INCREASE YOUR ENERGY EFFICIENCY WITH OUR SOLUTIONS.
TURBODEN FOR INDUSTRIAL PROCESS

We provide energy efficiency solutions to increase the sustainability of your industrial process.
OUR PRODUCTS

ORC SYSTEM

LARGE HEAT PUMP

GAS EXPANDER

Designed for decarbonisation.
Turboden Organic Rankine Cycle (ORC) units can produce electricity by recovering residual low-grade heat from industrial processes and from internal combustion engines, gas turbines, and fuel cells operating on open cycle. The generated power ranges up to 20 MW electric per single shaft.

### WHY CHOOSE ORC FOR ENERGY EFFICIENCY?

- Generate profit by valorising a waste heat source
- Reduce specific production cost by decreasing energy demand
- Improve company sustainability
- Contribute to lower carbonisation and combat climate change
ENERGY EFFICIENCY IN YOUR BUSINESS

PRODUCTION PROCESSES
Unexploited heat streams produced by industrial processes like cement, glass, steel, ferroalloy, non-ferrous metals (copper, aluminum, etc.), silicon metal, carbon black, etc.

OPEN CYCLES
Exhaust gases released by gas turbines, internal combustion engines, and fuel cells operating on open cycle.

OUTPUT
ELECTRIC POWER and/or MECHANICAL POWER

Last update: April 2020

41 plants in heat recovery
THE ORC CYCLE – HOW IT WORKS

The ORC turbogenerator uses medium-to-high temperature thermal oil to preheat and vaporize a suitable organic working fluid in the evaporator (4>5).

The organic fluid vapor rotates the turbine (5>6), which is directly coupled to the electric generator, resulting in clean, reliable electric power.

The exhaust vapor flows through the regenerator (6>7), where it heats the organic liquid (2>3) and is then condensed in the condenser and cooled by the cooling circuit (7>8>1).

The organic working fluid is then pumped (1>2) into the regenerator and evaporator, thus completing the closed-cycle operation.

The waste heat from production process is transferred to the ORC working fluid by means of an intermediate circuit or directly via the exhaust gases in direct exchange systems. The media used in the intermediate circuits are thermal oil, saturated steam or superheated water.
THERMODYNAMIC CYCLE: ORC VS STEAM

STEAM RANKINE CYCLE

- Superheating needed
- Risk of blade erosion due to possible liquid formation during the expansion
- High enthalpy drop – turbine with high stage number

ORGANIC RANKINE CYCLE

- No need to superheat
- No risk of blade erosion thanks to dry expansion in the turbine
- Small enthalpy drop - turbine with low stage number

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**Thermodynamic features and consequences**

- Water treatment required
- Highly skilled personnel needed
- Periodic major overhaul
- Water-free system
- Minimum Operation & Maintenance cost
- No major overhaul
- Completely automatic

**Operation and maintenance costs**

- Low flexibility with significantly lower performances at partial load
- Convenience for large plants and high temperatures
- High flexibility - Wide operational range from 10% to 110%
- High availability (average >98%)
COMPARISON WITH STEAM TECHNOLOGY

NOTE: steam turbine suffers partial load operation due to high risk of blade erosion.
ORC SYSTEM FEATURES

Simplicity
- Remote monitoring and automatic operation
- No water use and treatment required
- Minimal maintenance activities

Flexibility
- Ease of integration
- Excellent part load capability down to 10% load
- Different primary energy sources

Dependability
- High availability
- Long life (> 25 years)
- 40 years in the design and production of turbomachinery

Sustainability
- Core system for renewable energy and energy efficiency
- Clean generation of power and heat
- Reduction of CO₂ emissions
Large Heat Pumps are utility-scale heating plants that supply large quantities of high-temperature heat exploiting a colder energy source that would otherwise be wasted, e.g. through cooling towers. Hence, industrial processes or district heating networks can benefit from this new higher-grade heat source.

