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MOVE THE WORLD FORW>RD MITSUBISHI HEAVY INDUSTRIES GROUP



Waste Heat to Power

POWER GENERATION

Turboden S.p.A.

A Group Company of MITSUBISHI HEAVY INDUSTRIES

Turboden for Industrial Process

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



POWER GENERATION WASTE HEAT TO POWER

Our Products







POWER GENERATION WASTE HEAT TO POWER

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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 **40 MW electric** per single shaft.

WHY CHOOSE ORC FOR ENERGY EFFICIENCY?

- → Generate profit by valorizing a waste heat source
- → Reduce specific production cost by decreasing energy demand
- → Improve company sustainability
- → Contribute to lower carbonization and combat climate change

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Energy Efficiency for 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.



Electric power and/or Mechanical power

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Energy Efficiency for Your Business

56+ plants (220MWe)

Waste Heat to Power

- 45+ years experience
- 50+ countries presence
- High availability (98%)
- Customized after-sales service



Last update: Feb 2026

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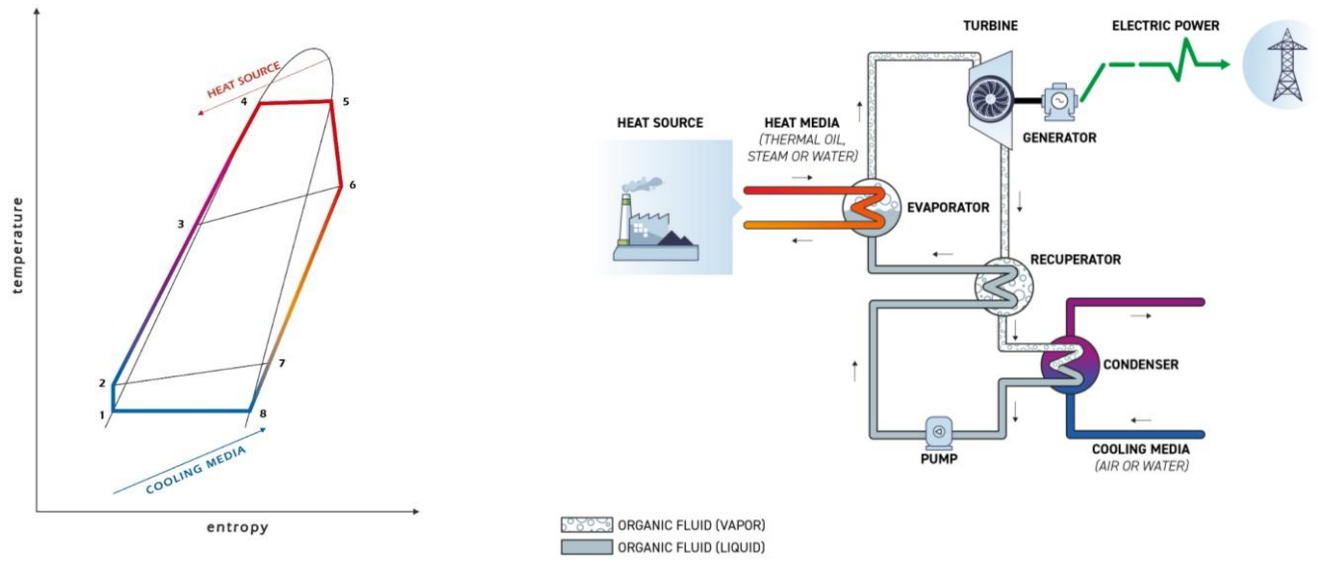
The ORC Cycle – How It Works

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 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.



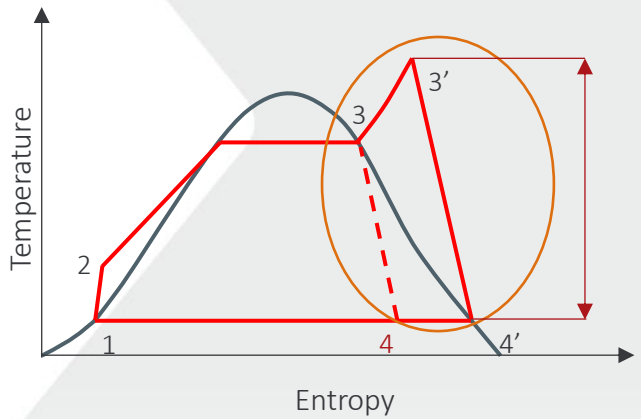
The waste heat from production process is transferred to the ORC working fluid by means of an intermediate circuit or directly via the exhaust gases in direct exchange systems. The media used in the intermediate circuits could be thermal oil, saturated steam or superheated water.

