ORegen™ Waste Heat Recovery: Development and Applications

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ORegen™

ORegen™ is GE Organic Rankine Cycle System designed to recover waste heat energy from GT or similar waste heat sources water & CO₂ free. Developed for power gen & mechanical drive application.

References
#1 17MW system sold in Canada on a pipeline station – delivered in December 2012 – COD Fall 2013
#3 17MW systems sold in China on 3 pipeline stations - delivery in March 2015 – COD August 2015
#1 17MW system sold in Brunei on a powergen station – delivery in December 2014 – COD June 2015
#1 17MW system sold in Thailand on a pipeline station – delivery in February 2015 – COD Summer 2015
Why waste heat recovery?

Gas Turbine

GT simple cycle efficiency: 25÷40%
O&G GT mainly in simple cycle
Global trends: CO₂ emission reduction
Increase efficiency
Increase in power demand

ORegen™

• Electricity production ... sell back to grid
• Help comply with CO₂-related regulations
• Increase plant efficiency

Up to 17MW of power recovery

77% of Oil and Gas installed Gas Turbines are in simple cycle

* ORegen is a trademark of Nuovo Pignone Spa and is available in selected markets
The ORC concept

The Organic Rankine Cycle is a thermodynamic cycle based on the Rankine classic cycle using an organic working fluid. GE selected cyclo-pentane as working fluid.

Working fluid selection by GRC Munich

Cyclo-pentane main characteristic
- Boiling point: 121°F (49.3°C)
- Freezing point: -137°F (-94 °C)
- Molecular Weight: 70.1
- Appearance: clear, colorless liquid
- No corrosion issue on plant equipment
ORegen™ plant schematic & scope of supply

PGT25+ case study ... overall plant efficiency up to 51%

The basic scope of supply for a typical conversion includes the following:

- Organic Fluid C5H10 system
- Diatermic oil system
- Vaporizer & heat exchangers
- Turboexpander genset
- Condenser
- C5 and oil pumps
TE Generator Arrangement (17MW)

- Scalable Size from 5MW to 17MW
- Outdoor installation w/ thermo-acoustic insulation
- Two separate Basements:
  - Ease of transportation
  - Reduced Installation cost
- Equipped with DGS & IGV on both stages

LxWxH:~ 13x4x5.5m
ORegen™ Typical Layout

- Diverter only interface with GT
- GT exhaust stack with ORegen installed
- Waste Heat Oil Heater
- GT exhaust stack
- Diathermal Oil piping
- Turbo-Expander
- Control cab
- C5 condenser
- Cyclo-pentane island
**ORegen™ configurations**

**Direct**

- GT#1
- WHRU
- ORC
- Condenser

**Parallel Oil**

- GT#1
- WHRU #1
- ORC
- Condenser

**Multi cycles**

- GT#1
- WHRU
- ORC#1
- Condenser #1
- ORC#2
- Condenser #2

**Parallel Gas**

- GT#1
- WHRU
- ORC
- Condenser

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Color codes:
- Yellow: To be defined as typical arrangement
- Green: To be scaled up / down from a standard design.
- Blue: To be selected case by case, depending on the site conditions and project requirements
## ORegen™ output

<table>
<thead>
<tr>
<th>GT Model</th>
<th>GT Power (KW)</th>
<th>Exhaust Flow (Kg/sec)</th>
<th>Exhaust Temp (°C)</th>
<th>GT Efficiency (%)</th>
<th>ORC Output (MWe)</th>
<th>System Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGT25 (*)</td>
<td>23 261</td>
<td>68.9</td>
<td>525</td>
<td>37.7%</td>
<td>6.9</td>
<td>48.9%</td>
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<tr>
<td>PGT25+ (*)</td>
<td>31 364</td>
<td>84.3</td>
<td>500</td>
<td>41.1%</td>
<td>7.9</td>
<td>51.5%</td>
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<tr>
<td>PGT25+ G4 (*)</td>
<td>33 973</td>
<td>89.0</td>
<td>510</td>
<td>41.1%</td>
<td>8.6</td>
<td>51.5%</td>
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<td>MS5001 (*)</td>
<td>26 830</td>
<td>125.2</td>
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<td>28.4%</td>
<td>11.3</td>
<td>40.4%</td>
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<tr>
<td>MS5002B (*)</td>
<td>26 100</td>
<td>121.6</td>
<td>491</td>
<td>28.8%</td>
<td>10.8</td>
<td>40.7%</td>
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<td>MS5002C (*)</td>
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<td>124.3</td>
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<td>41.4%</td>
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<tr>
<td>MS5002D (*)</td>
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<td>141.4</td>
<td>509</td>
<td>29.4%</td>
<td>13.8</td>
<td>41.9%</td>
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<tr>
<td>MS5002E (*)</td>
<td>32 000</td>
<td>101.0</td>
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<td>47.2%</td>
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<td>MS6001B (*)</td>
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<td>31.1</td>
<td>44.9%</td>
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<tr>
<td>LM6000 (**)</td>
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<td>125.6</td>
<td>454</td>
<td>41.7%</td>
<td>9.7</td>
<td>51.1%</td>
</tr>
<tr>
<td>LMS100 (**)</td>
<td>100 700</td>
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<td>423</td>
<td>43.8%</td>
<td>15.7</td>
<td>50.8%</td>
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</tbody>
</table>

Reference data @ISO Conditions. 100% GT Turbine load

(*) Values at gas turbine shaft

(**) Values at generator terminals
Case study ORegen™ benefits

First system sold in Canada in a pipeline application

3 GT connected to #1 ORegen
2 units running – 1 stand by

Net Output Power  ~14 MW
Produced Power  ~119,000 MWhr/y
Equivalent to  ~1,100,000 MM BTU/y

Equivalent to  ~38,000 ton/y CO₂ cut

14 MW Recovered power / +9 efficiency points
ORegen™ for Mechanical Drive application

Increase NG flow capability using GT waste heat

Flow Capability Increase
Waste energy used to drive an additional compressor through an ORegen cycle
New compressor in parallel with existing one
Mini ORC 2 MW size

- Modular approach 2 MW size
- Minimum waste heat temp 220°C
- Applicable to small to medium size waste heat sources
- Different working fluid
- Different cycle parameters
- Optimized solution for small gas turbines and low grade waste heat sources

Alternative solution to ORegen from 0.5÷2 MW size
• Efficiency improvement ↑20% ... CO₂ footprint ↓20%
• Carbon credits ... singular enabler
• Cyclo-pentane as working fluid in a closed loop ... no water!

ORegen™
Produce up to 17MW electric power with no additional fuel by recovering heat from GT exhaust