Intelligent Integration of Energy Storage Systems in the South Pacific Region

Pacific Power Association Conference 2018
Koror | Palau
July/August 2018

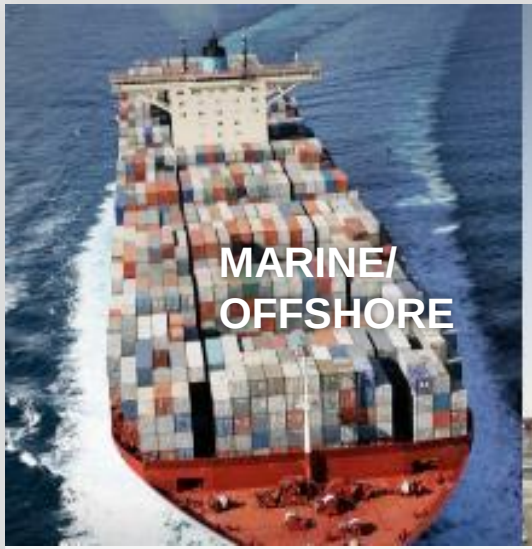
Wilhelm van Butselaar | Area Manager Energy Storage & Integration

Wärtsilä Singapore Pte Ltd

Greensmith
A WÄRTSILÄ COMPANY
ENERGY OPTIMIZED

REMEMBER?

