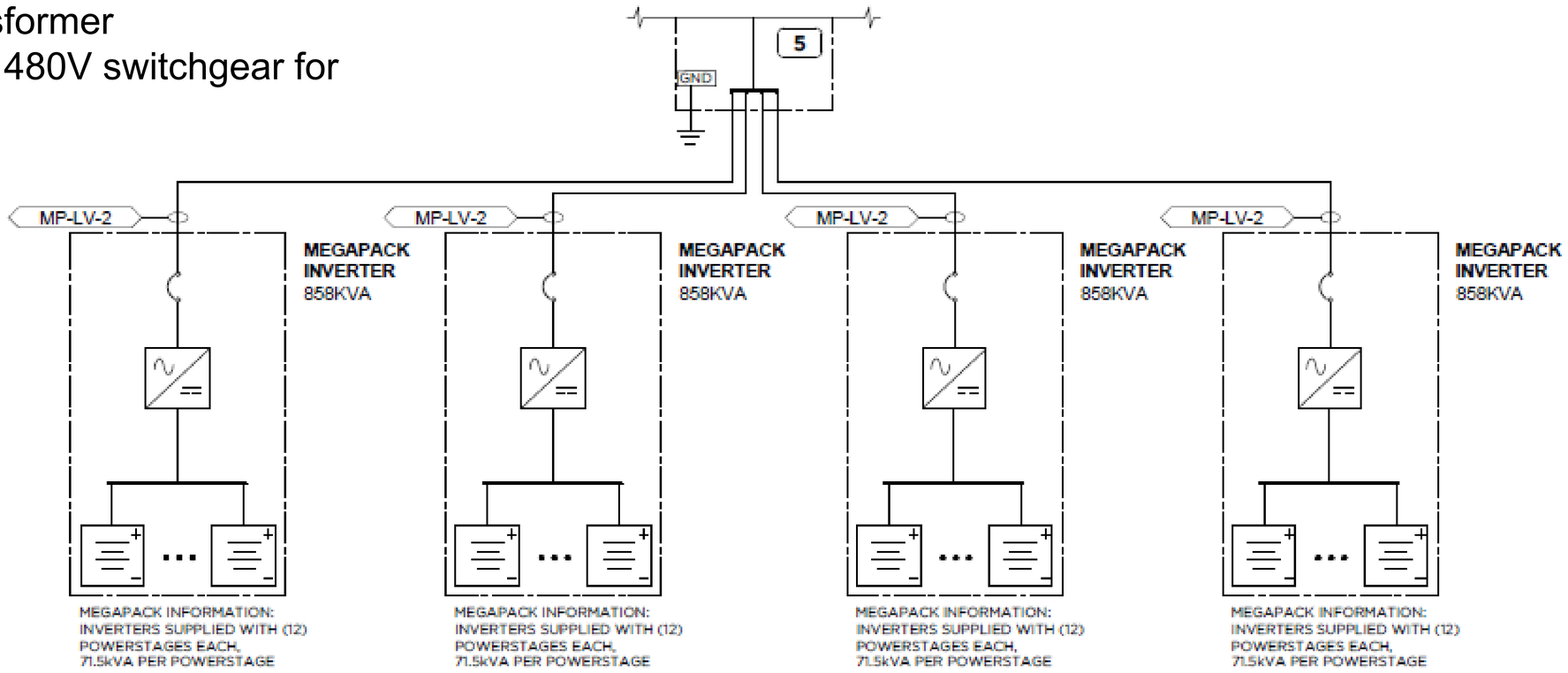
- Megapack is designed to be installed close together to improve on-site energy density
- Connects directly to a transformer, no additional switchgear required (AC breaker & included in ESS unit)
- All AC conduits run underground
- No DC connections required



Typical 4-Hour AC Transformer Block Layout

ESS INSTALLATION

- Typical ESS AC terminal voltage: 480V
- Connect directly to MV transformer
- Can also connect directly to 480V switchgear for smaller sites



TESLA MEGAPACK INVERTERS TO
3100/3450kVA TRANSFORMER
(4) INVERTER BLOCKS

BESS SAFETY STANDARDS

Product Functional Safety

- **UL 1642** – Standard for Lithium Batteries (**cell level certification**)
- **UL 1973** – Standard for Batteries for Use In Stationary Applications (**module level certification**)
- **UL 9540** – Standard for Energy Storage Systems and Equipment (**system level certification**)
- **UL 9540A** – Test Method for Evaluating Thermal Runaway Fire Propagation in Battery ESS → **NEW**
- **UL 1741** – Standard for Inverters, Controllers, Converters, and Interconnection Equipment for DER
- **UL 1998** – Standard for Software in Programmable Components
- **UL 991** – Standard for Tests for Safety-Related Controls Employing Solid-State Devices
- **IEC 62619** – Standard for Battery Safety in Stationary Applications
- + more

Electrical, Fire, and Safety Codes and Standards

For commercial applications: new code and standard requirements for ESS >20kWh

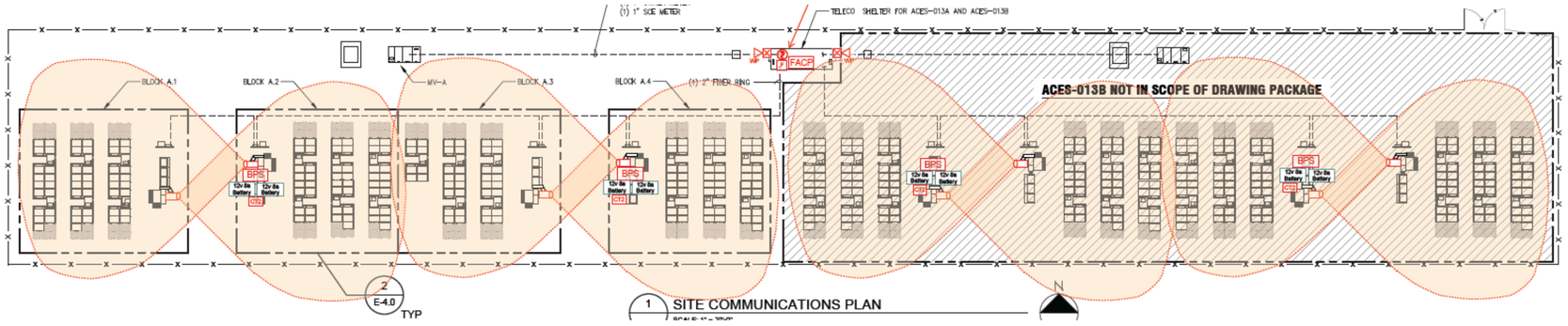
- **NFPA 855** – Standard for the Installation of Stationary Energy Storage Systems (2020) → location, separation, hazard detection, etc
- **NFPA 70** – NEC (2020), contains updated sections on batteries and energy storage systems
- **International Fire Code 2018 and 2021** – Dedicated sections on energy storage, language is harmonized with NFPA 855

SITE LEVEL CONSIDERATIONS

Code requirements:

- Large-scale fire testing and report may be required to meet exemptions in new codes and standards around:
  - Maximum allowable quantities (>600kWh)
  - Fire suppression sprinkler density
  - Size and separation of ESS
  - Means of egress

- IFC and NFPA language does not require detection or suppression for outdoor locations (except walk-in container ESS)
- Indoor locations require smoke detection / IR and fire suppression (water sprinkler)



Multispectrum IR Flame Detector

QUESTIONS?

Contact:
powerpack@tesla.com

Visit:
tesla.com/megapack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