Flexible Power Generation

Northwest Power and Conservation Council

February 27, 2014
Wärtsilä in short

**Business Areas**

- POWER PLANTS
- SHIP POWER
- SERVICES

- Founded in 1834
- Headquarters in Helsinki Finland
- Net Sales € 4.7 billion (2012)
- Presence in 170 locations in 70 countries

**What we bring to the market**

- Efficiency
- Environmental Solutions
- Fuel Flexibility

- We have 2 plants, Trieste (IT) & Vaasa (FI)
- Over 4300 MW production capacity
- 3.98% of Net Sales = R&D Budget (2012)
- Personnel 18,887

**Net Sales by Business**

- Power Plants 32%
- Ship Power 28%
- Service 40%

**Net Sales by Market Area**

- Asia 43%
- Europe 25%
- Americas 21%
- Other 11%
- Other 11%
Wärtsilä Power Plants Worldwide *

Total Output: 52,943 MW
Plants: 4,675
Engines: 10,520
Countries: 169

Europe
Output: 12,093 MW
Plants: 1792
Engines: 3360

Asia
Output: 18,651 MW
Plants: 1643
Engines: 3625

Americas
Output: 10,660 MW
Plants: 389
Engines: 1317

Africa & Middle East
Output: 11,539 MW
Plants: 851
Engines: 2718

USA
+2,300 MW

* Includes plants on order and in construction
Wärtsilä Lifecycle support around the world

→ 70 countries → 160 locations → 11,000 people → 7,500 field service forces

We are the only player in the market able to offer our clients 24/7 support, globally, in the fields of logistics, technical support and field service from a single source.
About Wärtsilä in North America

Wärtsilä USA since 1979. Currently 650 employees in North America

Helsinki, Wärtsilä HQ
Houston, USA HQ
Main Factories
US Service Offices
Wärtsilä Gas Engines

» 20V34SG* - 9.3 MW / unit
  45% efficiency

» 18V50SG* - 18.8 MW / unit
  46% efficiency

» + Combined Cycle (Flexicycle™)
  50.4% efficiency

» Arranged in parallel
to configure any
size plant in the
~10 to 500+ MW size range

» Required project MW capacity
met by multi-unit solution

* Similar Engines in DF configuration on gas/liquid fuel
## Wärtsilä Gas Engines

<table>
<thead>
<tr>
<th></th>
<th>20V34SG-D</th>
<th>18V50SG</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Output</strong></td>
<td>9,341 kWe</td>
<td>18,759 kWe</td>
</tr>
<tr>
<td><strong>Heat Rate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(LHV)</td>
<td>7,461 Btu/kWh</td>
<td>7,375 Btu/kWh</td>
</tr>
<tr>
<td>(HHV)</td>
<td>8,271 Btu/kWh</td>
<td>8,176 Btu/kWh</td>
</tr>
<tr>
<td><strong>Speed</strong></td>
<td>720 rpm</td>
<td>514 rpm</td>
</tr>
<tr>
<td><strong>Dimensions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(L/WH)</td>
<td>42’ x 11’ x 15’</td>
<td>63’ x 18’ x 21’</td>
</tr>
<tr>
<td></td>
<td>143 US tons</td>
<td>391 US tons</td>
</tr>
</tbody>
</table>

* At generator terminals (pf 0.8, 0% tolerance)
<table>
<thead>
<tr>
<th></th>
<th>20V34DF</th>
<th>18V50DF</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Output</strong></td>
<td>9,341 kWe</td>
<td>17,076 kWe</td>
</tr>
<tr>
<td><strong>Heat Rate</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(LHV)</td>
<td>7,525 Btu/kWh</td>
<td>7,460 Btu/kWh</td>
</tr>
<tr>
<td>(HHV)</td>
<td>8,341 Btu/kWh</td>
<td>8,271 Btu/kWh</td>
</tr>
<tr>
<td><strong>Speed</strong></td>
<td>720 rpm</td>
<td>514 rpm</td>
</tr>
<tr>
<td><strong>Start Time</strong></td>
<td>2 / 5 / 10</td>
<td>7 / 10</td>
</tr>
</tbody>
</table>

*At generator terminals (pf 0.8, 0% tolerance) when operating on natural gas with 1% liquid pilot fuel.
We offer the **best simple cycle efficiency** available in the market at **>46%**. Typical **net** plant heat rate of **<8400** Btu/kWh HHV at **95 °F**

Our power plants achieve high efficiency in a **wide range of ambient conditions**
Loading sequences for power plants

2 minutes to full load!

Additional power from Wärtsilä plant

- Coal Fired power plant
- Combined Cycle power plant (GTCC)
- Aeroderivative GT power plant (GTSC)
- Industrial GT power plant (GTSC)
- Combustion Engine power plant (W34SG)

Note: Start up times from warm stand-by!
Unloading sequences for power plants

Load % vs. mins

- Combined Cycle power plant (GTCC)
- Industrial GT power plant (GTSC)
- Combustion Engine power plant
Loading and unloading of a W34SG plant

(*) A power plant with e.g. 10 gensets can correspondingly operate at 3 % of its total nominal output.