**KEY POINTS**

- Large-scale: output from 3 MWth to 30 MWth per unit
- High-temperature lift (ΔT up to 80°C and more)
- High-temperature output: above 100°C, including steam generation
- Various industrial applications: steel, chemicals, food & beverages, glass, refractories, pulp & paper, etc.
LARGE HEAT PUMP SCHEMATIC

WASTE HEAT SOURCES

- Cooling in industrial processes
- Power plants waste heat
- Other waste heat
- Waste water
- Ground source
- River water

INDUSTRIAL PROCESS or DISTRICT HEATING

CONDENSER

ELECTRIC POWER (FROM THE GRID OR DEDICATED POWER PLANTS)

VALVE

COMPRESSOR

EVAPORATOR

WASTE HEAT
The low-grade heat that needs to be dissipated to cool a distillation column (n.1) can feed a LHP and therefore be used to displace other sources of higher-temperature heat in another distillation column (n.2).
EXAMPLE: STEELWORKS

Heat from the cooling of the steelmaking process can be upgraded through a LHP and used for district heating instead of being wasted, i.e. dissipated through cooling towers.
GAS EXPANDER

Turboden gas expander is an alternative solution to standard lamination valves, aimed at enhancing the energy efficiency of gas-intensive industries (or industrial parks). It produces clean electricity by exploiting gas pressure drop, otherwise wasted, from the delivery level to the one required by the industrial process. The decarbonised electricity is then delivered to the factory, reducing the associated costs.

- Design based on 40 years of experience, leveraging Mitsubishi Heavy Industries support
- Profit generation while reducing the gas pressure
- Improvement of industry green footprint
- Unmanned installations, thanks to specific technology features
- Over 60 Turboden turbine models within the 390 power plants fleet
GAS EXPANDER CONFIGURATION

GAS FEEDING LINE

GAS REDUCTION AND MEASUREMENT SYSTEM

NATURAL GAS

GAS EXPANSION SYSTEM

ELECTRIC POWER

GAS-INTENSIVE INDUSTRY
It is a technology developed to properly fit the natural gas pressure and flow rate distinctive of gas-intensive industries.

<table>
<thead>
<tr>
<th>EXPANDERS SIZES</th>
<th>EXP 400</th>
<th>EXP 600</th>
<th>EXP 900</th>
<th>EXP &gt; 1 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Turbine stages/admission</td>
<td>Single stage radial turbine</td>
<td></td>
<td>Multi stages axial turbine</td>
<td></td>
</tr>
<tr>
<td>✓ Flow rate</td>
<td>&gt;5000 Sm3/h</td>
<td></td>
<td>5,000 - 100,000 Sm3/h</td>
<td></td>
</tr>
<tr>
<td>✓ In - out gas pressure range</td>
<td></td>
<td></td>
<td>70 - 1 bar(g)</td>
<td></td>
</tr>
<tr>
<td>✓ Bearings</td>
<td>Magnetic or rolling bearing</td>
<td></td>
<td>Rolling bearing oil lubricated</td>
<td></td>
</tr>
<tr>
<td>✓ Seals</td>
<td>Single tight casing for impeller and generator</td>
<td></td>
<td>Mechanical</td>
<td></td>
</tr>
<tr>
<td>✓ Generator</td>
<td>Permanent Magnet generator</td>
<td></td>
<td>A/Synchronous LV - Eff. 97%</td>
<td></td>
</tr>
<tr>
<td>✓ Containerization</td>
<td>Sandwich panel REI 120 if 10m gate distance possible; or concrete if 2m gate distance possible. Necessary to segregate electrical panel and hot water boiler.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ Gas pre-heating</td>
<td>Hot water boiler fed by natural gas and shell&amp;tube heat exchangers + possible combination with electrical heaters and heat pumps – custom based on project specific.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CEMENT
WASTE HEAT RECOVERY IN CEMENT INDUSTRY

In cement production process, Turboden ORC systems can produce electric power by recovering waste heat from two hot gas streams:

- kiln pre-heater (PH) gas
- clinker cooler (CC) gas

Turboden ORC systems are easy to integrate, with no impact on industrial process or prime equipment (engine, gas turbine) operation.
## TURBODEN REFERENCES IN CEMENT

