The importance of Future-Proofing ESS investments

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4th International
Hybrid Power Systems Workshop

22 - 23 May 2019
Crete, Greece

- Wartsila Energy Storage Solutions
- Futureproofing and Bankability
- Flexible Performance Guarantee Designed for Trading with Case Study from USA

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Greensmith Energy
A Wärtsilä Company

Wärtsilä

- Leading systems integrator for ultra-flexible internal combustion engine based power plants, solar PV and LNG. 67 GW deployed in 177 countries

- Global EPC & service capabilities

- Highly experienced in electrically-islanded systems

- A Hybrid Future Realized—Unprecedented capabilities to integrate and manage engines, solar and wind plus storage
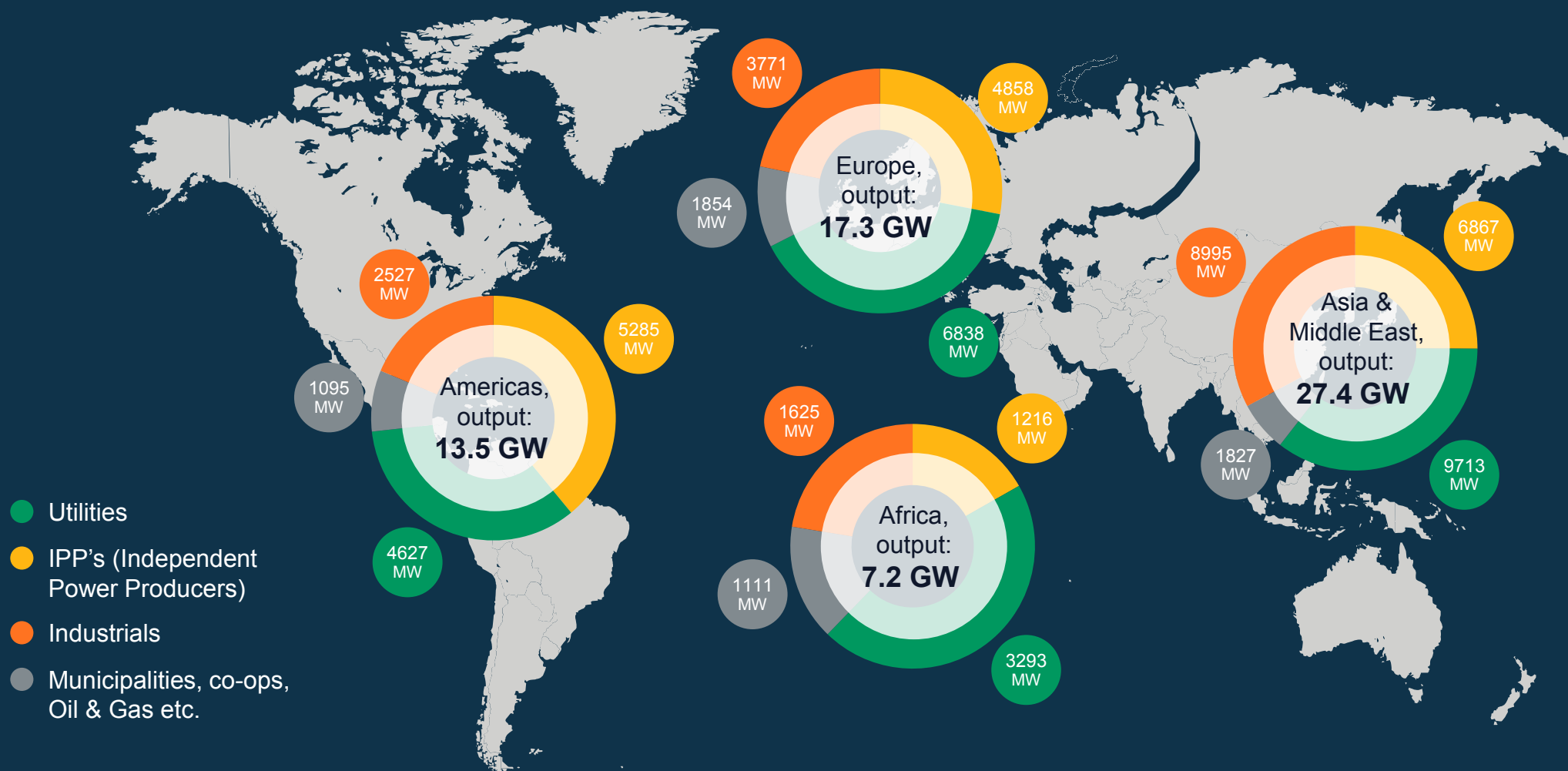
Greensmith

- Established energy storage leader since 2008 – unparalleled experience

- Over 80 storage – 300MWh+ systems deployed globally

- Leading energy storage software platform for building, monitoring and operating energy storage systems.

