High Flexible Distributed Power Plant to support Intermittent Renewable Power Generation

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Contents

- Introduction
- Decentralized Power
- Addressing the Energy Trilemma with Decentralized Power
- The Future of Power Generation?
- Conclusions
Introduction

The Energy Trilemma

- Growing demand for affordable electricity
- Modern society requires security of power supplies
- Need to limit impact of power generation on both the local and global environment

- Focus on only one area can cause problems
- High penetration of intermittent renewables has created security of supply and price problems
- Change in operational requirements of fossil fuel power
Introduction

Changing Operational Needs

- Constraint of surplus renewable power generation due to transmission system limitations
- Power plant designed for base load having to operate as mid-merit or peaking plant
- Part-load operation of fossil plant or spinning reserve
- ‘Clean’ natural gas fossil fuel generation under cost pressures
- Security of supply risks, increased emissions
Introduction

Changing demands on Power Plants

Flexibility
Fast Response
Frequent Cycling
Fuel Switching

Fossil Power Generation needed
Decentralized Power

Decentralised Power can help address the challenges of the Energy Trilemma

- Located close to load demand centres
  - Reduced transmission losses
  - Connected to distribution network
  - Frequency and voltage support
  - Can satisfy a local heat demand

- Multiple units
  - Increased availability
  - Enhanced operational range
  - High efficiency across wide load range
  - Minimised environmental footprint
  - Low initial investment
    - Easy expansion
## Siemens Gas Turbine Portfolio for Decentralized Power

### Heavy-duty gas turbines
- **SGT5-8000H**: 400 MW
- **SGT5-4000F**: 307 MW
- **SGT5-2000E**: 187 MW
- **SGT6-8000H**: 296 MW
- **SGT6-5000F**: 242 MW
- **SGT6-2000E**: 117 MW

### Industrial gas turbines
- **Industrial Trent 60**: 53 to 66/54 to 62 MW
- **SGT-800**: 48 to 53 MW
- **SGT-750**: 38/39 MW
- **SGT-700**: 33/34 MW

### Aeroderivative gas turbines
- **Industrial RB211**: 27 to 32/28 to 34 MW
- **SGT-600**: 24/25 MW
- **SGT-500**: 19/19 MW
- **SGT-400**: 13 to 14/13 to 15 MW
- **SGT-300**: 8/8 MW to 9 MW
- **SGT-200**: 7/8 MW
- **SGT-100**: 5/6 MW
- **Industrial 501-K**: 4 to 6 MW

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**With Rolls-Royce aeroderivative technology**
Addressing the Energy Trilemma with Decentralized Power

Price of Energy

- High Energy Efficiency
- Competitive Installed Costs
- Modular Packages – ease of future expansion
- Low maintenance costs
- Fast start-up possibilities with no maintenance penalties
- Low cost fuel potential
## Addressing the Energy Trilemma with Decentralized Power

### Price of Energy: Pulse Load Operation

<table>
<thead>
<tr>
<th>100MW Power Plant</th>
<th>ICE</th>
<th>CC ICE</th>
<th>Trent DLE OC</th>
<th>Trent DLE CCGT</th>
<th>Trent + ORC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Load Net Efficiency</td>
<td>%</td>
<td>44</td>
<td>49.2</td>
<td>41.87</td>
<td>53</td>
</tr>
<tr>
<td>Start-up time</td>
<td>Mins</td>
<td>5</td>
<td>50</td>
<td>10</td>
<td>40</td>
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<tr>
<td>Shut-down time</td>
<td>Mins</td>
<td>1</td>
<td>20</td>
<td>5</td>
<td>20</td>
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<tr>
<td>O&amp;M costs (2000 hrs/yr operation)</td>
<td>$/MWh</td>
<td>5.5</td>
<td>5.5</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Start-up costs</td>
<td>$/MW</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

![Graph showing price of energy for pulse load operation]
Security of Supply

- Potential to connect to Grid at Distribution level
- Voltage and frequency support to avoid the need for load shedding
- Multiple units: high station availability / low maintenance downtimes
- Black start and multi-fuel capability
- Fast start and cycling capability
- Potential to combine with energy storage solutions
Environment

- High Efficiency across wide load range through multiple units
- Low combustion emissions across wide load range and on start-up
- Water-free CCGT potential
  - Organic Rankine Cycle
  - Supercritical CO₂
- Reduced construction times through modularity
- Compact Footprint
- Biogas syngas and hydrogen fuel potential
The Future for Power Generation?

Totally Integrated Distributed Energy Solution

Wind Farm
Solar Farm
Energy Storage
Decentralised Power Plant
Natural Gas
Heat
H₂
Syngas
CO₂ Products
GTL Plant
Municipal and Industrial Wastes, Waste Water, Agricultural Residues
Waste Gasifier
Waste Management and Water Treatment Center
Solar Thermal System
Digester Gas
Heat
Heat
Heat
Transform Fuels

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Page 12
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Conclusions

Decentralised Power can play a major role in the future of Power Generation

- Flexibility to meet Market requirements
- Applicable for any power output needs
- Helps address the Energy Trilemma
  - Affordable cost of energy
  - Secure supplies
  - Minimised environmental footprint
- Support for Grids with high penetration of Intermittent Renewables
- Combined with other technologies to maximise operational flexibility
- Non-fossil fuel potential
Thank you for your attention!

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