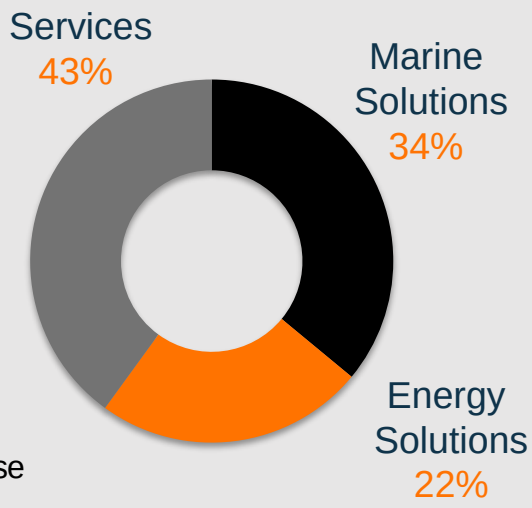
WÄRTSILÄ CORPORATION - INTRODUCTION



SERVICES

SOLUTIONS FOR

Net sales by business 2017



Listed in Helsinki

4,9 billion € turnover

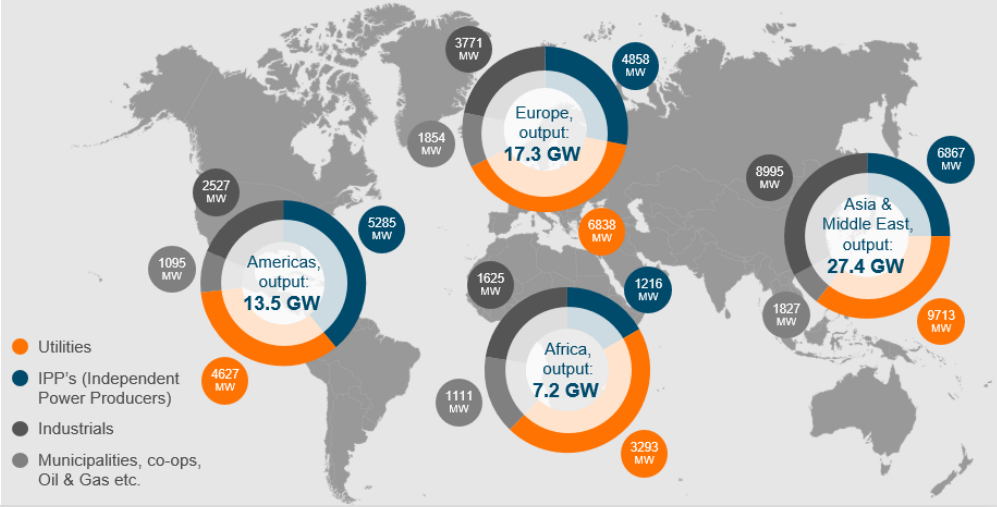
2,6% or 136M€ in R&D

27,400 MW Installed Base in Asia & Middles East

WÄRTSILÄ POWERING THE WORLD

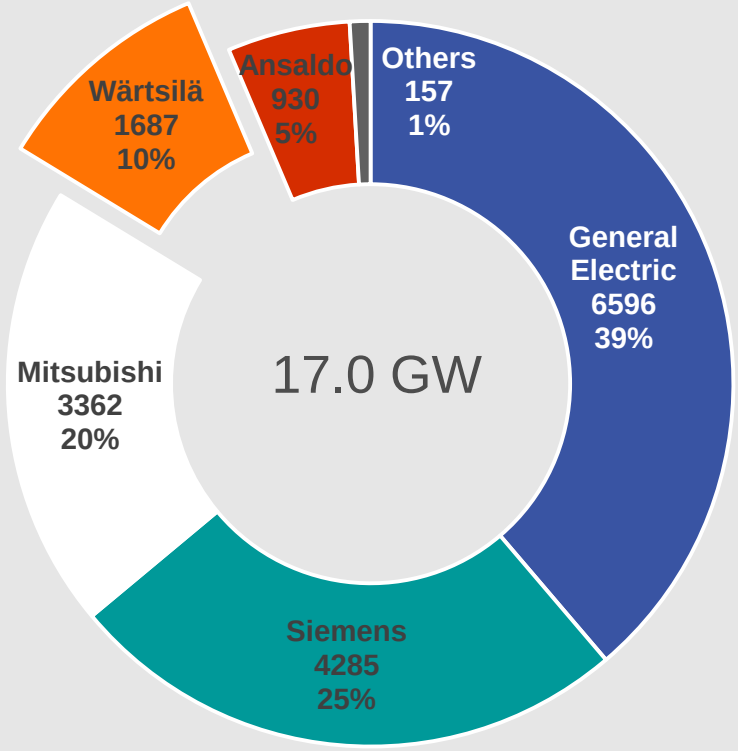
Installed power plant capacity

65 GW in **177** countries around the world

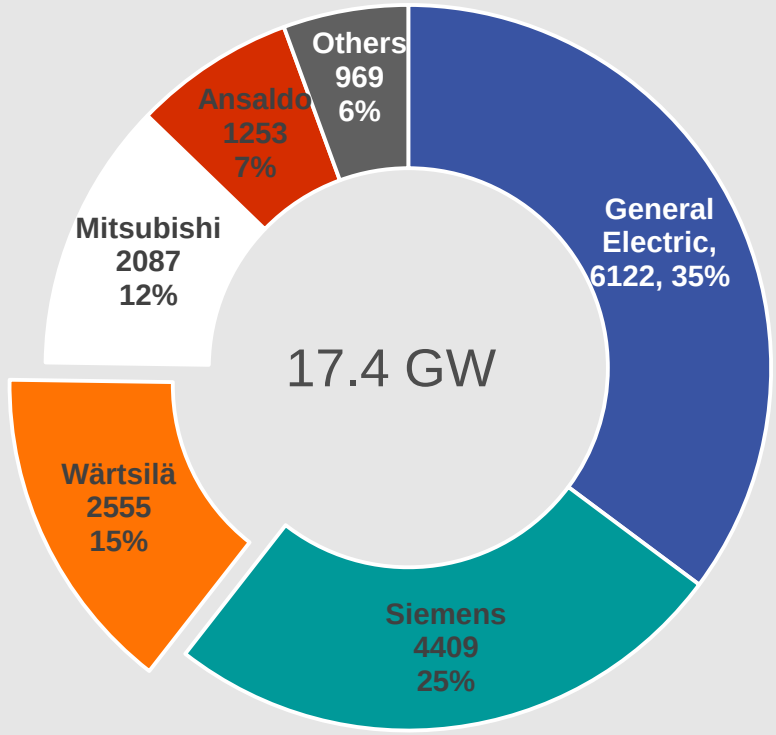


MARKET SHARE, <500 MW MARKET

September 2015



September 2016



Source: McCoy Power Report
Includes GT-based gas and liquid-fuelled, <500 MW power plants with prime movers above 5 MW
Includes estimated output of steam turbines for combined cycles (factor 0.5 for industrial turbines, 0.25 for aeros)
Oil & Gas projects not included. Other combustion engines not included.

Greensmith
A Wärtsilä Company

On July 3, 2017 Wärtsilä completed its acquisition of Greensmith

Wärtsilä

- Leading systems integrator for ultra-flexible internal combustion engine based power plants, solar PV and LNG
- Over 63 GW deployed in 176 countries; Strong market share in Caribbean
- Global EPC capabilities
- Experienced in electrically-islanded systems