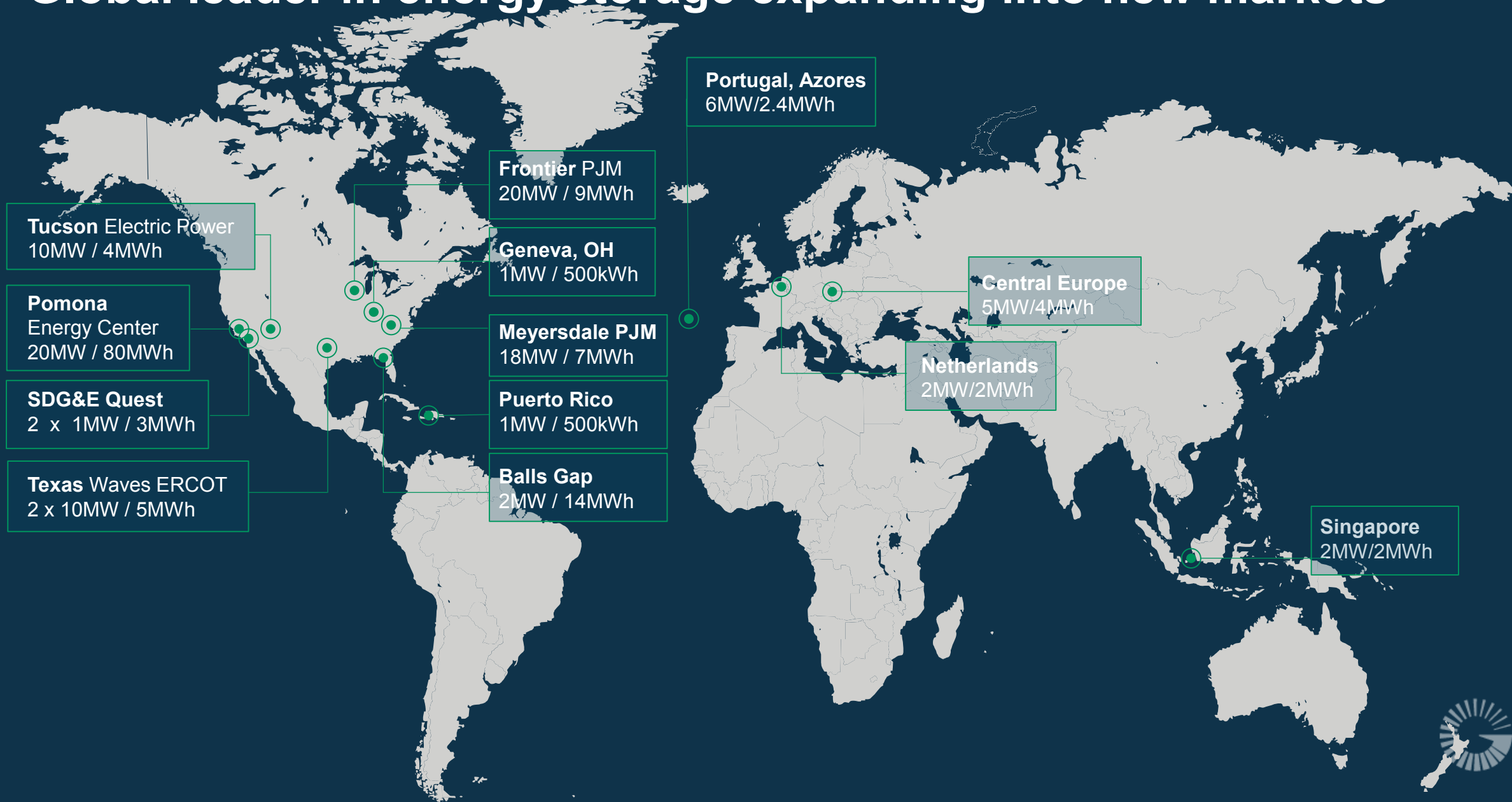- Technology neutral for best in class and future-proofing

Installed power plant capacity

67 GW in 177 countries around the world

Europe, output: **17.3 GW**
- 3771 MW
- 4858 MW
- 1854 MW
- 6838 MW

Americas, output: **13.5 GW**
- 2527 MW
- 5285 MW
- 1095 MW
- 4627 MW

Africa, output: **7.2 GW**
- 1625 MW
- 1216 MW
- 1111 MW
- 3293 MW

Asia & Middle East, output: **27.4 GW**
- 8995 MW
- 6867 MW
- 1827 MW
- 9713 MW

Legend:
- Utilities
- IPP's (Independent Power Producers)
- Industrials
- Municipalities, co-ops, Oil & Gas etc.

Global leader in energy storage expanding into new markets

Portugal, Azores
6MW/2.4MWh

Frontier PJM
20MW / 9MWh

Tucson Electric Power
10MW / 4MWh

Geneva, OH
1MW / 500kWh

Central Europe
5MW/4MWh

Pomona
Energy Center
20MW / 80MWh

Meyersdale PJM
18MW / 7MWh

Netherlands
2MW/2MWh

SDG&E Quest
2 x 1MW / 3MWh

Puerto Rico
1MW / 500kWh

Texas Waves ERCOT
2 x 10MW / 5MWh

Balls Gap
2MW / 14MWh

Singapore
2MW/2MWh

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Why Future-Proof?

Track record of ESS is short

- Median grid-scale ESS is <5 years old
- Only 14 grid-scale ESS globally have operating history of >10 years
- Multiple OEMs filed for bankruptcy
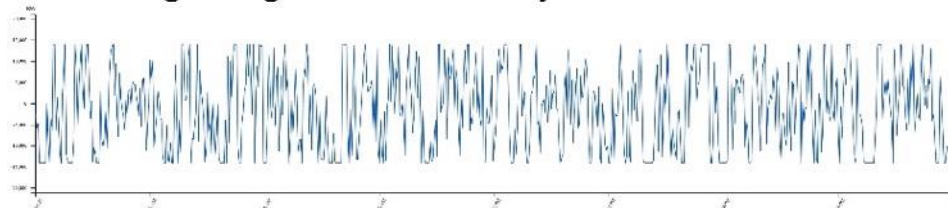- Recent fires at battery sites
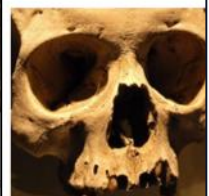
Market revenues are uncertain

