



The importance of Future-Proofing ESS investments

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Agenda



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



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Introduction

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

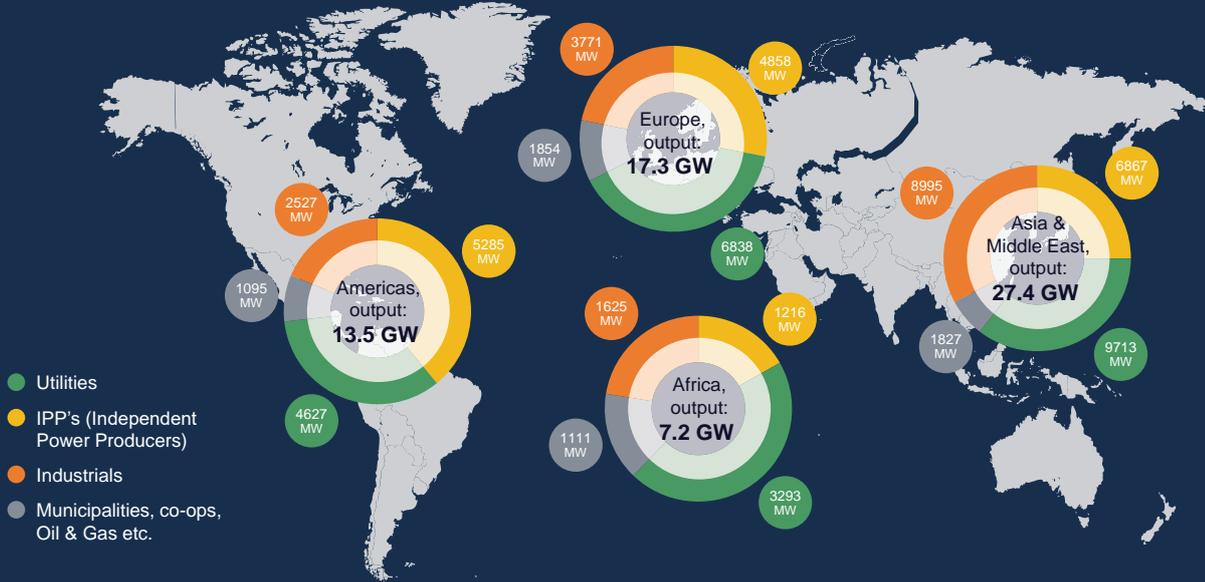


This is Wärtsilä



Installed power plant capacity

67 GW in 177 countries around the world



Energy Storage Installations



Global leader in energy storage expanding into new markets



- Wartsila Energy Storage Overview
- Futureproofing and Bankability
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Future-Proofing

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



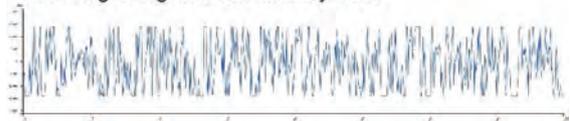
Market revenues are uncertain

- 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 Reg D Signal Pre-January 2017



PJM Reg D Signal Post-January 2017



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



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

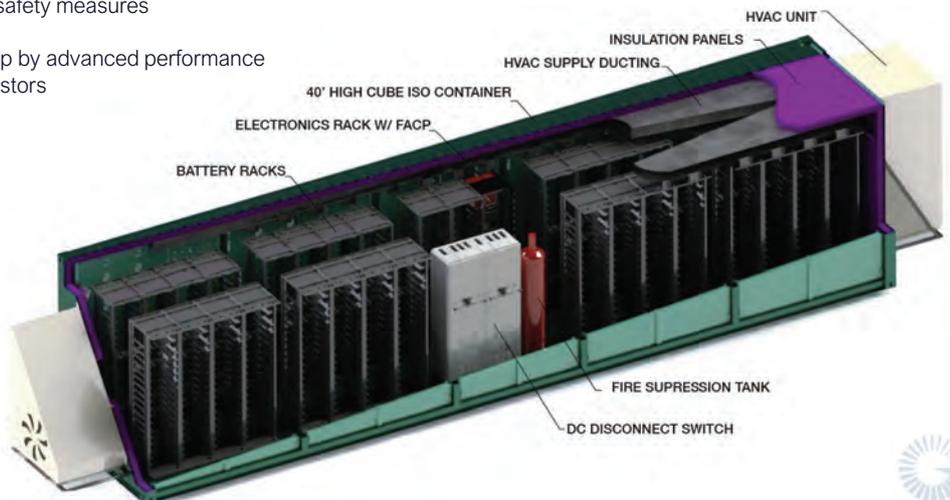
Warranty management of multiple battery technologies based on various applications

