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.
ORC SYSTEM

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

40+ plants in heat recovery

Last update: November 2021
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

**Thermodynamic features and consequences**

- Water treatment required
- Highly skilled personnel needed
- Periodic major overhaul

**Operation and maintenance costs**

- Water-free system
- Minimum Operation & Maintenance cost
- No major overhaul
- Completely automatic

**Other features**

- 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

Actual efficiency / Nominal efficiency

Actual load / Nominal load

- ORC
- STEAM

50% PARTIAL LOAD
ORC 90%
STEAM 70%

30% PARTIAL LOAD
ORC 80%
STEAM 55%

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.
Industrial processes

WASTE HEAT SOURCES

- Cooling in industrial processes
- Power plants waste heat
- Other waste heat
- Waste water
- Ground source
- River water
CASE STUDY: LHP IN A CHEMICAL PLANT

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.

KEY POINTS

- 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 400+ power plants fleet
GAS EXPANDER CONFIGURATION

GAS FEEDING LINE

GAS REDUCTION AND MEASUREMENT SYSTEM

NATURAL GAS

GAS EXPANSION SYSTEM

ELECTRIC POWER

GAS-INTENSIVE INDUSTRY

Industrial processes
GAS EXPANDER RATING

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>20,000 - 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>Rolling bearings</td>
<td>Self-lubricated rolling bearings</td>
<td></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>

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CEMENT
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>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>HOLCIM ROMANIA</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>(LafargeHolcim Group)</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>CRH SLOVAKIA</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>(former Holcim Group)</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>CARPATCEMENT</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>(HeidelbergCement Group)</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>JURA-CEMENT-FABRIKEN</td>
<td>Turkey</td>
<td>2020</td>
<td>6,000</td>
<td>PH + CC</td>
<td>thermal oil</td>
<td>7,300</td>
</tr>
<tr>
<td>(CRH Group)</td>
<td>Portugal</td>
<td>Under construction</td>
<td>3,800</td>
<td>PH + CC</td>
<td>thermal oil</td>
<td>7,200</td>
</tr>
<tr>
<td>CEMENTI ROSSI</td>
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<tr>
<td>ÇİMKO</td>
<td></td>
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</tr>
<tr>
<td>(Sanko Group) - EPC: CTP Team</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>HOLCIM SUISSE ECLÉPENS</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(LafargeHolcim Group)</td>
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</tr>
<tr>
<td>SÖNMEZ ÇİMENTO</td>
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<tr>
<td>EPC: CTP Team</td>
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<tr>
<td>SECIL</td>
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</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)
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)
SÖNMEZ ÇIMENTO

CUSTOMER:
CTP Team / Sönmez Çimento

COUNTRY:
Turkey

ORC ELECTRIC POWER:
7.3 MW

STATUS:
in operation since 2020

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)
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>billet</td>
<td>none – direct exchange</td>
</tr>
<tr>
<td><strong>ELBE STAHLWERKE FERALPI</strong> Germany</td>
<td>2013</td>
<td>steel electric arc furnace</td>
<td>scrap</td>
<td>saturated steam</td>
</tr>
<tr>
<td><strong>ORI MARTIN</strong> Italy</td>
<td>2016</td>
<td>steel electric arc furnace</td>
<td>scrap - consteel</td>
<td>saturated steam</td>
</tr>
<tr>
<td><strong>FONDERIA DI TORBOLE</strong> Italy</td>
<td>2016</td>
<td>iron cupola furnace</td>
<td>scrap, pigs</td>
<td>thermal oil</td>
</tr>
<tr>
<td><strong>ARVEDI</strong> Italy</td>
<td>2018</td>
<td>steel electric arc furnace</td>
<td>scrap</td>
<td>saturated steam</td>
</tr>
<tr>
<td><strong>SAFRAN</strong> EPC: INVEST ENERGY Malaysia</td>
<td>2019</td>
<td>chemical vapor infiltration furnace</td>
<td>n.a.</td>
<td>thermal oil</td>
</tr>
<tr>
<td><strong>POSCO ICT</strong> South Korea</td>
<td>2019</td>
<td>Fe-Mn submerged arc furnace</td>
<td>raw materials</td>
<td>thermal oil</td>
</tr>
<tr>
<td><strong>SACAL</strong> Italy</td>
<td>2019</td>
<td>aluminum rotative furnaces</td>
<td>scrap</td>
<td>thermal oil</td>
</tr>
</tbody>
</table>
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)
ORI MARTIN