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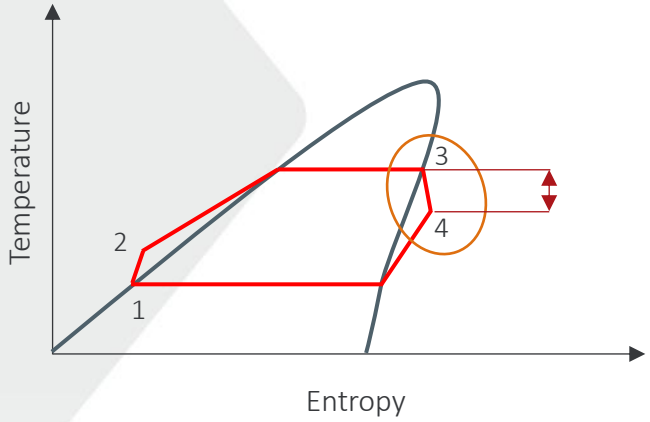
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Thermodynamic Cycle: ORC vs Steam

STEAM RANKINE CYCLE



ORGANIC RANKINE CYCLE

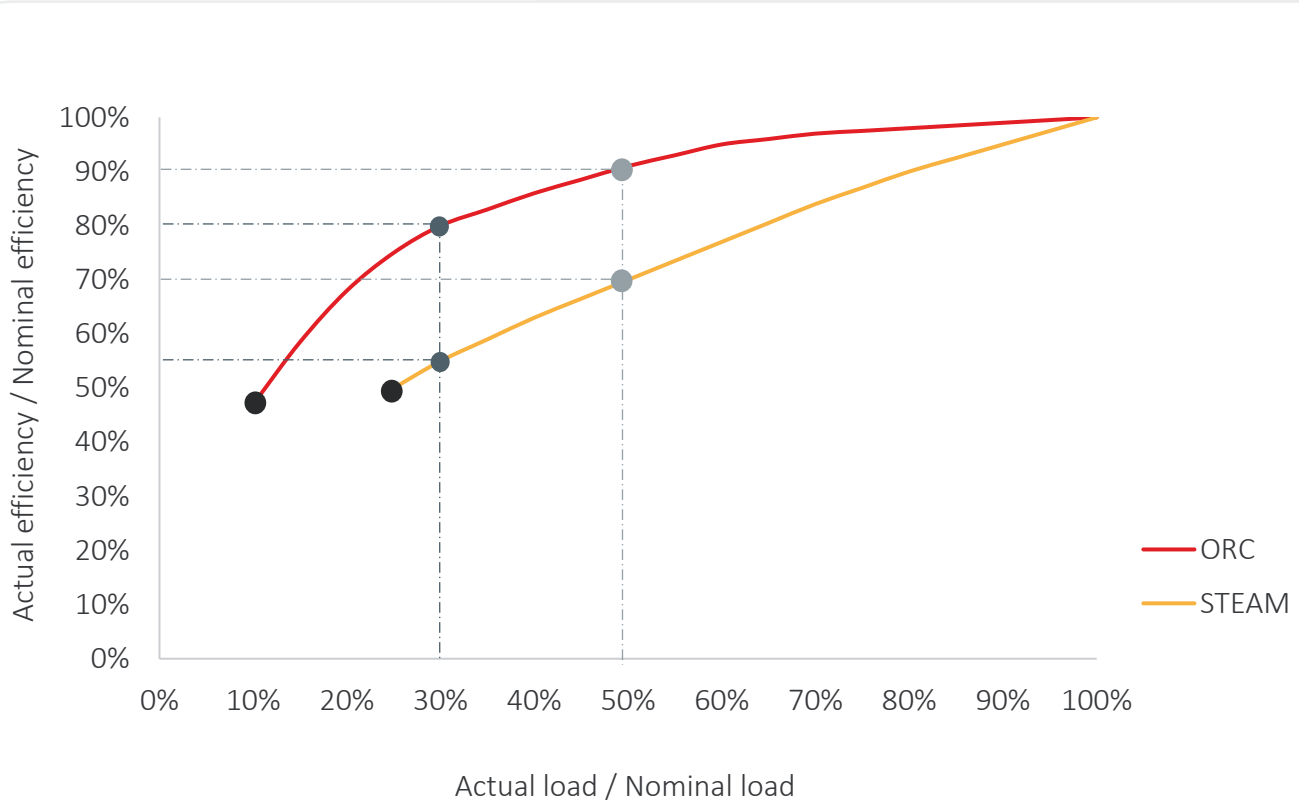


Thermodynamic features and consequences	▪ Superheating needed ▪ Risk of blade erosion due to possible liquid formation during the expansion ▪ High enthalpy drop – turbine with high stages number	▪ No need to superheat ▪ No risk of blade erosion thanks to dry expansion in the turbine ▪ Small enthalpy drop - turbine with low stage number
Operation and maintenance costs	▪ Water treatment required ▪ Highly skilled personnel needed ▪ Periodic major overhaul ▪ Supervised operation	▪ Water-free system ▪ Minimum Operation & Maintenance cost ▪ No major overhaul ▪ Completely automatic operation
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%)

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Partial load behaviour



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.