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...

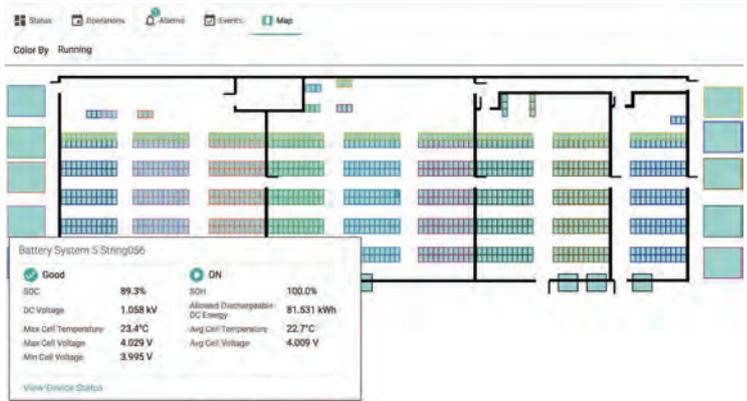
- Our standardized fully integrated container design adequately protects hardware assets
- GEMS ensures system safety with deep integration and monitoring of different hardware assets and additional safety measures
- Wärtsilä's strong balance sheet backed up by advanced performance guarantees provides full wrap for the investors



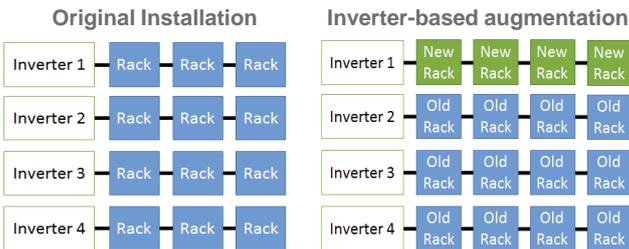
FUTURE-PROOFING ENERGY STORAGE

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



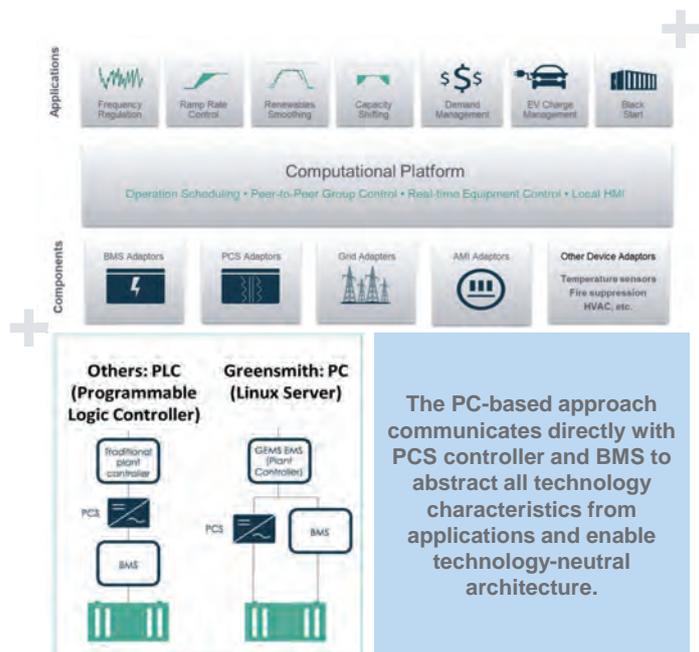
GEMS view of system layout, color coded to indicate battery augmentation plan



