Intelligent Integration of Energy Storage Systems in the South Pacific Region

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Koror | Palau
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Wilhelm van Butselaar | Area Manager Energy Storage & Integration

Wärtsilä Singapore Pte Ltd
WÄRTSILÄ CORPORATION - INTRODUCTION

WÄRTSILÄ POWERING THE WORLD

Listed in Helsinki
4.9 billion € turnover
2.6% or 136M€ in R&D
27,400 MW Installed Base in Asia & Middles East

Net sales by business
2017

Services 43%
Marine Solutions 34%
Energy Solutions 22%

Installed power plant capacity
65 GW in 177 countries around the world
MARKET SHARE, <500 MW MARKET

September 2015

- General Electric: 6596 MW (39%)
- Mitsubishi: 3362 MW (20%)
- Siemens: 4285 MW (25%)
- Wärtsilä: 1687 MW (10%)
- Ansaldo: 930 MW (5%)
- Others: 157 MW (1%)

17.0 GW

September 2016

- General Electric, 6122 MW (35%)
- Mitsubishi: 2087 MW (12%)
- Wärtsilä: 2555 MW (15%)
- Siemens: 4409 MW (25%)
- Ansaldo: 1253 MW (7%)
- Others: 969 MW (6%)

17.4 GW

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

**CAISO**
Reg Up/Reg Down
Merchant Market

**ERCOT**
REM: 60MW
Demo Market

**PJM**
Reg A: >2GW
Reg D: > 250MW
Merchant Market

**Hawaii**
Ramping/Duck Curve
Bilateral Agreements

**North America**
Bilateral Agreements with various integrated utilities

**United Kingdom**
EFR 201MW
FFR > 1GW
4,2 year contracts

**Germany/EU**
PRC > 1GW
Weekly Auction

**Thailand**
Bilateral Agreement

**Philippines**
Bilateral Agreement

**India**
Bilateral Agreement

**Australia**
FCAS: >1GW
Merchant

**Puerto Rico**
MTR: RRC -> FR
All solar
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

Balancing the Grid

Energy use cases

Power use cases

Frequency Response

Frequency Regulation via AGC

Voltage Control

Storage + Renewables

System Load Leveling

Bulk Capacity
Frequency regulation services has many forms

<table>
<thead>
<tr>
<th>Frequency services</th>
<th>Description</th>
<th>GS examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulation via AGC Signal</td>
<td>GEMS responds to an automated generator control signal to manage grid frequency deviations. Usually measured by accuracy and energy neutrality varies by market.</td>
<td>Frontier, Meyersdale, Beckjord, Pomona</td>
</tr>
<tr>
<td>Autonomous Response at POI</td>
<td>GEMS measures frequency locally and responds proportionally according to a predetermined response envelope</td>
<td>Texas Waves, German PCR</td>
</tr>
<tr>
<td>Frequency Droop Control/RRC</td>
<td>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.</td>
<td>Iron Horse, PRANG</td>
</tr>
</tbody>
</table>
Renewables + Storage: **A spectrum of benefits**

Energy storage enhances value of PV output through multiple paths

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

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-sta Storage System (ESS). CW Group and Red Dot Power in grants for the initiative to build this test-bed.
## Project Overview

<table>
<thead>
<tr>
<th>Project</th>
<th>Singapore’s First Utility-Scale Energy Storage System</th>
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</thead>
<tbody>
<tr>
<td>System Size</td>
<td>2.4MW / 2.4MWh</td>
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<tr>
<td>Location</td>
<td>Site A - SP Group Punggol substation next to 206A Punggol Place, S(821206)</td>
</tr>
<tr>
<td>Battery Chemistry</td>
<td>Lithium Iron Phosphate</td>
</tr>
<tr>
<td>Use Cases</td>
<td>Ancillary Services</td>
</tr>
<tr>
<td>Scope</td>
<td>Full Turnkey EPC by Wärtsilä / Greensmith</td>
</tr>
</tbody>
</table>
• **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
**Pomona Energy Center**

20MW/80MWh

- 20MW/80MWh ESS constructed in record time

**CASE STUDY**

**CLIENT PARTNER**
Alta Gas

**DEPLOYMENT**
20MW/80Mwh ESS

**SOLUTION**
Renewables integration

**KEY TAKEAWAY**
5 months NTP to COD!
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

GEMS OS
Operation Scheduling • Peer-to-Peer Group Control • Real-time Equipment Control • Local HMI

External
SCADA
Weather Forecasts
Energy Market Data

Grid Reliability
Renewable Integration
Micro Grids
Hybrid Engine Optimization

Batteries
Solar
Engines
Sensors
Applications for Greensmith solutions

**Grid Reliability**
- Frequency controls
- Volt/VAR control
- 1\textsuperscript{ary} and 2\textsuperscript{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

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
Battery Chemistry for Every Application

Source: EPRI and Greensmith
Sizing Strategy Impact on ROI

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Battery Price per kWh</th>
<th>MWh Deployed</th>
<th>Cash Cost</th>
<th>MWh Deployed</th>
<th>Cash Cost</th>
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NPV @ 7%: $19,650,837
NPV savings from Augmentation: 19% $3,701,837