- Many storage revenues are paid via short-term contracts/merchant markets
- In 2017 PJM changed Reg D signal, doubling intensity of signal
- In 2018 FFR contract prices collapsed
- In 2018 CM market revenues suspended

PJM's 2017 signal change increased ESS energy throughput by over 50% and changed the energy neutrality condition from 15 minutes to 30 minutes

WÄRTSILÄ

GEMS
ready for tomorrow

fu·ture-proof

BRITISH

verb
gerund or present participle: **future-proofing**

make (a product or system) future-proof.
"this approach allows you to future-proof your applications"

- Leveraging software-based intelligence, enabling modifications as applications and conditions evolve

- Ability to integrate any battery technology – technology agnostic flexible platform

Ability to develop new applications, update rules of existing applications, and optimize revenue streams across multiple applications while still complying with warranty requirements – ability to do all these remotely
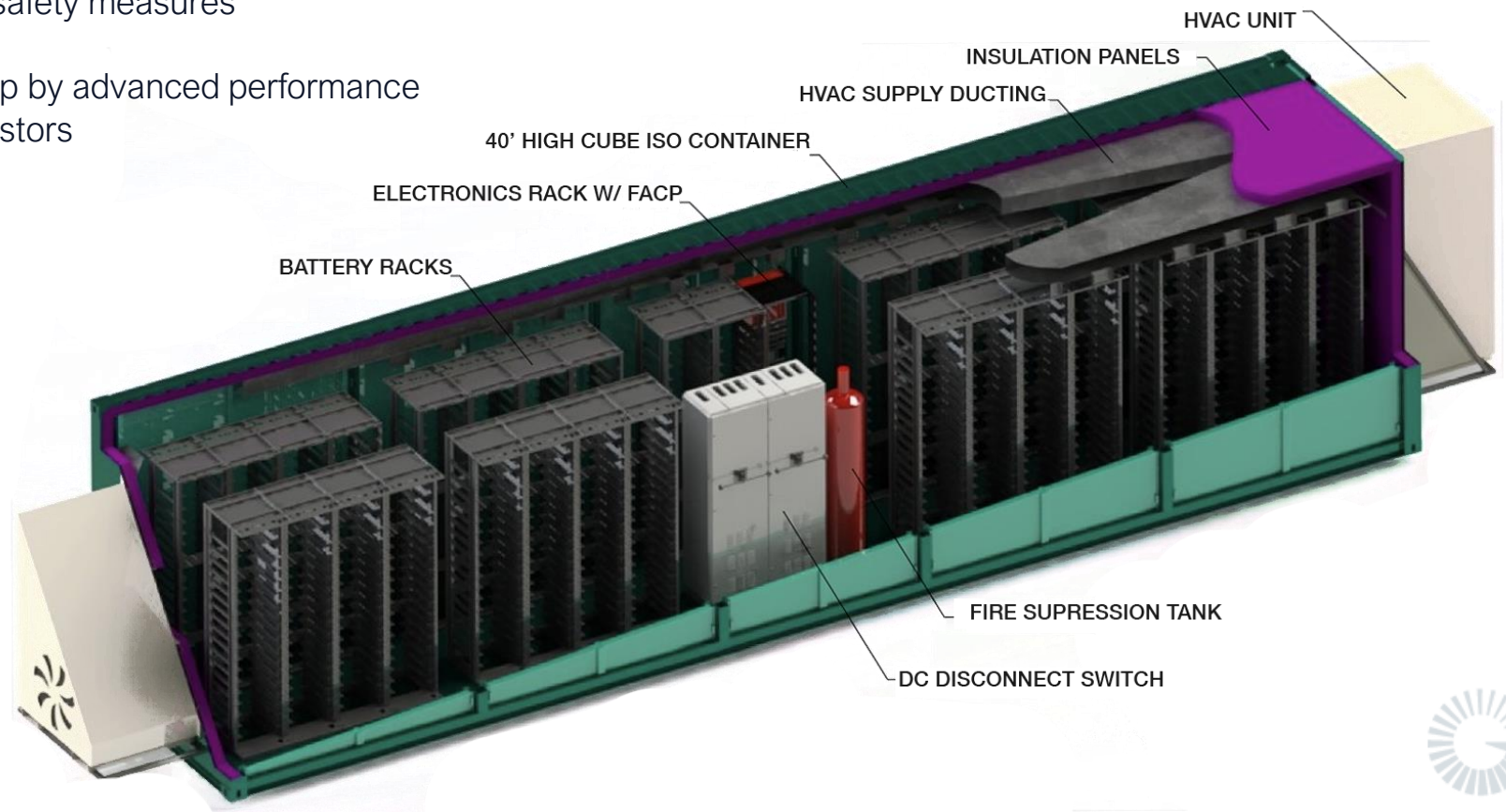
Warranty management of multiple battery technologies based on various applications

System balancing by individually controlling each inverter through VPP SW approach even if all the inverters don't have equal energy capacity

Start with strong foundations…

- Our standardized fully integrated container design adequately protects hardware assets

- GEMS ensures system safety with deep integration and monitoring of different hardware assets and additional safety measures

- Wärtsilä's strong balance sheet backed up by advanced performance guarantees provides full wrap for the investors

HVAC UNIT
INSULATION PANELS
HVAC SUPPLY DUCTING
40' HIGH CUBE ISO CONTAINER
ELECTRONICS RACK W/ FACP
BATTERY RACKS
FIRE SUPRESSION TANK
DC DISCONNECT SWITCH
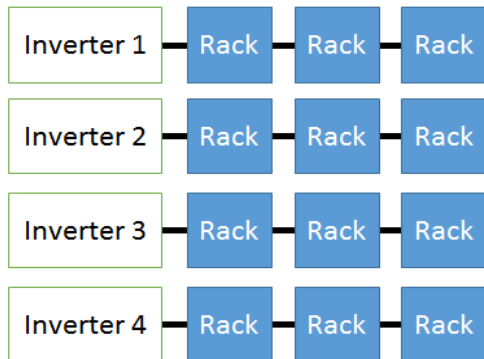
How to Future Proof?
Strategy 1: design for flexibility