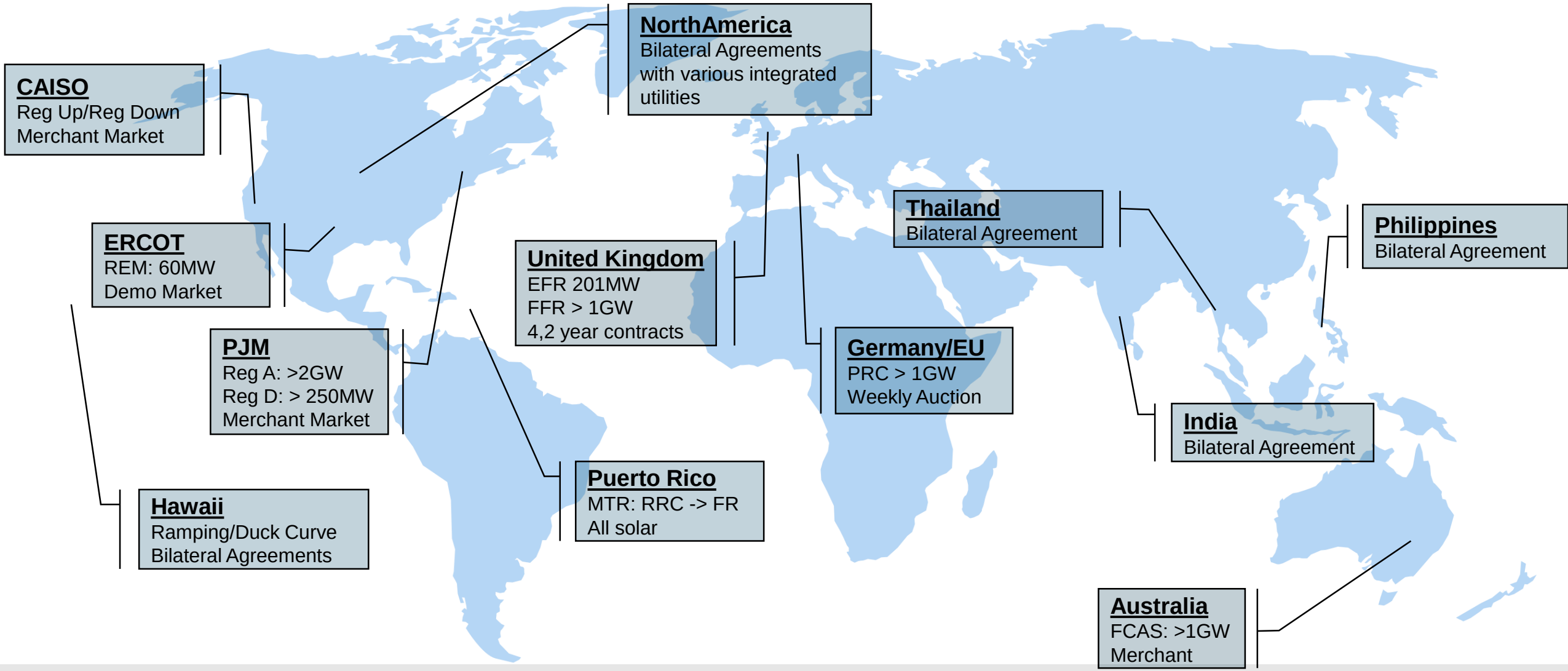
Greensmith

- Established energy storage leader – unparalleled experience, rapid deployment and proven performance and safety
- Deployed over 150MW energy storage – including largest indoor system in North America
- Leading energy storage management software controls to optimize and monetize solar + PV
- Technology-neutral for best of breed and future-proofing

The Modern Power System in the South pacific is facing Many Challenges

- Renewables Penetration rates
- Ramp rates and Curtailment
- Less Visibility / Fluctuating Demand
- Peaks shifting into evening
- Aging equipment

Markets for Ancillary Services are Developing Worldwide



Key Markets by Region

USA
- Vertically integrated utilities including storage in procurement plans for FR and T&D deferral

Caribbean Islands
- Mining/Off-grid hybrid engine opportunities
- Solar + storage applications

Chile, Argentina
- Mining/Off-grid hybrid engine opportunities
- Solar + storage applications

UK
- Continued EFR/FFR & capacity deployments

Germany
- German market led by solar self-consumption -> not our strength
- PCR market has low prices

France
- Island tenders

Middle East
- Solar + storage applications

Africa
- Mining/Off-grid hybrid engine opportunities
- Solar + storage applications

Australia
- Grid-tied market is policy-driven at state level
- Mining/Off-grid hybrid engine opportunities

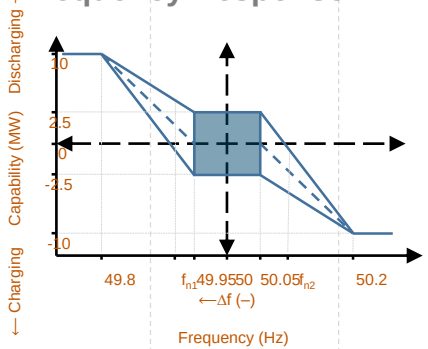
Philippines
- Hybrid engine opportunities
- Solar + storage applications
- Frequency and Voltage regulation

Thailand
- Utility drives storage test systems

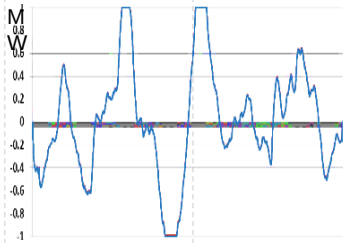
South Pacific Islands
- Mini Grids, Increased RE
- Reactive Power & f/U stabilisation

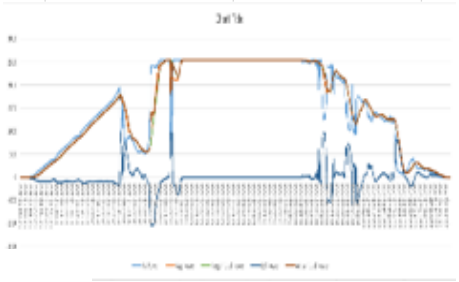
Energy storage solves multiple problems for utilities