<table>
<thead>
<tr>
<th>PLANT</th>
<th>COUNTRY</th>
<th>START UP</th>
<th>KILN CAPACITY (ton/day)</th>
<th>HEAT SOURCE</th>
<th>HEAT CARRIER</th>
<th>ORC GROSS EL. POWER (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIMENTS DU MAROC</td>
<td>Morocco</td>
<td>2010</td>
<td>5,000</td>
<td>PH</td>
<td>thermal oil</td>
<td>2,000</td>
</tr>
<tr>
<td>(HeidelbergCement Group, former Italcementi)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOLCIM ROMANIA</td>
<td>Romania</td>
<td>2012</td>
<td>4,000</td>
<td>PH + CC</td>
<td>thermal oil + superheated water</td>
<td>4,000</td>
</tr>
<tr>
<td>(LafargeHolcim Group)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRH SLOVAKIA</td>
<td>Slovakia</td>
<td>2014</td>
<td>3,600</td>
<td>PH + CC</td>
<td>thermal oil</td>
<td>5,000</td>
</tr>
<tr>
<td>(former Holcim Group)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CARPATEMENT</td>
<td>Romania</td>
<td>2015</td>
<td>3,500</td>
<td>PH + CC</td>
<td>thermal oil</td>
<td>3,800</td>
</tr>
<tr>
<td>(HeidelbergCement Group)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JURA-CEMENT-FABRIKEN</td>
<td>Switzerland</td>
<td>2016</td>
<td>3,000</td>
<td>PH</td>
<td>superheated water</td>
<td>2,300</td>
</tr>
<tr>
<td>(CRH Group)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEMENTI ROSSI</td>
<td>Italy</td>
<td>2018</td>
<td>3,500</td>
<td>PH + CC</td>
<td>none – direct exchange</td>
<td>2,000</td>
</tr>
<tr>
<td>ÇİMKO</td>
<td>Turkey</td>
<td>2019</td>
<td>9,500</td>
<td>CC</td>
<td>thermal oil</td>
<td>7,000</td>
</tr>
<tr>
<td>(Sanko Group) - EPC: CTP Team</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOLCIM SUISSE ECLÉPENS</td>
<td>Switzerland</td>
<td>2020</td>
<td>2,300</td>
<td>PH + CC</td>
<td>thermal oil</td>
<td>1,300</td>
</tr>
<tr>
<td>(LafargeHolcim Group)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SÖNMEZ ÇİMENTO</td>
<td>Turkey</td>
<td>under construction</td>
<td>6,000</td>
<td>PH + CC</td>
<td>thermal oil</td>
<td>7,300</td>
</tr>
<tr>
<td>EPC: CTP Team</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
HOLCIM ROMANIA

CUSTOMER:
Holcim Romania (LafargeHolcim Group)

COUNTRY:
Romania

ORC ELECTRIC POWER:
4 MW

STATUS:
in operation since 2012

CLINKER PRODUCTION CAPACITY:
≈ 4,000 ton/day

HEAT SOURCE:
pre-heater exhaust gas + clinker cooler air

HEAT CARRIER:
thermal oil + superheated water

COOLING SYSTEM:
water cooled condenser + cooling towers (open loop)
CRH

CUSTOMER: CRH (former Holcim Group)
COUNTRY: Slovakia
ORC ELECTRIC POWER: 5 MW
STATUS: in operation since 2014
CLINKER PRODUCTION CAPACITY: ≈ 3,600 ton/day
HEAT SOURCE: pre-heater exhaust gas + clinker cooler air
HEAT CARRIER: thermal oil
COOLING SYSTEM: water cooled condenser + cooling towers (open loop)
CARPATCEMENT

CUSTOMER: Carpatcement (HeidelbergCement Group)

COUNTRY: Romania

ORC ELECTRIC POWER: 3.8 MW

STATUS: in operation since 2015

CLINKER PRODUCTION CAPACITY: ≈ 3,500 ton/day

HEAT SOURCE: pre-heater exhaust gas + clinker cooler air

HEAT CARRIER: thermal oil

COOLING SYSTEM: air cooled condenser (no water consumption)
CUSTOMER:
CTP Team / Çimko (Sanko Holding)