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ORC System Features



Simplicity

- Remote monitoring and automatic operation, no personnel needed
- 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 CO_2 emissions

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Large Heat Pump

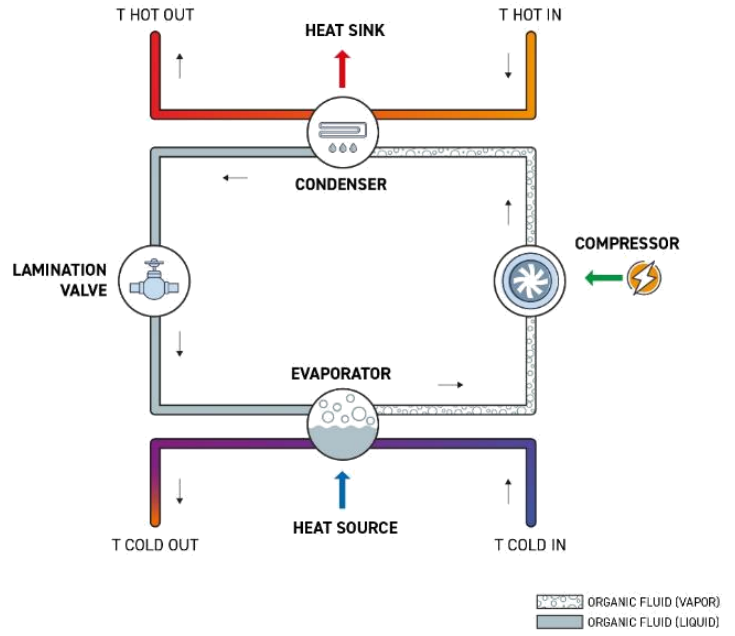
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A Portfolio to Cover Large Sizes and High Temperatures

Large Heat Pumps (LHP) are utility-scale heating plant, designed to transfer large quantities of heat from a lower temperature source to a higher temperature heat user, such as district heating grid or industrial process.



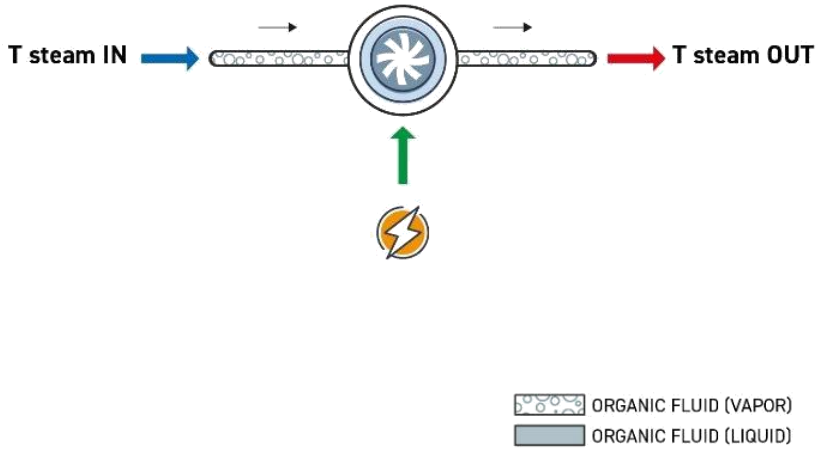


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A Portfolio to Cover Large Sizes and High Temperatures

Mechanical vapor recompression (MVR) system, acting as an open cycle water heat pump, increases both the temperature and the pressure of a water stream, to generate steam at specific conditions needed.