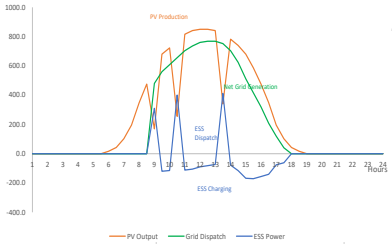
Frequency Response



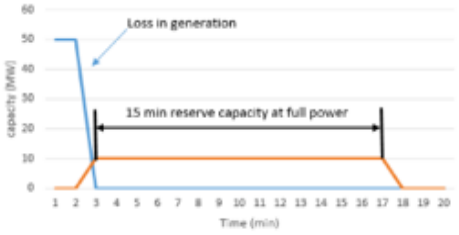
Frequency Regulation via AGC

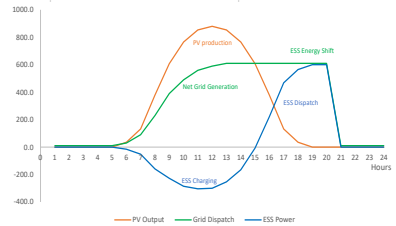




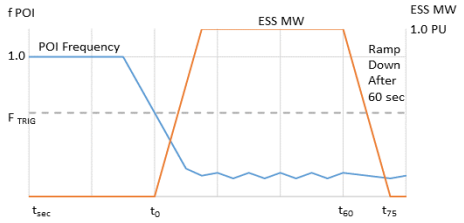


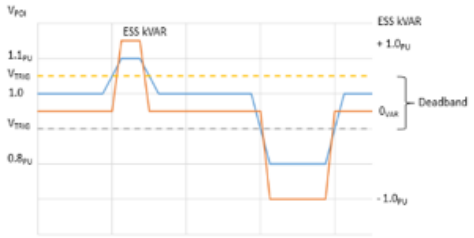
Bulk Capacity



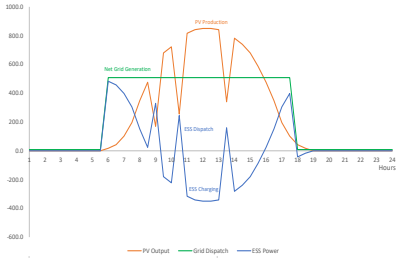


Voltage Control

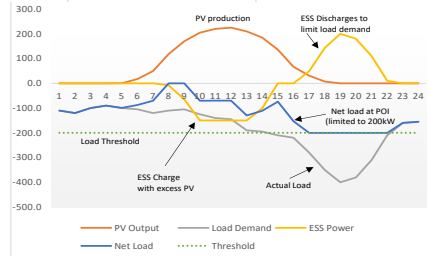




Storage + Renewables



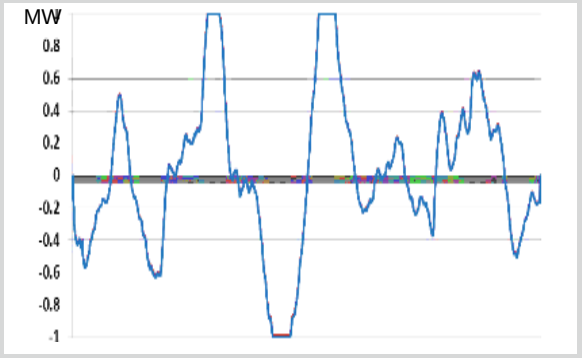
System Load Leveling

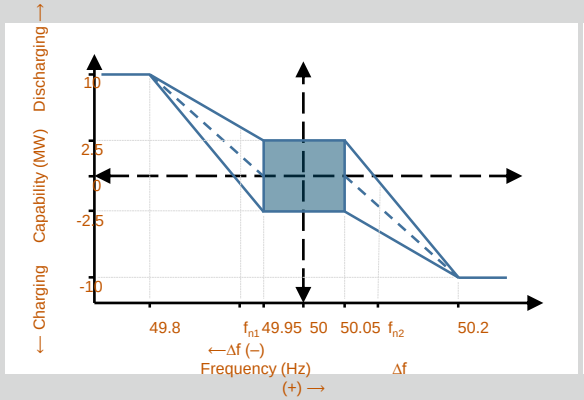


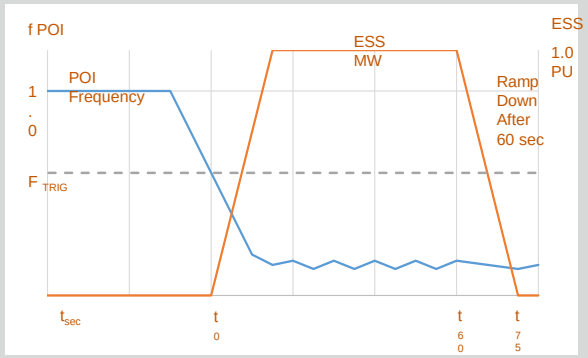
Power use cases

Energy use cases

Frequency regulation services has many forms





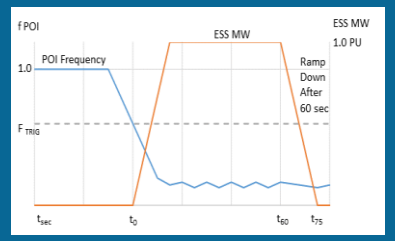


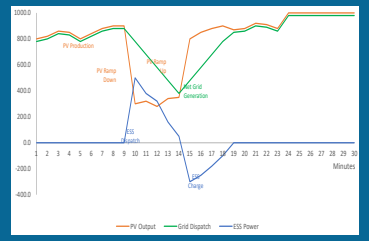
Regulation via AGC Signal → **Autonomous Response at POI** → **Frequency Droop Control**

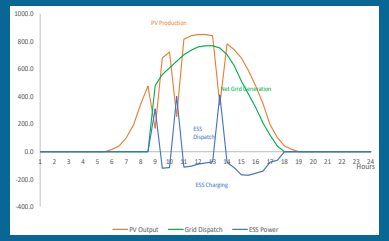
Frequency services	Description	GS examples
Regulation via AGC Signal	GEMS responds to an automated generator control signal to manage grid frequency deviations. Usually measured by accuracy and energy neutrality varies by market.	Frontier, Meyersdale, Beckjord, Pomona
Autonomous Response at POI	GEMS measures frequency locally and responds proportionally according to a predetermined response envelope	Texas Waves, German PCR
Frequency Droop Control/RRC	Provide near-instant reserve power in the case of a grid fault. GEMS measures frequency locally and can either dispatch centrally from a control room or autonomously from site.	Iron Horse, PRANG

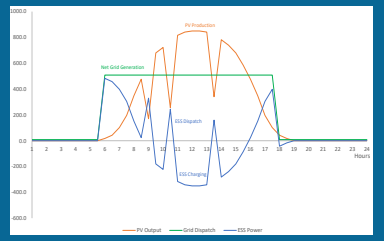
Renewables + Storage: A spectrum of benefits

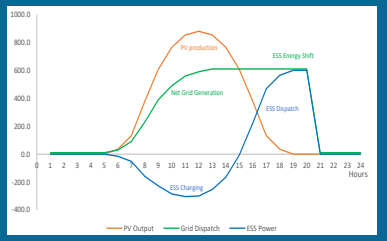
Energy storage enhances value of PV output through multiple paths











Frequency Response | **Ramp Rate Control** | **Renewables Smoothing** | **Renewables Firming** | **Renewables Shifting**

Power-centric application

ESS Application	Description	ESS Sizing
Frequency Response	Corrects over and under frequency	15-30 minutes
