Siemens Organic Rankine Cycle
Waste Heat Recovery with ORC
Requirements of the Future: Efficiency

Benefits of Waste Heat Recovery
- Lowering the CO$_2$ emissions by effective use of waste heat
- Reduced demand on primary energy because more power output can be achieved with the same amount of fuel
- Saved natural resources by reduction of fuel demand
- Enhance sustainability by highest efficiency of the power conversion cycle

Often waste heat is of low temperature quality and it can be difficult to efficiently utilize the quantity heat contained. In these cases the ORC-Technology can bring an additional benefit to raise the overall plant efficiency.

The Organic Rankine Cycle (ORC) unit utilizes this otherwise lost energy and converts it into power.
Decentralized Power Supply

The Organic Rankine Cycle is a perfect solution for decentralized power supply.

The Siemens ORC-Module makes use of medium temperatures around 300 °C and transfers them into electricity up to 2 MW.

The combination of several ORC-Modules allows a higher power output.

Heat for the ORC-Technology can be won from:

- Biomass and biogas
- Sewage gas
- Exhaust gas of gas turbines
- Waste heat of industrial processes
- Process Steam
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- Typical Applications
- Customer Benefits
- Main Components
The ORC-Technology enables Siemens to provide solutions with well-proven components even for heat sources with lower temperatures.

Siemens first utilized its Organic Rankine Cycle Technology in 2013. The working medium is a chlorine free, non-toxic substance with a zero ozone depletion potential.
Power Supply without extra Fuel

The ORC-Module is capable to generate a power output from 300 kW up to 2 MW.
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The Organic Rankine Cycle (ORC) is named after the Scottish engineer and physics William John Macquorn Rankine (1820–1872).

Instead of water-steam, the ORC system vaporizes an organic, high molecular mass fluid with a liquid-vapor phase change, or boiling point, occurring at a lower temperature than the water-steam phase.

The fluid allows ORC-cycle heat recovery from lower temperature sources such as biomass combustion, industrial waste heat, geothermal heat, solar ponds etc. The low-temperature heat is converted into useful work, that can itself be converted into electricity.
Our Technological Answer:
Siemens ORC-Technology
Our Technological Answer: Siemens ORC-Technology

1. Turbine
2. Generator
3. Recuperator
4. Condenser
5. Feed pump
6. Partial flow pre-heater
7. Main flow pre-heater
8. Evaporator
9. Bypass valve
## Benefits of the Siemens ORC-Module

### Efficient:
- Highly efficient ORC-Turbine based on proven Siemens steam turbine SST-060
- Good part load efficiency

### Reliable:
- No blade erosion due to superheated turbine exhaust vapor (dry ORC fluid used)
- ORC-turbine development based on proven SST-060 (more than 850 installations)

### Flexible:
- Wide operation range possible (10-100%)

### Low investment costs:
- Simple and compact plant design
- Lower temperatures and pressures compared to conventional steam applications

### Low operation costs:
- No make-up water treatment necessary
- Unattended operation possible
- Low demand on repair and maintenance
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ORC-Module: Typical Applications

- Biomass & Biogas
- Exhaust Gas of Gas Turbines & Process Steam
- Waste Heat of Industrial Processes
### Typical Industries with Waste Heat

<table>
<thead>
<tr>
<th>Industry</th>
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<tbody>
<tr>
<td>Chemical Industry</td>
</tr>
<tr>
<td>Glass, Cement, Ceramic Industry</td>
</tr>
<tr>
<td>Food &amp; Beverage Industry</td>
</tr>
<tr>
<td>Rubber &amp; Plastic Industry</td>
</tr>
<tr>
<td>Pulp &amp; Paper Industry</td>
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<tr>
<td>Coke Industry</td>
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The ORC-Technology allows the use of waste heat independent from the way of the production of this heat. Any process utilizing waste heat in a certain amount and temperature can drive an Organic Rankine Cycle.
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Customer Benefits

Reference ORC-Modules combine customer requirements and low life-cycle costs due to:

- high design quality by means of pre-planning and check for completeness and collisions
- provision of documentation at project start
- short lead time schedule
- low risk
- high operational flexibility
- high reliability
- high availability
- high process and component efficiency
- high degree of maintainability
The Siemens ORC-Modules
3D layout 1000 kW module