COUNTRY:
Turkey

ORC ELECTRIC POWER:
7 MW

STATUS:
in operation since 2019

CLINKER PRODUCTION CAPACITY:
≈ 9,500 ton/day

HEAT SOURCE:
clinker cooler air

HEAT CARRIER:
thermal oil

COOLING SYSTEM:
air cooled condenser (no water consumption)
CUSTOMER: CTP Team / Sönmez Çimento
COUNTRY: Turkey
ORC ELECTRIC POWER: 7.3 MW
STATUS: under construction
CLINKER PRODUCTION CAPACITY: ≈ 6,000 ton/day
HEAT SOURCE: pre-heater exhaust gas + clinker cooler air
HEAT CARRIER: thermal oil
COOLING SYSTEM: air cooled condenser (no water consumption)
STEEL & METALS
INTEGRATED STEEL PLANTS
(SINTER COOLER, ETC.)
medium temperature, high flow rate

ELECTRIC ARC FURNACE
(EAF)
high flow rate at high temperatures, high dust content, large variations in operating cycle

SUBMERGED ARC FURNACE
(SAF)
high flow rate at medium temperatures, medium dust content, stable flow rate

PROCESS FURNACE
(RE-HEATING, ETC.)
low temperature power available, small WHR plants

MAIN HEAT SOURCES
# TURBODEN REFERENCES IN STEEL & METAL

<table>
<thead>
<tr>
<th>PLANT</th>
<th>START UP</th>
<th>MAIN PROCESS EQUIPMENT</th>
<th>HEAT CARRIER</th>
<th>ORC gross electric power (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NATSTEEL</strong> Singapore</td>
<td>2013</td>
<td>steel rolling mill billet reheating furnace</td>
<td>none – direct exchange</td>
<td>700</td>
</tr>
<tr>
<td><strong>ELBE STAHLWERKE FERALPI</strong> Germany</td>
<td>2013</td>
<td>steel electric arc furnace</td>
<td>saturated steam</td>
<td>2,700</td>
</tr>
<tr>
<td><strong>ORI MARTIN</strong> Italy</td>
<td>2016</td>
<td>steel electric arc furnace</td>
<td>saturated steam</td>
<td>2,200</td>
</tr>
<tr>
<td><strong>FONDERIA DI TORBOLE</strong> Italy</td>
<td>2016</td>
<td>iron cupola furnace</td>
<td>thermal oil</td>
<td>700</td>
</tr>
<tr>
<td><strong>ARVEDI</strong> Italy</td>
<td>2018</td>
<td>steel electric arc furnace</td>
<td>saturated steam</td>
<td>10,000</td>
</tr>
<tr>
<td><strong>SAFRAN</strong> EPC: INVEST ENERGY Malaysia</td>
<td>2019</td>
<td>chemical vapor infiltration furnace</td>
<td>thermal oil</td>
<td>1,900</td>
</tr>
<tr>
<td><strong>POSCO ICT</strong> South Korea</td>
<td>2019</td>
<td>Fe-Mn submerged arc furnace</td>
<td>thermal oil</td>
<td>1,200</td>
</tr>
<tr>
<td><strong>SACAL</strong> Italy</td>
<td>2019</td>
<td>aluminum rotative furnaces</td>
<td>thermal oil</td>
<td>2,100</td>
</tr>
</tbody>
</table>

## Note
- ORC: Organic Rankine Cycle
- EPC: Engineering, Procurement, and Construction
ESF ELBE-STAHLWERKE FERALPI

CUSTOMER:
ESF Elbe-Stahlwerke Feralpi GmbH

COUNTRY:
Germany

ORC ELECTRIC POWER:
2.7 MW

STATUS:
in operation since 2013

TYPE OF PROCESS FOR WHR:
steel - electric arc furnace

HEAT SOURCE:
EAF exhaust gas

HEAT CARRIER:
saturated steam

COOLING SYSTEM:
water cooled condenser + cooling towers (open loop)
FONDERIA DI TORBOLE

CUSTOMER:
Fonderia di Torbole

COUNTRY:
Italy

ORC ELECTRIC POWER:
0.7 MW

STATUS:
in operation since 2016

TYPE OF PROCESS FOR WHR:
iron cupola furnace

HEAT SOURCE:
cupola furnace exhaust gas

HEAT CARRIER:
thermal oil

COOLING SYSTEM:
water cooled condenser + air coolers (no water consumption)
ARVEDI

CUSTOMER:
Arvedi S.p.A.