Ramp Rate Control	Mitigates ramping at generation source	30-45 minutes
Renewables Smoothing	Maintains approximate solar curve	1 hour +
Renewables Firming	Creates Firm committed load shape	2 hours +
Renewables Shifting	Shifts solar to evening hours w/ or w/o commit	4 hours +

Award of 2.4MW/2.4MWh ESS Test Bed for EMA and SP Group announced in Singapore International Energy Week (SIEW) 2017 – 23 October 2017

SPgroup

ENERGY MARKET AUTHORITY
Smart Energy, Sustainable Future

MEDIA RELEASE

23 October 2017

Launch of Singapore's First Utility-Scale Ene

The Energy Market Authority (EMA) and SP
Singapore-led consortiums to implement the city-stat
Storage System (ESS). CW Group and Red Dot Power w
in grants for the initiative to build this test-bed.

Wärtsilä to build energy storage system for Singapore's Energy M Authority and SP Group

Wärtsilä Corporation, Press release, 24 October 2017 at 12:00 PM E. Europe Standard Time

CW

CW GROUP HOLDINGS LIMITED
創達科技控股有限公司
(Incorporated in the Cayman Islands with limited liability)
(Stock code: 1322)

VOLUNTARY ANNOUNCEMENT
ENERGY STORAGE PROGRAMME GRANT

This is a voluntary announcement made by CW Group Holdings Limited (the "**Company**", together with its subsidiaries, the "**Group**").

The board (the "**Board**") of directors (the "**Directors**") of the Company is pleased to announce that, on 17 October 2017, CW Group Pte. Ltd. (the "**Subsidiary**"), an indirect wholly owned subsidiary of the Company, was awarded a grant of close to S$8.9 million (the "**Grant**") from the Energy Market Authority of Singapore (the "**EMA**") for a term of 3 years from 1 November 2017 to 31 October 2020 under the "Energy Storage Programme – Energy Storage Systems ("**ESS**") Test-Bed" (the "**Energy Storage Programme**"). The Subsidiary will utilise the Grant on building the ESS Test-Bed which involves lithium-ion solutions for high power applications (the "**Project**"),