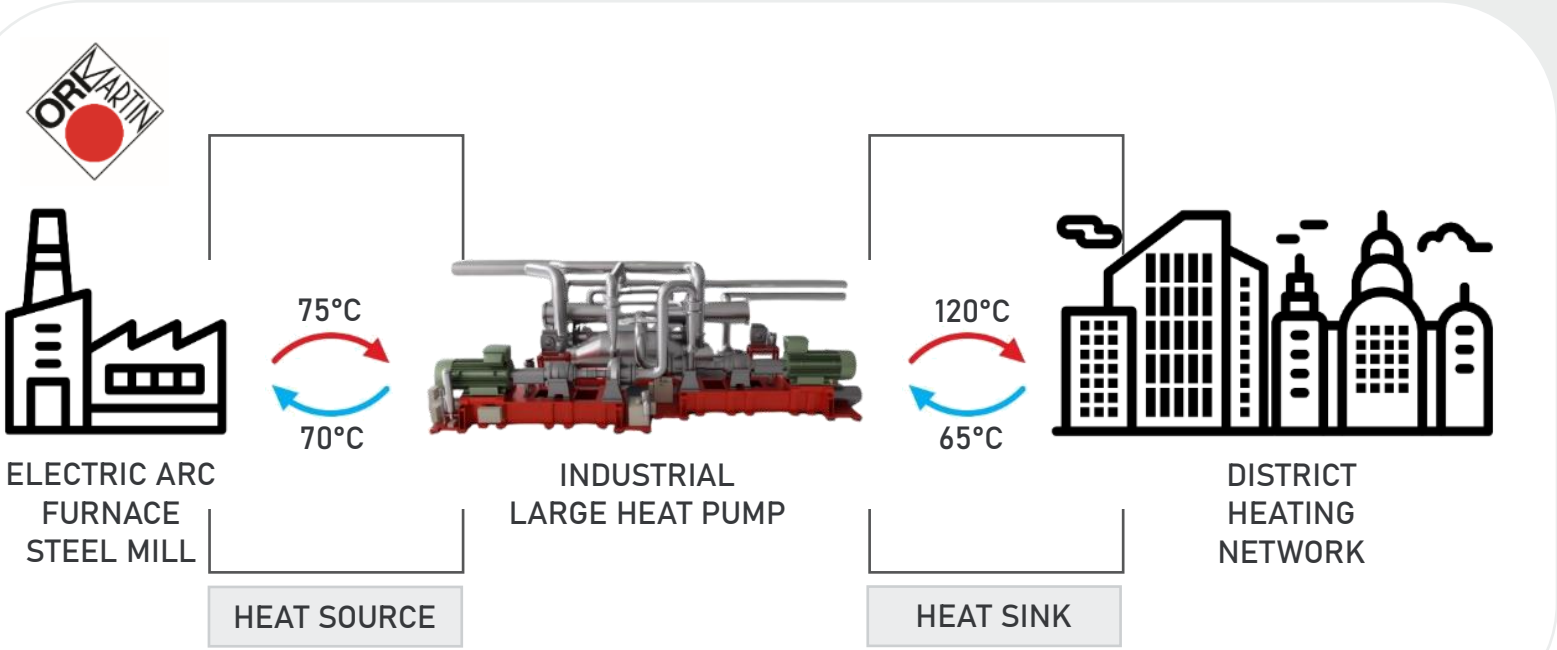




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Case History: ORI Martin Steelworks



Instead of wasting the heat generated during the steelmaking process and dissipated through cooling towers, the customer enhanced its value by installing a LHP to upgrade the heat for district heating, taking advantage of a more efficient and sustainable solution.

PROJECT FEATURES

- Country: Italy, in operation since 2023
- Size: 6 MWth (equivalent to 3,500 houses)
- Exploitation of steel mill waste heat to serve local district heating network
- Output: pressurized water at 120°C delivered to the district heating network