COUNTRY:
Italy

ORC ELECTRIC POWER:
10 MW

STATUS:
in operation since 2018

TYPE OF PROCESS FOR WHR:
steel - electric arc furnace

HEAT SOURCE:
EAF exhaust gas

HEAT CARRIER:
saturated steam

COOLING SYSTEM:
water cooled condenser + cooling towers (open loop)
CUSTOMER: ORI Martin
COUNTRY: Italy
ORC ELECTRIC POWER: 2.2 MW
STATUS: in operation since 2016
TYPE OF PROCESS FOR WHR: steel - electric arc furnace
HEAT SOURCE: EAF exhaust gas
HEAT CARRIER: saturated steam
COOLING SYSTEM: water cooled condenser + cooling towers (open loop)
GLASS

Waste heat can be recovered from the production process of:

- Float glass
- Container glass
## NEW SOLUTIONS FOR CONTAINER GLASS

### ELECTRIC POWER

- ORC TURBINE
- ELECTRIC GENERATOR

### COMPRESSED AIR

- ORC TURBINE
- AIR COMPRESSOR

### POWER & AIR

- ORC TURBINE
- ELECTRIC GENERATOR
- AIR COMPRESSOR

- **NEW SCHEME**

- **HYBRID SCHEME**
  - Up to 800 kW
  - Modular design
  - Direct exchange configuration

### FOR CONTAINER GLASS
## TURBODEN REFERENCES IN GLASS INDUSTRY

<table>
<thead>
<tr>
<th>PLANT</th>
<th>COUNTRY</th>
<th>START UP</th>
<th>MAIN PROCESS EQUIPMENT</th>
<th>HEAT CARRIER</th>
<th>ORC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>type</td>
<td>capacity</td>
<td>gross electric power (kW)</td>
</tr>
<tr>
<td>AGC (GEA Bishoff)</td>
<td>Italy</td>
<td>2012</td>
<td>float glass</td>
<td>600 ton/d</td>
<td>thermal oil</td>
</tr>
<tr>
<td>undisclosed</td>
<td>Italy</td>
<td>2015</td>
<td>container glass</td>
<td>500 ton/d</td>
<td>thermal oil</td>
</tr>
<tr>
<td>DÜZCE CAM (Çalbıyık Grup)</td>
<td>Turkey</td>
<td>2018</td>
<td>float glass</td>
<td>2 x 600 ton/d</td>
<td>thermal oil</td>
</tr>
<tr>
<td>SAINT-GOBAIN (GEA Bishoff)</td>
<td>India</td>
<td>under construction</td>
<td>float glass</td>
<td>600 ton/d</td>
<td>thermal oil</td>
</tr>
<tr>
<td>SAINT-GOBAIN (GEA Process Engineering)</td>
<td>Italy</td>
<td>2019</td>
<td>float glass</td>
<td>600 ton/d</td>
<td>thermal oil</td>
</tr>
</tbody>
</table>

(1,200 mechanical power used to produce compressed air)
AGC

EPC / FINAL USER:
GEA Bischoff / AGC Flat Glass Italia

COUNTRY:
Italy

STATUS:
in operation since February 2012

ORC ELECTRIC POWER:
1.3 MW

GLASS PRODUCTION CAPACITY:
600 ton/day

HEAT SOURCE:
float glass furnace exhaust gas

HEAT CARRIER:
thermal oil

COOLING SYSTEM:
water cooled condenser + cooling towers
GLASS PRODUCER

EPC / FINAL USER:
undisclosed

COUNTRY:
Italy

STATUS:
in operation since May 2015

ORC ELECTRIC POWER:
0.5 MW

GLASS PRODUCTION CAPACITY:
500 ton/day

HEAT SOURCE:
container glass furnace exhaust gas

HEAT CARRIER:
thermal oil

COOLING SYSTEM:
water cooled condenser + closed loop cooling towers
DÜZCE CAM

EPC / FINAL USER:
Calbiyık Grup / Düzce Cam

COUNTRY:
Turkey

STATUS:
in operation since September 2018

ORC ELECTRIC POWER:
6.2 MW

GLASS PRODUCTION CAPACITY:
2 x 600 ton/day

HEAT SOURCE:
two float glass furnaces exhaust gas

HEAT CARRIER:
thermal oil

COOLING SYSTEM:
air cooled condenser (no water consumption)
SAINT GOBAIN ITALY

EPC / FINAL USER:
GEA Process engineering / Saint Gobain Italy

COUNTRY:
Italy

STATUS:
in operation since September 2019

SOLUTION:
ORC turbine connected to double-shaft generator and air compressor

ORC ELECTRIC POWER:
1 MW

COMPRESSED AIR PRODUCTION:
84 Nm3/min at 7 bar(g)