- ## Inverter-based augmentation

  - **Futureproofs from technology risk**

  - **Enables capacity increase with minimal cost**

  - **Requires planning in original site layout, wiring, battery warranty**

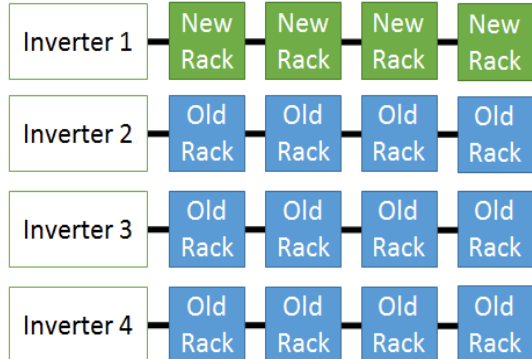 - **Requires EMS able to optimize strings of different vintage battery**
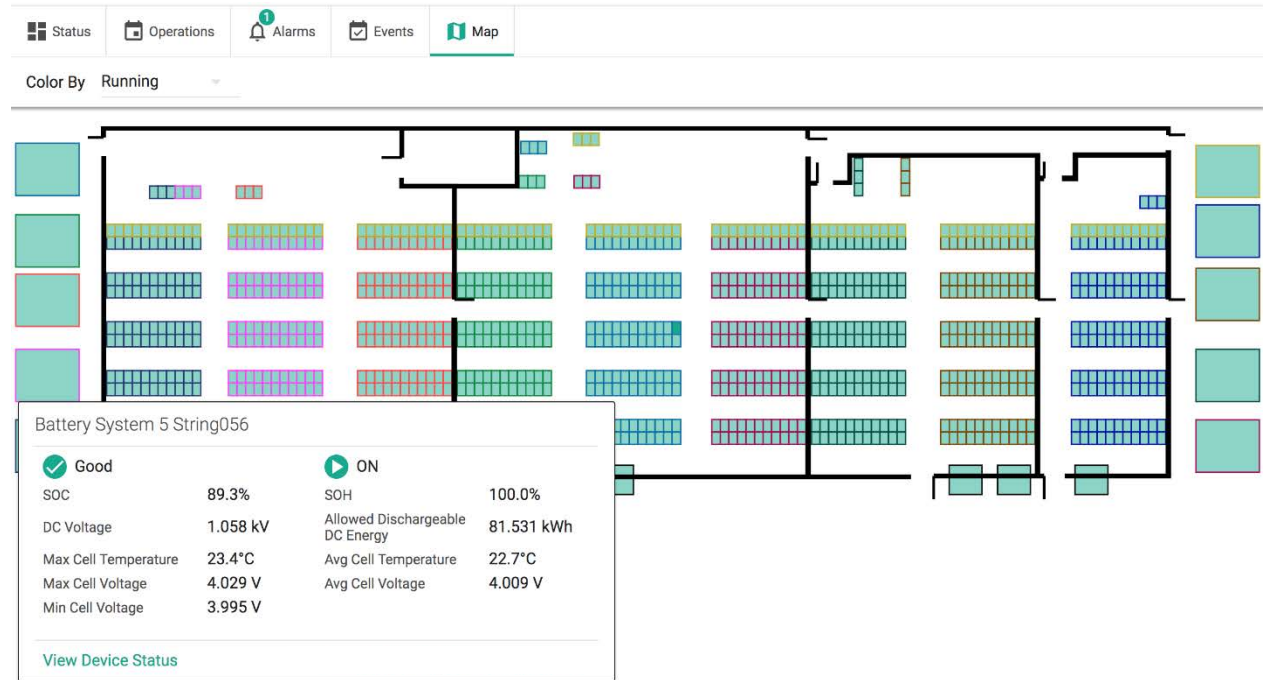
GEMS view of system layout, color coded to indicate battery augmentation plan
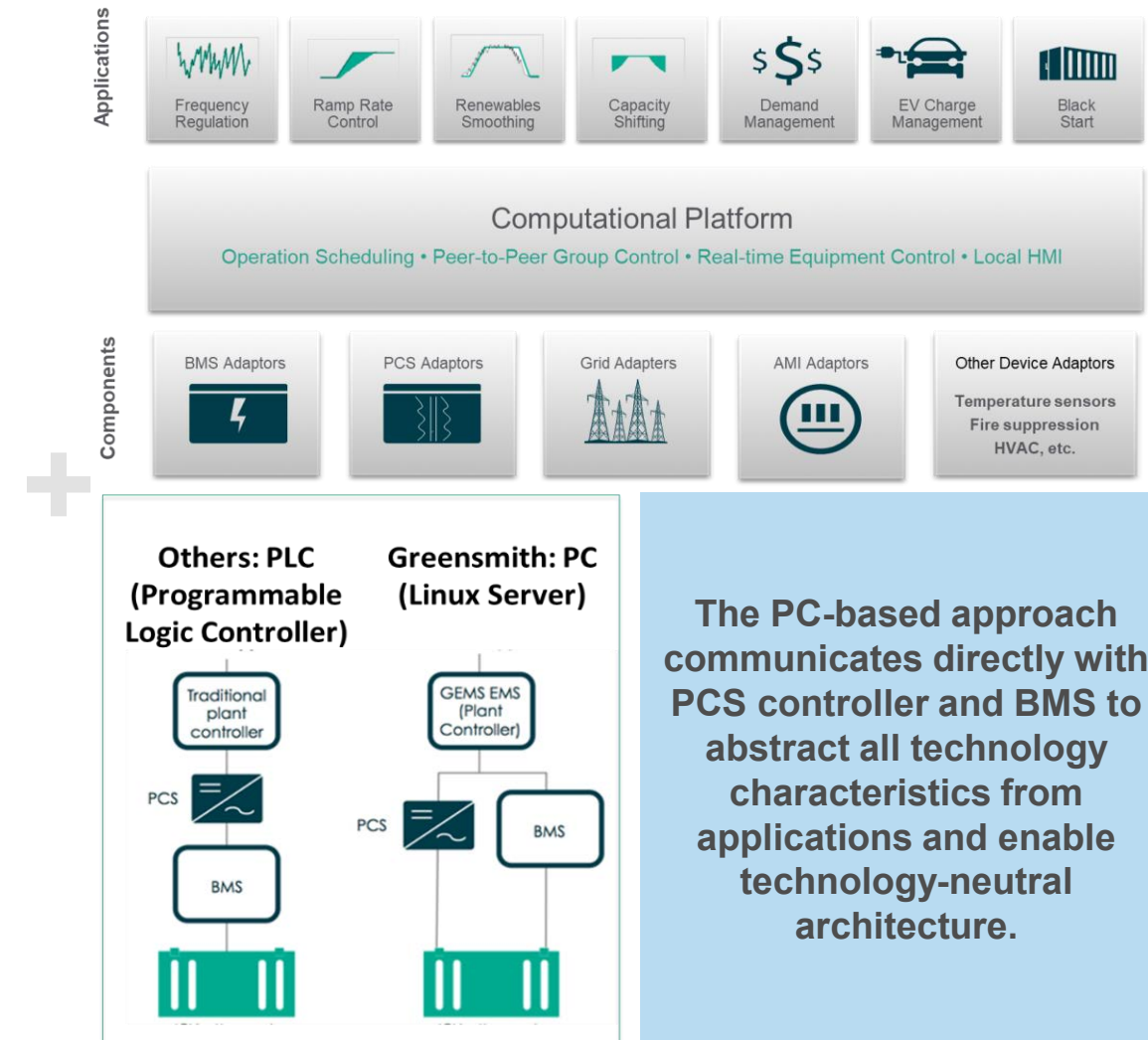
Original Installation