FUTURE-PROOFING ENERGY STORAGE

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



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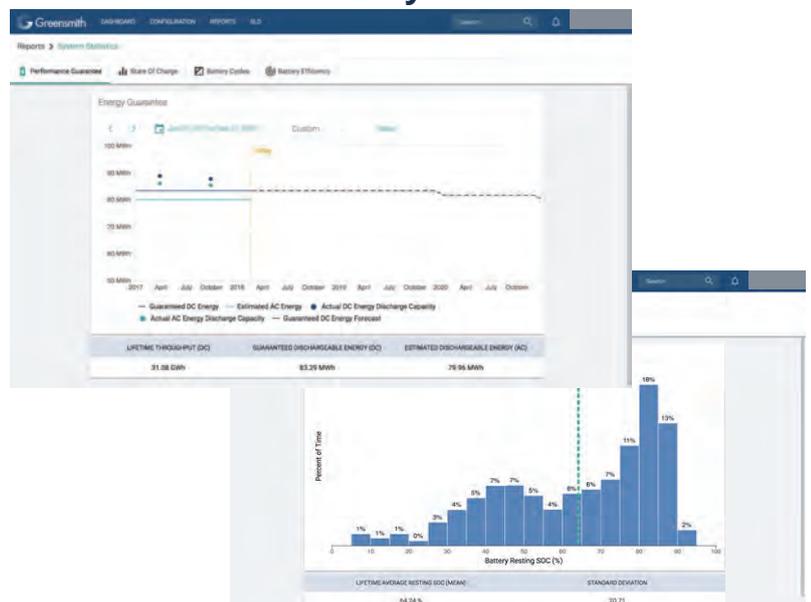


FUTURE-PROOFING ENERGY STORAGE

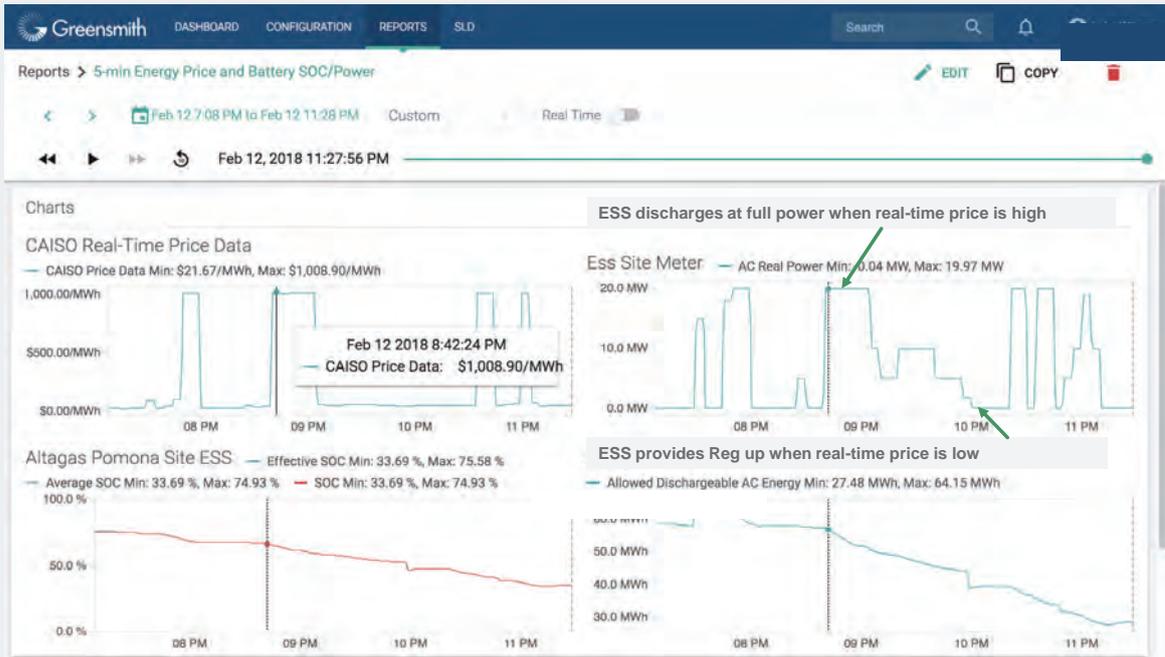
How to Future Proof?