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)
Waste heat can be recovered from the production process of:

- Float glass
- Container glass
NEW SOLUTIONS FOR CONTAINER GLASS

TYPICAL SCHEME
- ELECTRIC POWER
- ORC TURBINE
- ELECTRIC GENERATOR

NEW SCHEME
- COMPRESSED AIR
- ORC TURBINE
- AIR COMPRESSOR

HYBRID SCHEME
- POWER & AIR
- ORC TURBINE
- ELECTRIC GENERATOR
- AIR COMPRESSOR

- Up to 800 kW
- Modular design
- Direct exchange configuration
### 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>AGC (GEA Bishoff)</td>
<td>Italy</td>
<td>2012</td>
<td>float glass</td>
<td>thermal oil</td>
<td>1,300</td>
</tr>
<tr>
<td>undisclosed</td>
<td>Italy</td>
<td>2015</td>
<td>container glass</td>
<td>thermal oil</td>
<td>500</td>
</tr>
<tr>
<td>DÜZCE CAM (Çalbıyık Grup)</td>
<td>Turkey</td>
<td>2018</td>
<td>float glass</td>
<td>thermal oil</td>
<td>6,200</td>
</tr>
<tr>
<td>SAINT-GOBAIN (GEA Bishoff)</td>
<td>India</td>
<td>2019</td>
<td>float glass</td>
<td>thermal oil</td>
<td>1,200</td>
</tr>
<tr>
<td>SAINT-GOBAIN (GEA Process Engineering)</td>
<td>Italy</td>
<td>2019</td>
<td>float glass</td>
<td>thermal oil</td>
<td>1,200 (mechanical power used to produce compressed air)</td>
</tr>
</tbody>
</table>

**Notes:**
- The table lists references in the glass industry involving ORC (Organic Rankine Cycle) systems for various glass production capacities and heat carriers.
- The ORC capacity is given in gross electric power (kW).
AGC

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

COUNTRY:
Italy

STATUS:
in operation since 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 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:
Calbiyik Grup / Düzce Cam

COUNTRY:
Turkey

STATUS:
in operation since 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 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
OVERALL PLANT PERFORMANCES

GAS TURBINES

30±40% ORC additional power*

GT USEFUL POWER

EXHAUST GAS**

ORC unit

18 ± 30% Useful power ***
80 ± 68% Thermal power
2% Thermal losses

INTERNAL COMBUSTION ENGINES

10% ORC additional power*

EXHAUST GAS**

ICE USEFUL POWER

JACKET WATER

2% Thermal losses
80 ± 72% Thermal power
18 ± 26% Useful power ***

* 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.
## TURBODEN REFERENCES IN COMBINED CYCLES

<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>TRANSNGAS</td>
<td>Canada</td>
<td>2011</td>
<td>1</td>
<td>Solar Centaur 40 gas turbine in gas compressor station</td>
</tr>
<tr>
<td>UZTRANSNGAZ</td>
<td>Uzbekistan</td>
<td>2021</td>
<td>1</td>
<td>3 GE LM 1600 gas turbines in gas compressor station</td>
</tr>
<tr>
<td>GASCO</td>
<td>Egypt</td>
<td>under construction</td>
<td>24</td>
<td>5 X 30 MWe gas turbines (4 in operation, 1 in stand-by) 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>ULmj</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>under construction</td>
<td>2 x 2.3</td>
<td>28 x 1.4 MWe Jenbacher engines + 4 x 1.2 MWe MWM engines – landfill gas</td>
</tr>
<tr>
<td>ORTADOGU II</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>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>
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: in operation since 2021
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
DAHSHOUR

CUSTOMER: GASCO
COUNTRY: Egypt
STATUS: under construction
DESCRIPTION: power generation from waste heat from 5 simple cycle GTs (4 in operation 1 in standby) in gas compressor station.

ORC ELECTRIC POWER: 24+ MWe to feed 2 electrical motor driven compressors of 10 MW each that will empower compressor station pumping capacity.
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)