Inverter 1	Rack	Rack	Rack
Inverter 2	Rack	Rack	Rack
Inverter 3	Rack	Rack	Rack
Inverter 4	Rack	Rack	Rack

Inverter-based augmentation

Inverter 1	New Rack	New Rack	New Rack	New Rack
Inverter 2	Old Rack	Old Rack	Old Rack	Old Rack
Inverter 3	Old Rack	Old Rack	Old Rack	Old Rack
Inverter 4	Old Rack	Old Rack	Old Rack	Old Rack

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How to Future Proof?
Strategy 2: use flexible architecture

- ## PLC
    - **Designed for assembly manufacturing**
    - **"Hard coded" with limited inputs, outputs**
    - **Modification possible with significant time and effort**

- ## PC
    - **Open source & secure software stack**
    - **Flexible across technology and use case**
    - **Easy modification with remote download**

- ## PC-based architecture enables:
    1. **Repurposing of existing ESS assets**
    2. **Revenue stacking and multiple operations**
    3. **Co-optimization of hybrid assets**
    4. **Flexible battery augmentation plans**

The PC-based approach communicates directly with PCS controller and BMS to abstract all technology characteristics from applications and enable technology-neutral architecture.

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How to Future Proof?
Strategy 3: track ongoing operation with flexible warranty

- Battery warranties are complex
  - Annual energy throughput
  - Peak DC charge/discharge rate
  - Daily average DC charge/discharge rate
  - Average daily temperature
  - Maximum temperature deviation across measurement points
  - Common mode noise level (voltage)
  - Common mode noise level (current)

- BMS does not track!