Project Overview

Project	Singapore's First Utility-Scale Energy Storage System
System Size	2.4MW / 2.4MWh
Location	Site A - SP Group Punggol substation next to 206A Punggol Place, S(821206)
Battery Chemistry	Lithium Iron Phosphate
Use Cases	Ancillary Services
Scope	Full Turnkey EPC by Wärtsilä / Greensmith

CASE STUDY – CALIFORNIA (US) – MULTIPLE REVENUE MODELS

20MW/80MWh RESOURCE ADEQUACY / FREQ. REGULATION

- **Customer:** AltaGas, California, USA
- **Type:** Energy Storage System (Li-Ion)
- **Operating mode:** Resource Adequacy
- Frequency Regulation
- **Inverters:** 20MW, Parker
- **Batteries:** 80MWh, Samsung
- **Energy Management System:** GEMS5
- **Delivered:** 2016

WÄRTSILÄ

Greensmith
A WÄRTSILÄ COMPANY
ENERGY OPTIMIZED

CASE STUDY

Pomona Energy Center
20MW/80MWh

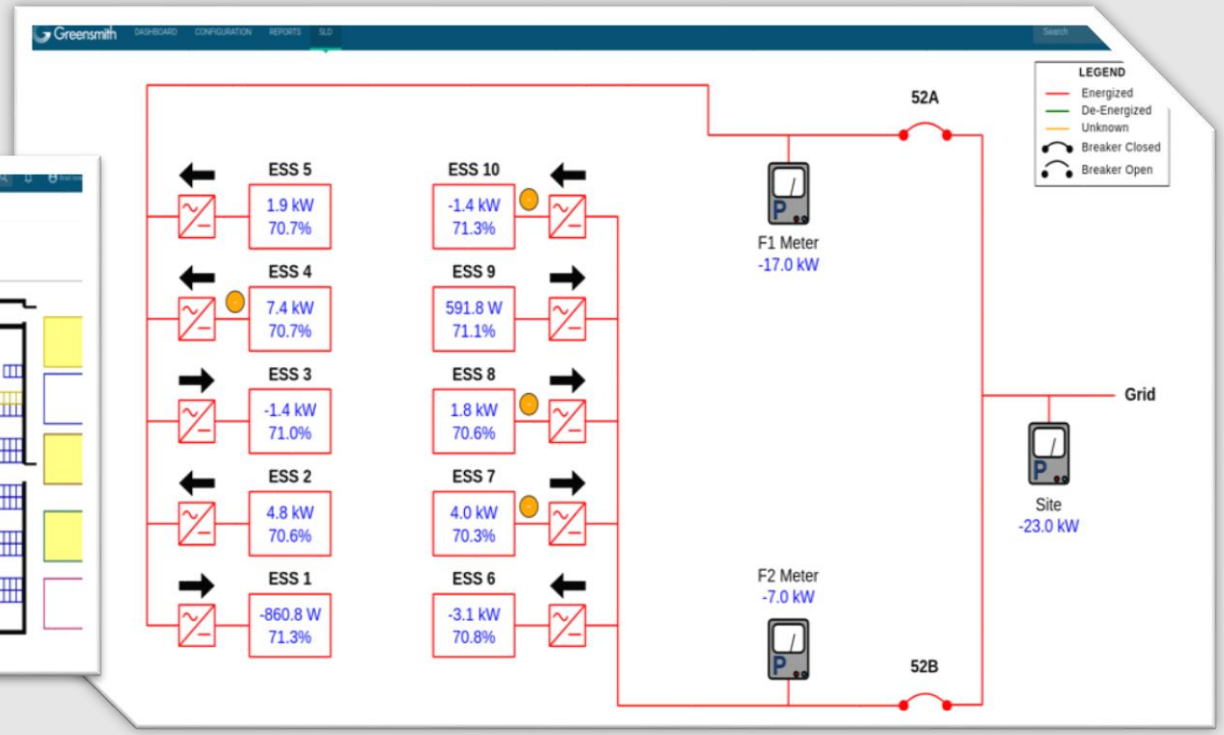
CLIENT PARTNER
Alta Gas

DEPLOYMENT
20MW/80Mwh ESS

SOLUTION
Renewables integration

KEY TAKEAWAY
5 months NTP to COD!