Note: Start-up times from hot stand-by!
Cycling of a W34SG plant

Fast Ramp Rate
1 min from 30% load to full load

No maintenance impact from frequent cycling

Wärtsilä 34 gas power plant

Note: Start-up times from hot stand-by!
Quick Start

Start up and loading of a Gas Engine power plant compared to a GTCC

Case Study*
STEC Pearsall  24 x W20V34SG Simple Cycle
STEC Sam Rayburn  3 x 1 GE LM6000 Combined Cycle
ERCOT Market at $3,000/MWh  $895,000 per start
ERCOT Market at $100/MWh  $30,000 per start
ERCOT Market at $30/MWh  $10,000 per start

*John Packard, STEC, PowerGen 2011 Presentation
Relative part load efficiency per technology

- Gas Engines
- Gas Turbine OC
- Gas Turbine CCGT

Relative efficiency vs. Relative output graph.
No start penalties & No start-up costs

**Unlimited** starts & stops with **no impact** on cost or maintenance schedule.

This is unique, no competing technology offers the same.

Dispatcher’s dream plant
Plains End 227 MW
Colorado
Emissions

» Nox - Nitrogen oxides: 5 ppm (0.064 g/kWh) (as NO2) (dry, at 15 vol-% O2) - with SCR

» CO - Carbon monoxide: 15 ppm (0.12 g/kWh) (dry, at 15 vol-% O2) - with CO catalyst

» VOC 25 ppm (0.12 g/kWh) (dry, at 15 vol-% O2)

» Particulates (total) (0.12 g/kWh) (at 15 vol-% O2)
Noise levels

Engine noise at 1 meter: \( \sim 115 \text{ dBA} \)
Power House interior: \( \sim 110 \text{ dBA} \)
Outside: typical design is 65 dBA @ 600 ft but can meet local requirements
Minimum water use

Wärtsilä’s solutions minimize not only fuel but also water consumption thereby providing major environmental benefits. Our power plants use a **closed loop cooling system** that **requires minimum water**

Simple Cycle water consumption = 1 gal/engine/week

Combined Cycle water consumption is **1/3 of GTCC Plant**
Wärtsilä power plants use low pressure natural gas (75 psig). No need for aux. gas compressor or high pressure gas line.
Modularity

Our modular design allows for **easy capacity additions** and makes it simple for our customers to construct an optimally sized plant.
Busting a myth: the power density disadvantage

2x CCGT

Output: 360MW
Area req.: 20,000m²
Power density: 18 kW/m²

8x 18MW Gas Engine

Output: 155MW
Area req.: 8,100m²
Power density: 19 kW/m²
Availability and reliability

**Firm capacity**

**Comparison**
Wärtsilä design makes the project look like a commercial building.
No visible smoke, fumes or steam release
Levelized Cost, Capex+Opex

KEMA study (CAISO) & Redpoint (UK) studies…..

1) Adding SPG reduces OPEX, total operational cost of fleet
2) But we have not addressed CAPEX

To take CAPEX into account (along with OPEX), we can look at levelized cost

1) For simple cycle, look at capacity factors 10% to 20%
2) For others (GTCC, Flexicycle) look at capacity factor of 30% & 40%
3) Assume plant running 80% load
4) Daily starts/stops, across 5 day / week (hours per day adjusted to achieve cf).
Wärtsilä 200 MW vs. Industrial GT (10% cf)
Wärtsilä vs. Industrial GT (200 MW)

Busbar Cost

<table>
<thead>
<tr>
<th>CF</th>
<th>$ / MWh</th>
<th>Wärtsilä Simple Cycle</th>
<th>Industrial GT</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>201</td>
<td>224</td>
<td></td>
</tr>
</tbody>
</table>

Total Production Cost

<table>
<thead>
<tr>
<th>CF</th>
<th>M$ (20 years)</th>
<th>Wärtsilä Simple Cycle</th>
<th>Industrial GT</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>708</td>
<td>80 MUSD Savings</td>
<td></td>
</tr>
<tr>
<td>20%</td>
<td>901</td>
<td>134 MUSD Savings</td>
<td></td>
</tr>
<tr>
<td>20%</td>
<td>1,035</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Wärtsilä vs. Aero GT (200 MW)

Busbar Cost

10% CF

- Wärtsilä Simple Cycle: $201/MWh
- Aeroderivative GT: $219/MWh

Total Production Cost

- Wärtsilä Simple Cycle: $708 M (20 years)
- Aeroderivative GT: $771 M

Savings

- 63 MUSD
- 85 MUSD
### Wärtsilä Flexicycle vs. GTCC 1x1 (300 MW)