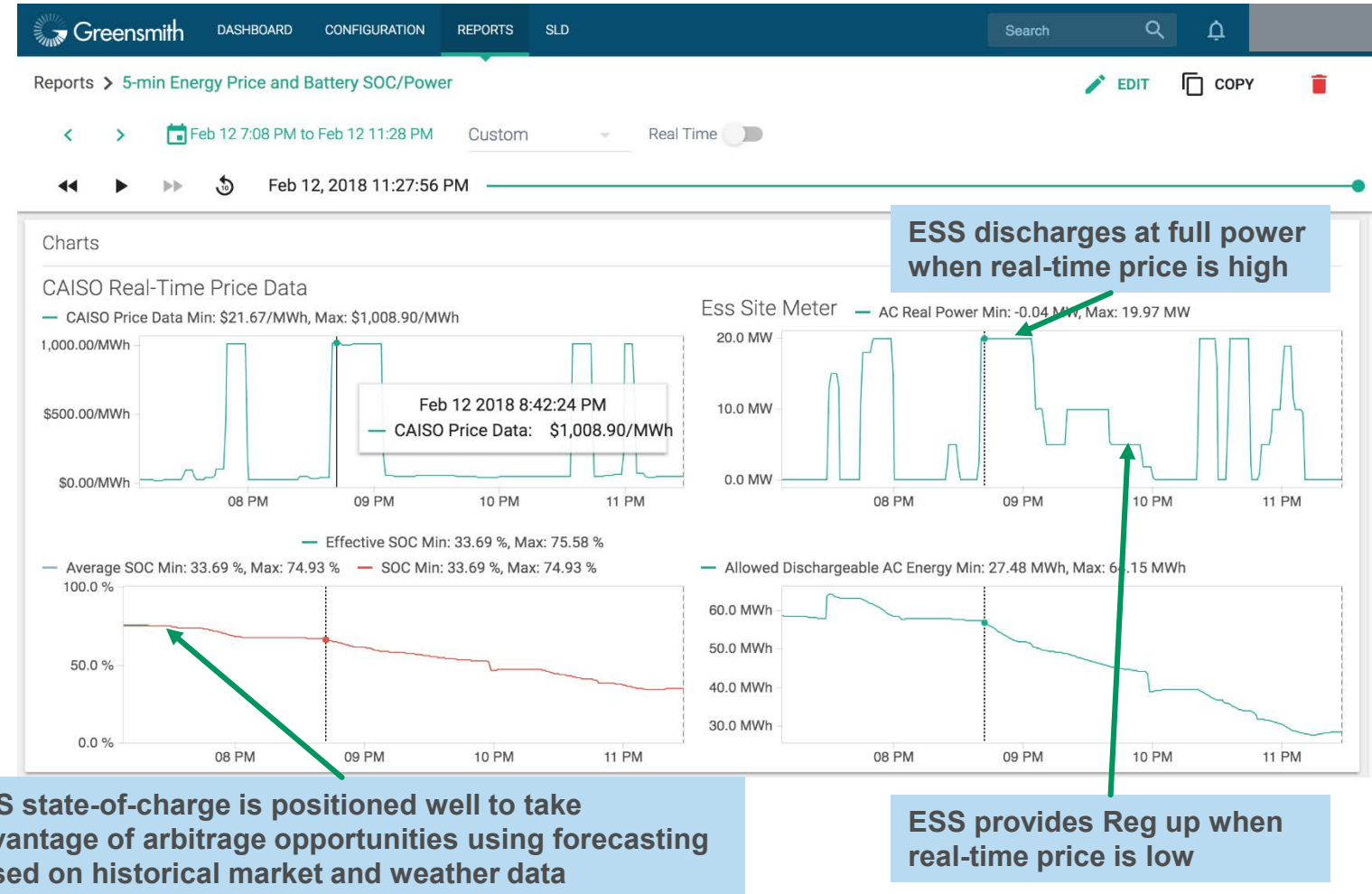- GEMS tracks all values and provides analytics for on-going plant optimization
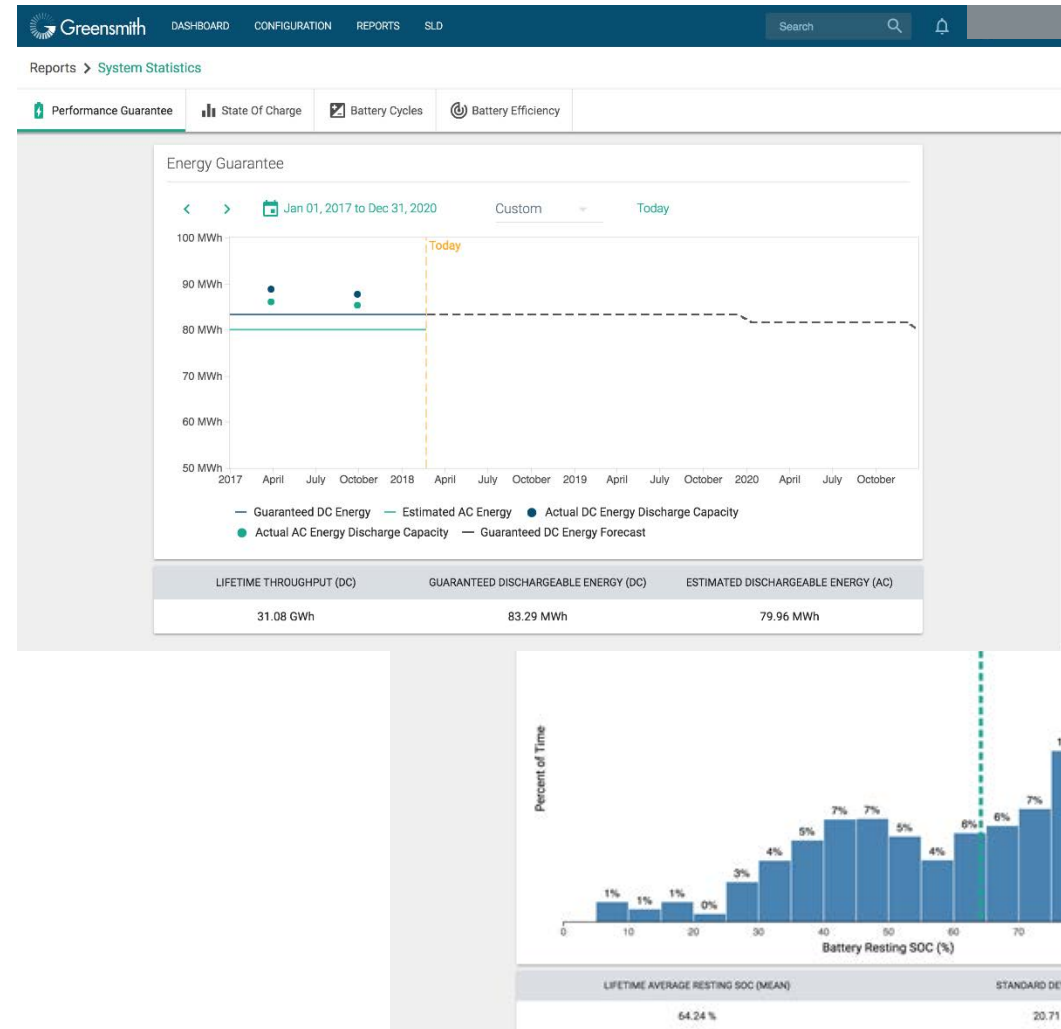
Stacked Benefits ESS Optimization
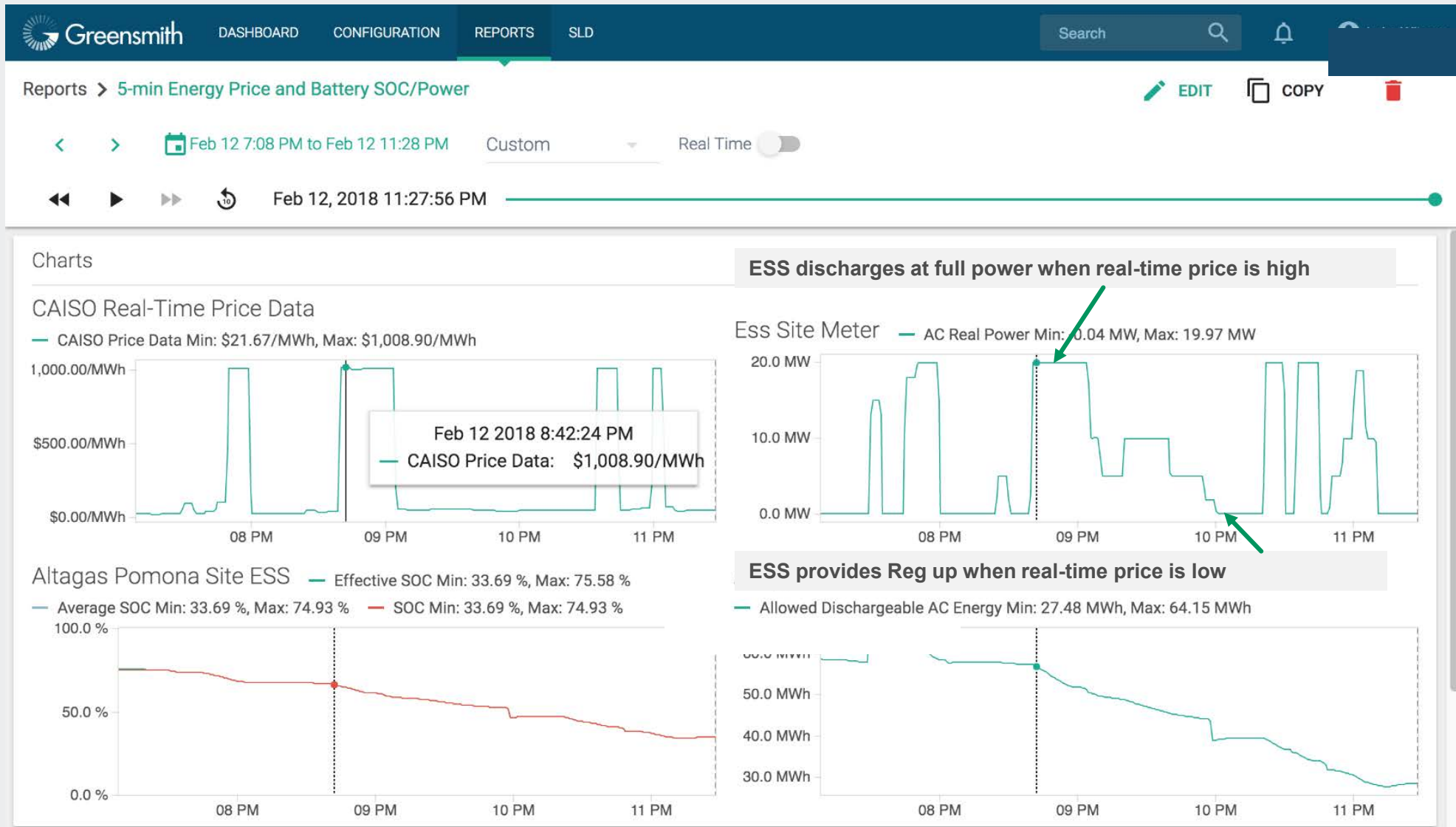
Multiple revenue streams leveraged through the same system