- **20MW/80MWh ESS constructed in record time**



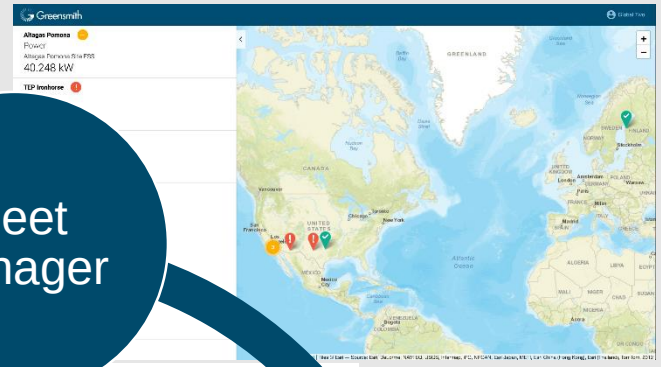
Graciosa (Azores) Microgrid

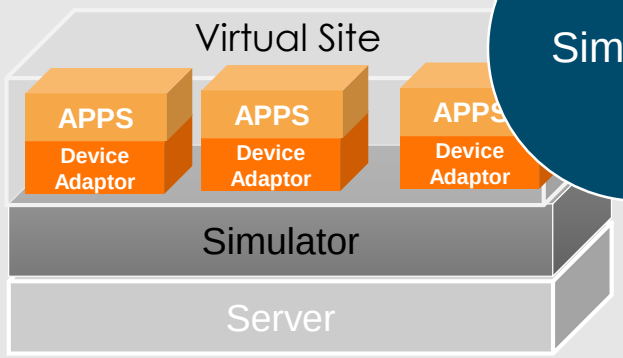
Deployment details

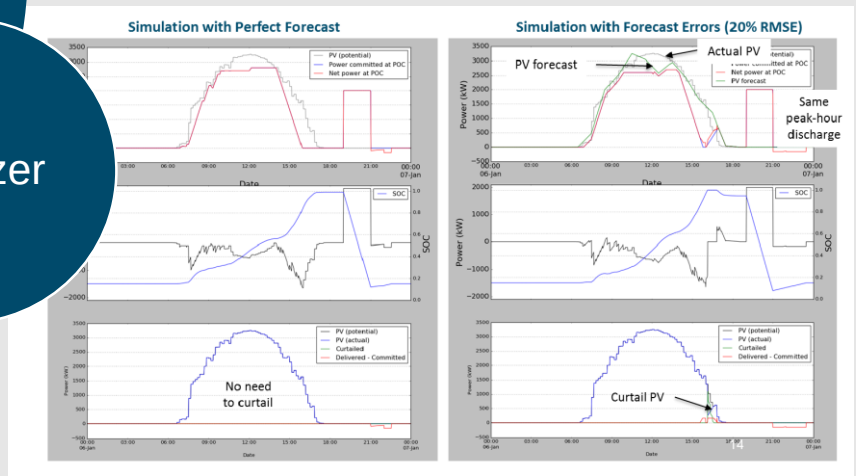
- EU funding >$20M for wind turbines, battery, & solar
- 5 Enercon 900 KW Wind Turbines
- 1 MW Solar
- 6MW/2.6MWh Battery
- Greensmith as overall integrator
- PPA based on fuel savings
- Goal of 65% renewables
- Renewables complete
- Battery Inverters and System commissioning

GEMS turns batteries to Revenue

GREENSMITH EMS - GEMS







GEMS - ALL REVENUE MODELS

Grid Reliability

- Frequency controls
- Volt/VAR control
- 1^{ary} and 2^{ary} Reserves
- Distribution deferral
- Peak Shifting
- Load Leveling

Thermal generation optimization

- Power to grid time
- Spinning reserve
- Grid forming capability
- O&M optimization

+

Renewable Integration

- PV Ramp Control
- PV Smoothing
- PV Firming and Shifting
- Curtailment Capture
- Capacity-based Solar PPAs

Micro grid

- On grid/off grid seamless transfer
- Renewables integration/ grid forming
- Renewables integration
- Black start

FUTURE-PROOF

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"