GLASS PRODUCTION CAPACITY:
600 ton/day

HEAT SOURCE:
float glass furnace exhaust gas

HEAT CARRIER:
thermal oil

COOLING SYSTEM:
water cooled condenser + closed loop cooling towers
COMBINED CYCLES
OVERALL PLANT PERFORMANCES

**GAS TURBINES**

30÷40% ORC additional power*

- Usefulness power: 18 ÷ 30%
- Thermal power: 80 ÷ 68%
- Thermal losses: 2%

**INTERNAL COMBUSTION ENGINES**

10% ORC additional power*

- Usefulness power: 18 ÷ 26%
- Thermal power: 80 ÷ 72%
- Thermal losses: 2%

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* ORC power output compared to GT or ICE shaft capacity (e.g. 10 MW GT → 3÷4 MWe ORC; 10 MW ICE → approx. 1 MWe ORC).
** Min. flow to ORC: from GT 10-15 kg/s; from ICE 30-40 kg/s.
*** Mechanical and/or electric, calculated on thermal power input to ORC.
EXHAUST GAS HEAT RECOVERY EXCHANGER CONFIGURATION

- EGHEs installed in **by-pass** to the main exhaust gas ducting in order to avoid any impact on the gas turbines operation in any circumstance.
- **EGHEs completely isolable** with a diverter prior to the EGHEs and an insulation valve right after it. Diverter equipped with air sealing to ensure 100% insulation. This permits to **insulate the EGHEs, ensuring gas turbines operation** even in case of major issues on the EGHEs.
- Pneumatic **safety-closed diverter** to avoid any impact on gas turbines operation even during emergency situation.
- EGHE equipped with sparking detector, flame detector and thermocouples in different bundle position to ensure the maximum safety of the system.
- **False air** fan installed in order to keep the EGHE temperature at acceptable level even in case of gas turbines particular operation cases.
<table>
<thead>
<tr>
<th>PLANT</th>
<th>COUNTRY</th>
<th>START UP</th>
<th>ORC SIZE (MWe)</th>
<th>HEAT SOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSGAS</td>
<td>Canada</td>
<td>2011</td>
<td>1</td>
<td>Solar Centaur 40 gas turbine in gas compressor station</td>
</tr>
<tr>
<td>UZTRANSGAZ</td>
<td>Uzbekistan</td>
<td>under commissioning</td>
<td>1</td>
<td>3 GE LM 1600 gas turbines in gas compressor station</td>
</tr>
<tr>
<td>SHURTANNEFTEGAZ</td>
<td>Uzbekistan</td>
<td>under construction</td>
<td>5.5</td>
<td>1 MW GE LM 2500 gas turbine in gas compressor station</td>
</tr>
<tr>
<td>PISTICCI I</td>
<td>Italy</td>
<td>2010</td>
<td>1.8</td>
<td>3 x 8 MWe Wärtsilä diesel engines</td>
</tr>
<tr>
<td>TERMOINDUSTRIALE</td>
<td>Italy</td>
<td>2008</td>
<td>0.5</td>
<td>1 x 8 MWe MAN diesel engine</td>
</tr>
<tr>
<td>PISTICCI II</td>
<td>Italy</td>
<td>2012</td>
<td>4</td>
<td>2 x 17 MWe Wärtsilä diesel engines</td>
</tr>
<tr>
<td>CEREAL DOCKS</td>
<td>Italy</td>
<td>2012</td>
<td>0.5 (direct exchange)</td>
<td>1 x 7 MWe Wärtsilä diesel engine</td>
</tr>
<tr>
<td>E&amp;S ENERGY</td>
<td>Italy</td>
<td>2010</td>
<td>0.6</td>
<td>2 x 1 MWe Jenbacher gas engines + 3 x 0.8 MWe Jenbacher gas engines + 1 x 0.6 MWe Jenbacher gas engine – landfill gas</td>
</tr>
<tr>
<td>ULM</td>
<td>Germany</td>
<td>2012</td>
<td>0.7</td>
<td>2 x 2 MW Jenbacher gas engines (+ additional heat from process)</td>
</tr>
<tr>
<td>KEMPEN</td>
<td>Germany</td>
<td>2012</td>
<td>0.6</td>
<td>Gas engines</td>
</tr>
<tr>
<td>MONDO POWER</td>
<td>Italy</td>
<td>2012</td>
<td>1</td>
<td>1 x 17 MWe Wärtsilä diesel engine</td>
</tr>
<tr>
<td>HSY</td>
<td>Finland</td>
<td>2011</td>
<td>1.3</td>
<td>4 x 4 MWe MWM gas engines – landfill gas</td>
</tr>
<tr>
<td>FATER</td>
<td>Italy</td>
<td>2013</td>
<td>0.7 (direct exchange)</td>
<td>1 x 8 MWe Wärtsilä diesel engine</td>
</tr>
<tr>
<td>ORTADOGU I</td>
<td>Turkey</td>
<td>2020</td>
<td>2.3</td>
<td>12 x 1.4 MWe Jenbacher engines – landfill gas</td>
</tr>
<tr>
<td>ORTADOGU II</td>
<td>Turkey</td>
<td>under construction</td>
<td>2 x 2.3</td>
<td>20 x 1.4 MWe Jenbacher engines + 4 x 1.2 MWe MWM engines – landfill gas</td>
</tr>
<tr>
<td>BIOGASTECH</td>
<td>Belgium</td>
<td>2019</td>
<td>0.7</td>
<td>4 x 3.3 MWe Jenbacher gas engines</td>
</tr>
</tbody>
</table>
TRANSGAS