- CAISO real time price can be as much as $1000/MWh **(20MW x $1000/MWh = $20000/hour revenue stream)**

- CAISO Ancillary Services Reg up and down can provide consistent revenue stream

- CAISO RA market provides long-term contracted revenue stream and is dispatched infrequently

- Operational Logic:
  - **Bid-in 5mins CAISO Ancillary Services Reg up and down markets**
  - **Arbitrage in California ISO real time market when prices warrant**
  - **Be ready to be dispatched for RA market when called on**

ESS discharges at full power when real-time price is high

ESS provides Reg up when real-time price is low

ESS state-of-charge is positioned well to take advantage of arbitrage opportunities using forecasting based on historical market and weather data

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# Flexible Performance Guarantee for Trading

Flexible Parameters

- Rest SOC
- Centre SOC
- Energy Throughput
- Temperature

Fixed Parameter

- Charge C-rate
- Discharge C-rate
- Depth of Discharge

– – – = Predefined capacity guaranteed <u>for reference</u> (MWh)

——— = Lower than planned utilization of batteries (MWh)

● = Contractual guarantee at the end of the year (MWh)

——— = Higher than planned utilization of batteries (MWh)

● = Contractual guarantee at the end of the year (MWh)

- - - = Future utilization of batteries (MWh)

