WEBINAR: The Future of Energy is Hybrid

WÄRTSILÄ HYBRID POWER PLANTS, ENGINES+STORAGE & WÄRTSILÄ ENERGY STORAGE SOLUTIONS

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Manager, Business Development Energy Solutions
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2. Energy Solutions strategy
3. Energy storage market data
4. Introducing Wärtsilä hybrid power plants, engines+storage
5. Introducing Wärtsilä energy storage
6. Large scale energy storage
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ENERGY SOLUTIONS

We are a leading global systems integrator offering a broad range of environmentally sound solutions. Our flexible and efficient solutions provide superior value to customers and enable a transition to a more sustainable and modern energy system.
What we bring to the market

ENGINE POWER PLANTS
LNG INFRASTRUCTURE
SOLAR PV AND ENGINE-SOLAR HYBRID POWER PLANTS

DEVELOPMENT & FINANCIAL SERVICES
PROJECT MANAGEMENT
LIFECYCLE SOLUTIONS
Installed base
Over 63 GW in 176 countries around the world
Renewables and systems integration are at the core of Wärtsilä’s strategy:

**ENGINE POWER PLANTS**
- Power generation solutions with unique combination of energy efficiency, fuel flexibility and operational flexibility.

**LNG SOLUTIONS**
- Small and medium size LNG terminals and liquefaction solutions with EPC.

**RENEWABLES**
- Solar PV and engine+solar hybrid solutions in selected target markets.

**ENERGY STORAGE AND INTEGRATION**
- Energy storage solutions,
- engine+storage hybrid power plants and system integration.
Market is in its childhood and getting its momentum
Utility scale installations dominating until 2020

Source: BNEF: Global Energy Storage Forecast, 2016-24
Global commissioned energy storage by region, 2009-16 (MW)

Note: 2016 pipeline includes utility-scale projects that have an estimated commissioning date of 2016.
Source: Bloomberg New Energy Finance
Technology mix of utility-scale commissioned storage projects (% by MW)

<table>
<thead>
<tr>
<th>Year</th>
<th>Lithium-ion batteries</th>
<th>Sodium sulphur batteries</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>47%</td>
<td>30%</td>
<td>53%</td>
</tr>
<tr>
<td>2012</td>
<td>66%</td>
<td>61%</td>
<td>3%</td>
</tr>
<tr>
<td>2013</td>
<td>33%</td>
<td>68%</td>
<td>6%</td>
</tr>
<tr>
<td>2014</td>
<td>30%</td>
<td>62%</td>
<td>19%</td>
</tr>
<tr>
<td>2015</td>
<td>19%</td>
<td>7%</td>
<td>91%</td>
</tr>
<tr>
<td>2016</td>
<td>7%</td>
<td>57%</td>
<td>31%</td>
</tr>
</tbody>
</table>

Technology mix of utility-scale commissioned storage projects (% by MWH)

<table>
<thead>
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<th>Year</th>
<th>Lithium-ion batteries</th>
<th>Sodium sulphur batteries</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>69%</td>
<td>9%</td>
<td>27%</td>
</tr>
<tr>
<td>2012</td>
<td>83%</td>
<td>19%</td>
<td>30%</td>
</tr>
<tr>
<td>2013</td>
<td>29%</td>
<td>43%</td>
<td>31%</td>
</tr>
<tr>
<td>2014</td>
<td>31%</td>
<td>64%</td>
<td>16%</td>
</tr>
<tr>
<td>2015</td>
<td>57%</td>
<td>24%</td>
<td>24%</td>
</tr>
<tr>
<td>2016</td>
<td>73%</td>
<td>19%</td>
<td>16%</td>
</tr>
</tbody>
</table>

Note: “Other” includes lead-based batteries, flywheels, compressed air energy storage, sodium nickel chloride batteries, flow batteries and other non-hydro related energy storage technologies.
Source: Bloomberg New Energy Finance
INTRODUCING WÄRTSILÄ HYBRID POWER PLANT, ENGINES+STORAGE

Hybrid power plant configuration example
- Internal combustion engines: 60MW
- Energy storage: 10MW / 2.5MWh
- Hybrid output: -10MW...+70MW

1. Energy storage building
2. Engine hall
3. Electrical equipment building
4. Fuel treatment building
5. Administration building
6. Workshop and warehouse
WÄRTSILÄ HYBRID POWER PLANT, ENGINES+STORAGE MAIN FEATURES

- Spinning reserve replacement
- Power quality
  - Frequency control
  - Voltage control
- Ancillary services
- Instant power

MAXIMIZING CUSTOMER VALUE

- Optimized plant operation
- Fuel savings
- O&M optimization and savings
- Regulation compliance
- Enhanced dispatchability
- Reduced emissions

Lower average load. Year average 74%, ave. efficiency 42.2%
SPINNING RESERVE BY ENGINES
Engine load %

Higher average load. Year average 90%, ave. efficiency 43.0%
SPINNING RESERVE BY STORAGE
Engine load %
Introducing

WÄRTSILÄ ENERGY STORAGE
Wärtsilä Energy Storage main features

- Energy shifting
- Power quality
  - Frequency control
  - Voltage control
- Instant power

Maximizing customer value

- Peak demand management
- Demand charge reduction (C&I)
- Electricity market(s) opportunities
- Back-up capacity
LARGE SCALE ENERGY STORAGE
CONTAINERIZED ENERGY STORAGE

Containerized solutions:

1,5…4MWh / container
**BATTERY SYSTEM OVERVIEW**

**ELECTRICAL**

- **CELL**
- **MODULE**
- **RACK**

**DC SYSTEM**

- DC Switch fuse
- DC Busbar
- DC breaker

**Energy**

- 0.25kWh
- 6.5kWh
- 65.5kWh
- 1500kWh (5540 cells)
- 0.25kWh 6.5kWh 65.5kWh 1500kWh (5540 cells)

**Voltage**

- 4.2VDC
- 50.4VDC
- 1050VDC

**MARKET INTERFACE**

- Power converter + DC and AC breaker,

**AUTOMATION**

- DC Bus
  - xxx-1200 V
- AC 380- xxx V
- AC 6.3 - xxx kV

**ENERGY MANAGEMENT SYSTEM**

- MARKET INTERFACE
- ENERGY MANAGEMENT SYSTEM
- BATTERY MANAGEMENT
LATEST NEWS
Wärtsilä Corporation, press release, 15 May 2017

- Leading North America storage system supplier
- Built over 150MW energy storage, including largest indoor system
- Grid-scale, microgrid and BTM
- GEMS5 software to optimize and monetize
- Technology neutral for best of breed
- Expertise in DC block design
50+ installations | 25 customers | 9 utilities/IPPs

Greensmith Customers:
- SDGE (San Diego Gas & Electric)
- TEP (Tucson Electric Power)
- Johnson Controls
- Deltro Energy
- AltaGas
- AEP (American Electric Power)
- Duke Energy
- Southern California Edison
- e.on (Climate & Renewables)
- nrg
- Southern Company
- NextEra Energy
ENERGY SYSTEM INTEGRATOR

- ENGINE POWER GENERATION
- SMART POWER GENERATION
- SOLAR GENERATION
- OPTIMISED GENERATION
- ENERGY SYSTEM MANAGEMENT
- RENEWABLES GENERATION
- SYSTEM STABILITY
THANK YOU

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