#### Busbar Cost

<table>
<thead>
<tr>
<th>CF</th>
<th>Wärtsilä Flexicycle</th>
<th>GTCC 1x1</th>
</tr>
</thead>
<tbody>
<tr>
<td>30%</td>
<td>108</td>
<td>117</td>
</tr>
<tr>
<td>40%</td>
<td>94</td>
<td>100</td>
</tr>
</tbody>
</table>

#### Total Production Cost

<table>
<thead>
<tr>
<th>CF</th>
<th>Wärtsilä Flexicycle</th>
<th>GTCC 1x1</th>
</tr>
</thead>
<tbody>
<tr>
<td>30%</td>
<td>1711</td>
<td>1853</td>
</tr>
<tr>
<td>40%</td>
<td>1985</td>
<td>2112</td>
</tr>
</tbody>
</table>

- **30% CF Savings**: 142 MUSD
- **40% CF Savings**: 127 MUSD
System benefits of Smart Power Generation

### NEED FOR SYSTEM FLEXIBILITY
1. Unplanned outages of power plants or/and transmission lines
2. Electricity demand (load) deviating from the forecast
3. Intermittent renewable generation output deviating from forecast

### SMART POWER GENERATION CAN
- Provide spin capacity for regulation, spinning reserve, load following
- Provide MW to grid in 1 minute or less
- Produce energy & AS at high efficiency over a wide load range

### SYSTEM BENEFITS OF SMART POWER GENERATION
- Reduce costly cycling/starts for high efficiency thermal plants
- Enable high efficiency thermal plants to full load instead of part load
- Enable stopping part loaded low efficiency steam power plants (that are providing reserves)

### VALUE OF SMART POWER GENERATION
- Reduced use of fuels
- Reduced CO2 emissions
- Reduced system operating costs
- Lower wholesale price of electricity
- Lower cost of electricity to consumers
**REDUCTION OF CYCLING ON THE GTCC**

- Recip units can cycle on and off as needed w/o start/stop penalty
- High efficiency from part load through full load
- Take over AS provision (Load Following, Reg Up) and ramping
- Reduce Cycling on the GTCCs and don’t exercise the stress curve on the GTs and HRSGs as much thus reducing maintenance cost and maintaining life of the GTCCs
Recent Wärtsilä US Flexible Power

- Plains End I / II, Colorado, 227 MW
- Barrick, Nevada, 116 MW
- Midwest Energy, Kansas, 76 MW
- STEC Texas 203 MW
- Greenville, Texas, 25 MW
- Modesto, California, 50 MW
- Golden Spread Texas 170 MW
- Lea County Coop 43 MW
Wärtsilä Smart Power Generation - Texas

3 x 20V34SG
25 MW – GEUS – Greenville, TX

18 x 20V34SG
170 MW – GSEC - Abernathy, TX

24 x 20V34SG
203 MW – STEC - Pearsall, TX
GEUS – Greenville, Texas

3 x 20V34SG
25 MW
The South Texas Electric Cooperative (STEC) Pearsall Power Plant in addition to serving load at member cooperatives, participates in the ERCOT Ancillary Services Market providing quick start reserves, spinning reserves, regulation and other high value products.
The South Texas Electric Cooperative (STEC) Red Gate Power Project is one Wärtsilä’s new flexible power plants with fast start, fast ramping, high efficiency at full and part load with minimal water use. Commercial operation is planned for early 2015. The plant layout will accommodate future expansion to Flexicycle™ (combined cycle). *Net Output at 95 F
Wärtsilä Smart Power Generation - California

Pacific Gas & Electric, Humboldt - Eureka, California
10 x 18V50DF - 162 MW
PGE – PORT WESTWARD II

- 2,964 Stone Columns completed for soil stabilization
- Engine Halls underway
- Underground pipe and electric underway
- Tie Ins to PW1 started

12 x 18V50 SG (224 MW)
21 x 18V50SG
384 MW Boyuk Shor – Baku, Azerbaijan
Reciprocating engines in the 21st century

» Reciprocating engines are no longer a technology only suitable for small-sized projects or emergency generation

» Today’s engines are competitive in many aspects
  – All plant sizes 1-600 MW
  – Operation on all kinds of gas and liquid fuels
  – Baseload, grid stability, standby-backup
  – Combined cycle, CHP, trigeneration
  – Industrial self-generation

» They are excellent for Smart Power Generation, a concept in which Wärtsilä is the global leader
Today’s reciprocating engines...

... are generally more efficient than comparable gas turbine technology

... perform much better at part load and at extreme ambient conditions

... are less sensitive to changing operational conditions

... offer better availability

... offer solutions for all kind of industrial needs

... are very competitive in terms of CAPEX and OPEX
Wärtsilä the Leader in Smart Power Generation

Please visit our website at:
smartpowergeneration.com

John Robbins
Business Development Manager
West Coast Region
Wärtsilä North America, Inc.
(503) 720 – 3081
John.robbins@wartsila.com