1. Pump
2. Recuperator / Condenser
3. Turbine
4. Generator
5. Evaporator
6. Preheater
Siemens ORC-Modules
Arrangement of the 1000 kW module

Following arrangement concept has been fixed:

- Base frame for the evaporator and pre-heaters (as one functional unit)
- Turbine and generator on separate turbine base frame (as one functional unit)
- Recuperator directly placed on the foundation
- Feed pump located in a separate room or cellar below the ORC-Module (required due to the NPSH requirement of the feed pump)
- Electrical equipment of the ORC-Module installed in pre-fabricated cabinets and located at the ORC room wall
- Operator workstation of ORC-Module located in the customer’s central control room
## Reference ORC-Modules
Standard modules for CHP applications

<table>
<thead>
<tr>
<th>Module</th>
<th>ORC-Module1</th>
<th>ORC-Module2</th>
<th>ORC-Module3</th>
<th>ORC-Module4</th>
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<tbody>
<tr>
<td><strong>Performance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power output</td>
<td>kW</td>
<td>400</td>
<td>600</td>
<td>1000</td>
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<tr>
<td>Aux. power consumption</td>
<td>kW</td>
<td>25</td>
<td>33</td>
<td>52</td>
</tr>
<tr>
<td>Efficiency gross</td>
<td></td>
<td>18.4%</td>
<td>19.4%</td>
<td>19.6%</td>
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<tr>
<td><strong>Heat Input ORC-Module</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High temperature (HT) circuit</td>
<td>kWth</td>
<td>1990</td>
<td>2840</td>
<td>4680</td>
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<tr>
<td>Nominal temperature HT circuit</td>
<td>ºC</td>
<td>300/240</td>
<td>300/240</td>
<td>300/240</td>
</tr>
<tr>
<td>Low temperature (LT) circuit</td>
<td>kWth</td>
<td>180</td>
<td>260</td>
<td>420</td>
</tr>
<tr>
<td>Nominal temperature LT circuit</td>
<td>ºC</td>
<td>240/140</td>
<td>240/140</td>
<td>240/140</td>
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<tr>
<td>Sum heat input</td>
<td>kWth</td>
<td>2170</td>
<td>3100</td>
<td>5100</td>
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<tr>
<td><strong>Condenser Output</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal temperature (in/out)</td>
<td>ºC</td>
<td>60/80</td>
<td>60/80</td>
<td>60/80</td>
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<tr>
<td>Heat transfer to DH system</td>
<td>kWth</td>
<td>1740</td>
<td>2450</td>
<td>4050</td>
</tr>
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Siemens ORC-Module: Main Components
Industrial turbine SST-060 (1/2)

- The SST-060 stands out by rugged design and renowned reliability even under the most severe operating conditions.
- It is ideal for saturated steam conditions.
- Its suitability for use as condensation or back-pressure turbine in combination with various integral gear modules opens up a broad application range.

Range of application:
- Waste to energy plants
- Biomass plants
- Combined cycle plants
- District heating plants
- Industrial steam power plants
- ORC applications
Siemens ORC-Module: Main Components

Industrial turbine SST-060 (2/2)

Key figures
- Live Steam Parameters
  - Inlet Pressure: $\leq 131$ bar/$1,900$ psi
  - Inlet Temperature: $\leq 530^\circ$C/$985^\circ$F
- Exhaust conditions
  - Back-pressure: $\leq 29$ bar/$420$ psi
  - District Heating: possible
  - Condensing: $\geq 0.08$ bar(a)
- Power output: up to $6,000$ kW

Design features
- Backpressure or condensing type
- Package unit design
- Oil unit integrated in base frame
- Quick-start without pre-heating
- ATEX version available
- Suitable for ORC (Organic Rankine Cycle)
Siemens ORC-Module: Main Components
The recuperator and working medium

The recuperator
Siemens delivers a recuperative ORC-Technology. Here a recuperator is used employing the turbine outlet vapor to heat up the liquid working fluid going via the pre-heater to the evaporator.

The recuperator reduces the heat load in the evaporator and herewith increases the thermal efficiency to produce more power.

The working medium
The working medium indicates optimal characteristics for a working fluid: It is a silicon oil, which is a chlorine free, non-toxic, substance with a zero ozone depletion potential.
Contact

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