○ = Typically void situation with <u>traditional guarantee</u> (MWh)
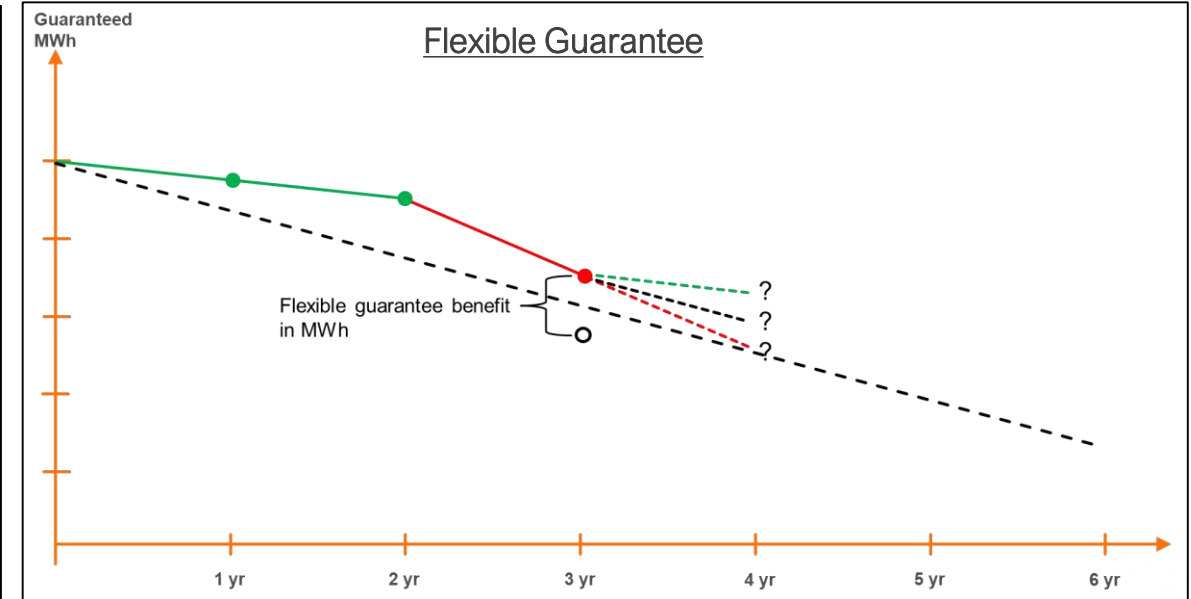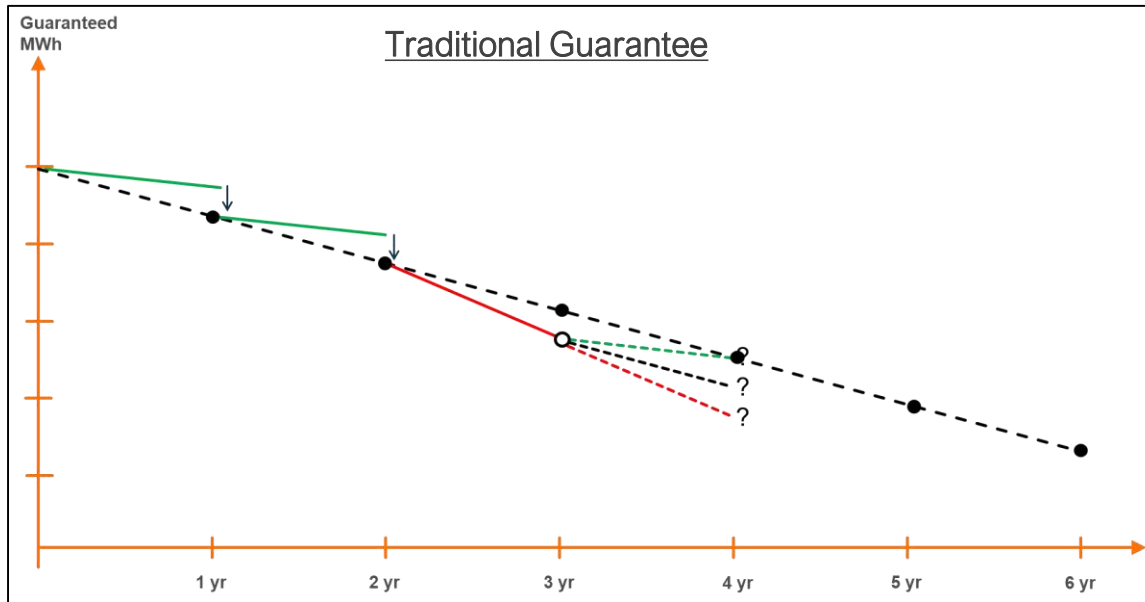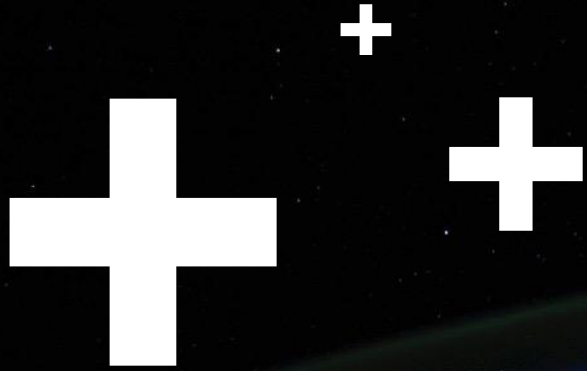
THE NEW EVERYDAY ENERGY

RENEWABLES**+**GENERATION**+**STORAGE**=**

REQUIRES LIMITLESS FLEXIBILITY