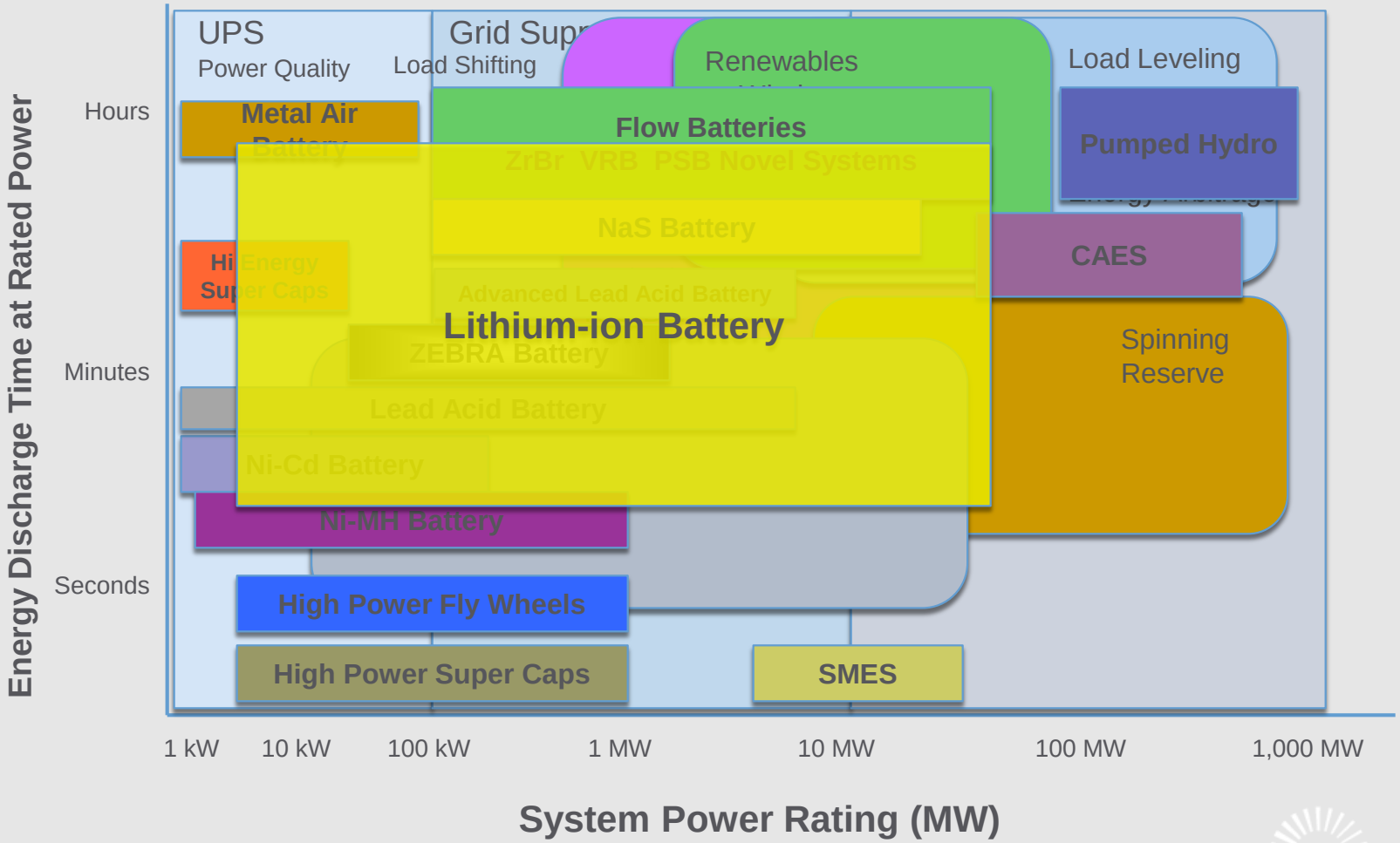
Technology neutral.
Total flexibility.

Batteries

Power electronics

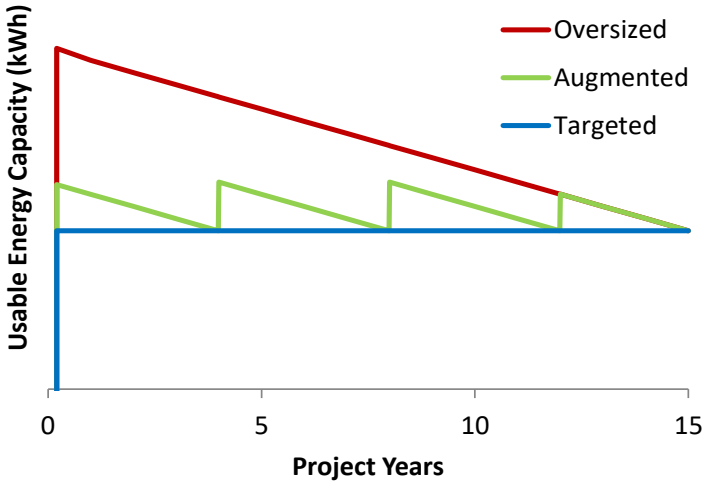
21

Battery Chemistry for Every Application



Source: EPRI and Greensmith

Sizing Strategy Impact on ROI



- Rapidly declining cost curves needs **creative** deployment strategies
- Augmentation strategy allows IPP to benefit from declining cost curves and TVM
- Results in 19% savings

		Oversize		Augmentation	
Year	Battery Price per kWh	MWh Deployed	Cash Cost	MWh Deployed	Cash Cost
2018	$225	72.6	$16,335,000	51.0	$11,475,000
2019	$170	0	$0	0	$0
2020	$163	0	$0	0	$0
2021	$157	0	$0	0	$0
2022	$151	0	$0	9.0	$1,359,000
2023	$150	0	$0	0	$0
2024	$150	0	$0	0	$0
2025	$150	0	$0	0	$0
2026	$150	0	$0	0	$0
2027	$150	0	$0	7.0	$1,050,000
2028	$150	0	$0	0	$0
2029	$150	0	$0	0	$0
2030	$150	0	$0	0	$0
2031	$150	0	$0	0	$0
2032	$150	57.0	$8,550,000	40.0	$6,000,000
2033	$150	0	$0	0	$0
2034	$150	0	$0	0	$0
2035	$150	0	$0	0	$0
2036	$150	0	$0	0	$0
2037	$150	0	$0	13.0	$1,950,000
2038	$150	0	$0	0	$0
2039	$150	0	$0	0	$0
2040	$150	0	$0	0	$0
2041	$150	0	$0	0	$0
2042	$150	0	$0	0	$0
NPV @ 7%			$19,650,837		$15,949,000
NPV savings from Augmentation				19%	$3,701,837

THANK YOU

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