CUSTOMER:
TransGas

COUNTRY:
Canada

STATUS:
in operation since 2011

DESCRIPTION:
power generation from waste heat from Solar Centaur 40 gas turbine in a gas compressor station

ORC ELECTRIC POWER:
1 MW (more than 28% of gas turbine shaft power)

GAS TURBINE PRIME POWER:
3.5 MWm

GAS TURBINE EFFICIENCY:
28%
CUSTOMER: Uztransgaz
COUNTRY: Uzbekistan
STATUS: under finalization of commissioning
DESCRIPTION: power generation from waste heat from 3 GE LM 1600 gas turbines in Hodzhaabad gas compressor station operated by Uztransgaz
ORC ELECTRIC POWER: 1 MW - island mode operation. The ORC unit covers the compressor station captive consumption
FEATURES: solution with air-cooled condenser, no water needed, containerized solution
CUSTOMER: Shurtanneftegaz

COUNTRY: Uzbekistan

STATUS: contract signed, engineering completed, waiting for project execution starting

DESCRIPTION: power generation from waste heat from 1 MW GE LM 2500 gas turbine in Shurtan gas compressor station operated by Shurtanneftegaz, part of Uzneftegazdobycha, a subdivision of the National Holding Company Uzbekneftegaz.

ORC ELECTRIC POWER: 5.5 MW - island mode operation. The ORC unit covers the compressor station captive consumption.
CEREAL DOCKS

CUSTOMER:
Cereal Docks

COUNTRY:
Italy

STATUS:
in operation since 2012

DESCRIPTION:
power generation from exhaust gas of 1 x 7 MWe Wärtsilä diesel engine

ORC ELECTRIC POWER:
0.5 MW

HEAT CARRIER:
none – direct exchange

COOLING SYSTEM:
water cooled condenser + air coolers (closed water loop)
HSY

CUSTOMER: Helsinki Region Environmental Services Authority HSY

COUNTRY: Finland

STATUS: in operation since 2011

DESCRIPTION: power generation from exhaust gas of 4 x 4 MWe MWM gas engines – landfill gas

ORC ELECTRIC POWER: 1.3 MW

HEAT CARRIER: thermal oil

COOLING SYSTEM: water cooled condenser + air coolers (closed water loop)
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