SMART POWER GENERATION – FLEXIBILITY AND EFFICIENCY

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The world demands

DESIRED FUTURE OF POWER SYSTEMS

Affordable

Smart Power System

Reliable

Sustainable
Load variations in power systems

- **Base load**
  - Constant generation 24/7/365
  - Nuclear and coal plants
- **Intermediate load**
  - Normal daily load variations
  - Increase of wind and solar power introduce uncertainty which leads to large generation variations
- **Peak load**
  - Covering high demand hours
- **Regulation**
  - Balancing the system (frequency & voltage)
- **Reserves**
  - Contingency situations
Growing challenges for power systems

• Variability of generation, intermittency
  – Increasing wind and solar production
• Forecasting error
  – Intermittent generation
• Increasing demand variations
  – Electricity intensity and less industrial production
• Power plant commitment
  – Inflexible generation

INCREASING DEMAND FOR FLEXIBLE POWER GENERATION
The perfect match
Case study: Smart wind chasing in Colorado, US

PLAINS END POWER PLANT, COLORADO, USA
Type: Grid stability
Engines: 20 x Wärtsilä 18V34SG, 14 x Wärtsilä 20V34SG
Total output: 227 MW
Fuel: Natural gas
Installed: 2002 and 2008

Screen shot from Colorado Dispatch Center, Xcel Energy, USA
3 May 2008

Remote controlled from Colorado Dispatch Center
Operational flexibility AND electrical efficiency

FUTURE POWER PLANTS:

- Efficiency
- Starting & stopping times
- Ramp rate
- Part load operation
- Firm capacity

Wärtsilä Flexicycle™

Wärtsilä

Electrical efficiency

- CCGT
- OCGT Aero
- OCGT Industrial

Flexibility

- Medium
- High

Nuclear Power Plants
Steam Power Plants
Gas Turbine Plants
Open Cycle (OC)
Combined Cycle (CC)
Combustion Engine Plants

Coal

30%
40%
50%
Wind will impact the whole system

Wind generation is very variable, leading to periods of very high generation and low periods of very low generation.

Thermal plants will have to operate in a different manner, with lower load factors and higher risk.

Prices may become highly volatile and driven increasingly by wind generation.

Source: Impact of Intermittency: How wind variability could change the shape of the British and Irish electricity market, July 2009
Engines are more efficient across the operation range.

Average efficiency, start to stop.

<table>
<thead>
<tr>
<th>Operation Time</th>
<th>Wärtsilä Combustion Engine</th>
<th>OCGT Aero</th>
<th>OCGT Industrial</th>
<th>Wärtsilä Flexicycle</th>
<th>CCGT</th>
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<tbody>
<tr>
<td>8 hours</td>
<td>55.0</td>
<td>45.0</td>
<td>40.0</td>
<td>50.0</td>
<td>45.0</td>
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<tr>
<td>4 hours</td>
<td>50.0</td>
<td>40.0</td>
<td>35.0</td>
<td>45.0</td>
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<td>2 hours</td>
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<td>35.0</td>
<td>30.0</td>
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<tr>
<td>1 hour</td>
<td>40.0</td>
<td>30.0</td>
<td>25.0</td>
<td>35.0</td>
<td>30.0</td>
</tr>
</tbody>
</table>

The chart illustrates the average efficiency of Wärtsilä engines across different operation times.
High efficiency due to multiple units

Part load efficiency

Plant efficiency, % (net)

Plant output, %

5 units 6 units 7 units 8 units 9 units 10 units

20 25 30 35 40 45

10 X Combustion engine 1 x OCGT, aero 1 x OCGT, industrial

GT performances: GTPro by Thermoflow

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High reliability due to multiple units
True and lower cost of generation

Electricity generation cost
€/MWh

- **WÄRTSILÄ**
  - **Flexicycle plant:** 256 MW
  - **Combined Cycle Gas Turbine plant:** 225 MW

### Site conditions
- Ambient: 15→25°C
- Gas pressure: 30→10 bar
- Altitude: 0→300m

### Operational expenses
- Capital
- O&M
- Std. conditions

### Performance degradation
- Degr. and aging, output
- Degr. and aging, efficiency

### Running profile
- Running hrs: 8000→4000
- Average load: 100→80%

### Operation mode
- Daily starts, start-up fuel
- Daily starts, Steam cycle maint.

### Delta Costs
- Δ10,5 €/MWh
- 89,5 €/MWh
- 30,3 €/MWh
Benefits to power producers

- Operation in different generation modes
- High efficiency
- Fuel flexibility
- Dependable and committable
  - Multiple generating units
- Operate on multiple markets
  - Energy markets
  - Capacity markets
  - Ancillary services markets
- Optimum plant location close to consumers
- Fast access to income through fast-track project delivery
- Competitive O&M costs
Benefits to power systems

- Secures the supply of affordable and sustainable power
  - Enable highest penetration of wind and solar power capacity
  - Maximising the use of wind power capacity by minimising wind curtailment
  - Ensure system stability in wind variability and contingency situations

- Ensures true optimisation of the total power system operation
  - Remove the abusive starts and stops, and cyclic load from baseload plants that are not designed for it
  - Improves the total system efficiency
Matching changing requirements

**DESIRE FUTURE OF POWER SYSTEM**

- Affordable
- Smart Power System
- Reliable
- Sustainable

**WÄRTSILÄ’S OFFER**

- Energy Efficiency
- Smart Power Generation
- Fuel Flexibility
- Operational Flexibility