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

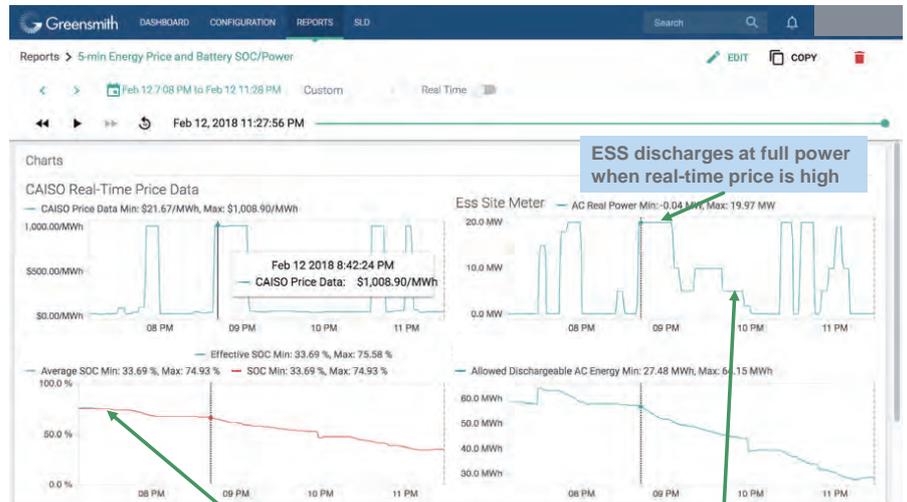


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FUTURE-PROOFING ENERGY STORAGE

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



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Flexible Performance Guarantee

Flexible Performance Guarantee for Trading

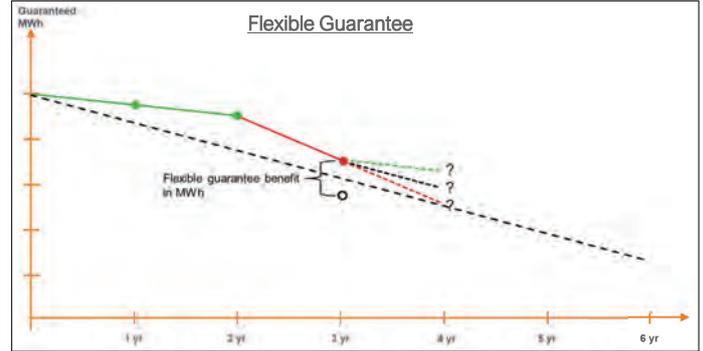
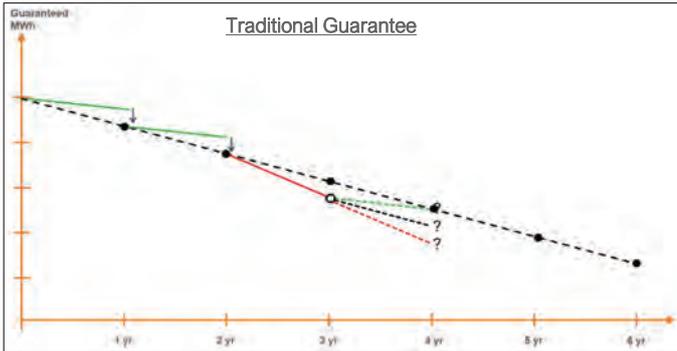
Flexible Parameters

- Rest SOC
- Centre SOC
- Energy Throughput
- Temperature

Fixed Parameter

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

- = Predefined capacity guaranteed for reference (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 traditional guarantee (MWh)



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