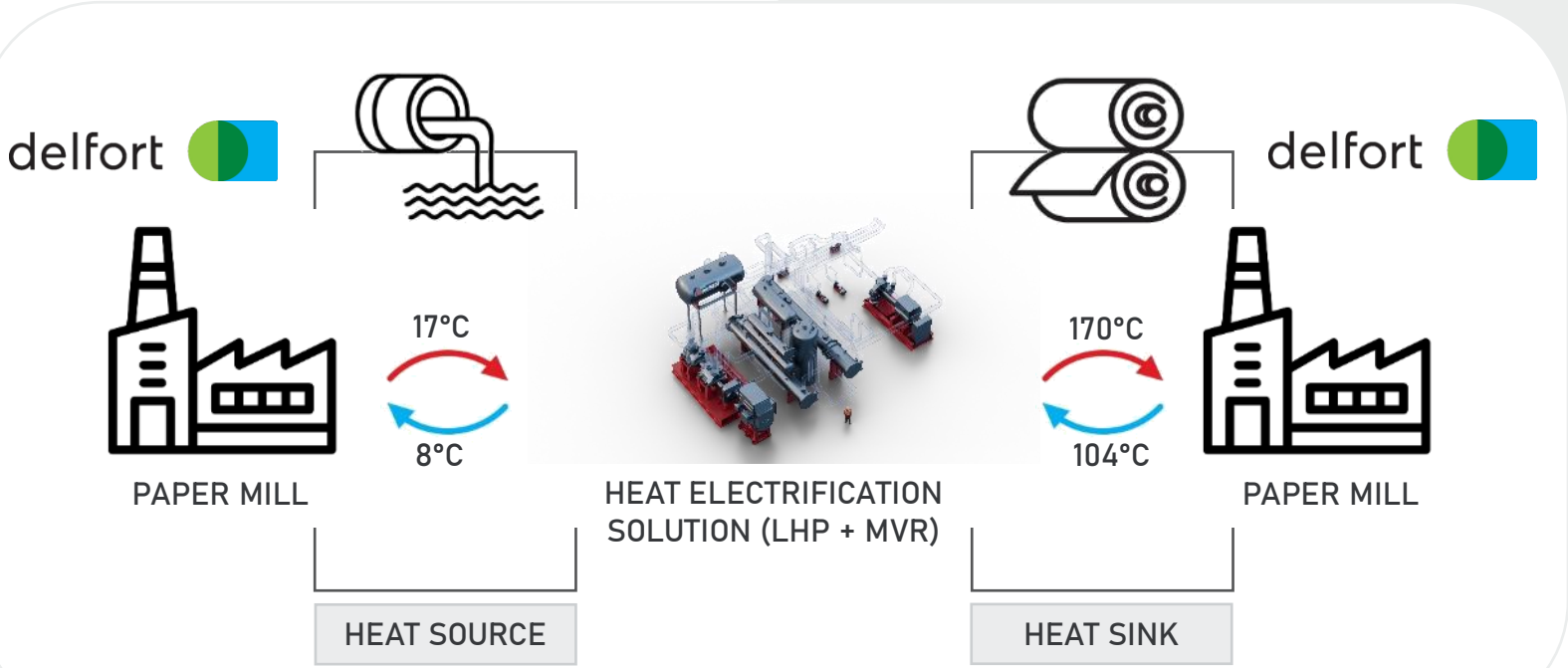
TECHNICAL FEATURES

- Centrifugal innovative compressor designed by Turboden
- LHP working fluid: synthetic refrigerant

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Case History: Delfort Paper Mill



The customer valorized the low-temperature wastewater from the paper mill by installing an innovative heat-upgrade solution, a LHP together with an MVR, to produce valuable steam for the paper mill itself.

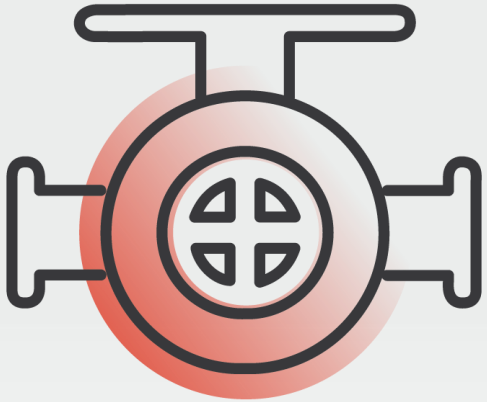
PROJECT FEATURES

- Country: Finland, in operation since 2026
- Size: 12 MWth
- Exploitation of paper mill waste heat to generate steam for the process
- Output: superheated steam at 170°C delivered to the paper mill

TECHNICAL FEATURES

- Integration of LHP with MVR to provide high-temperature steam at high efficiency (COP 2)
- Centrifugal MCO compressor
- LHP working fluid: natural refrigerant

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Gas Expander

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Gas Expander



Turboden gas expander is a solution to enhance the energy efficiency of a natural gas network infrastructure, producing electricity by taking advantage of the reduction of gas pressure from the delivery level to the one required by users, be they residential or industrial.

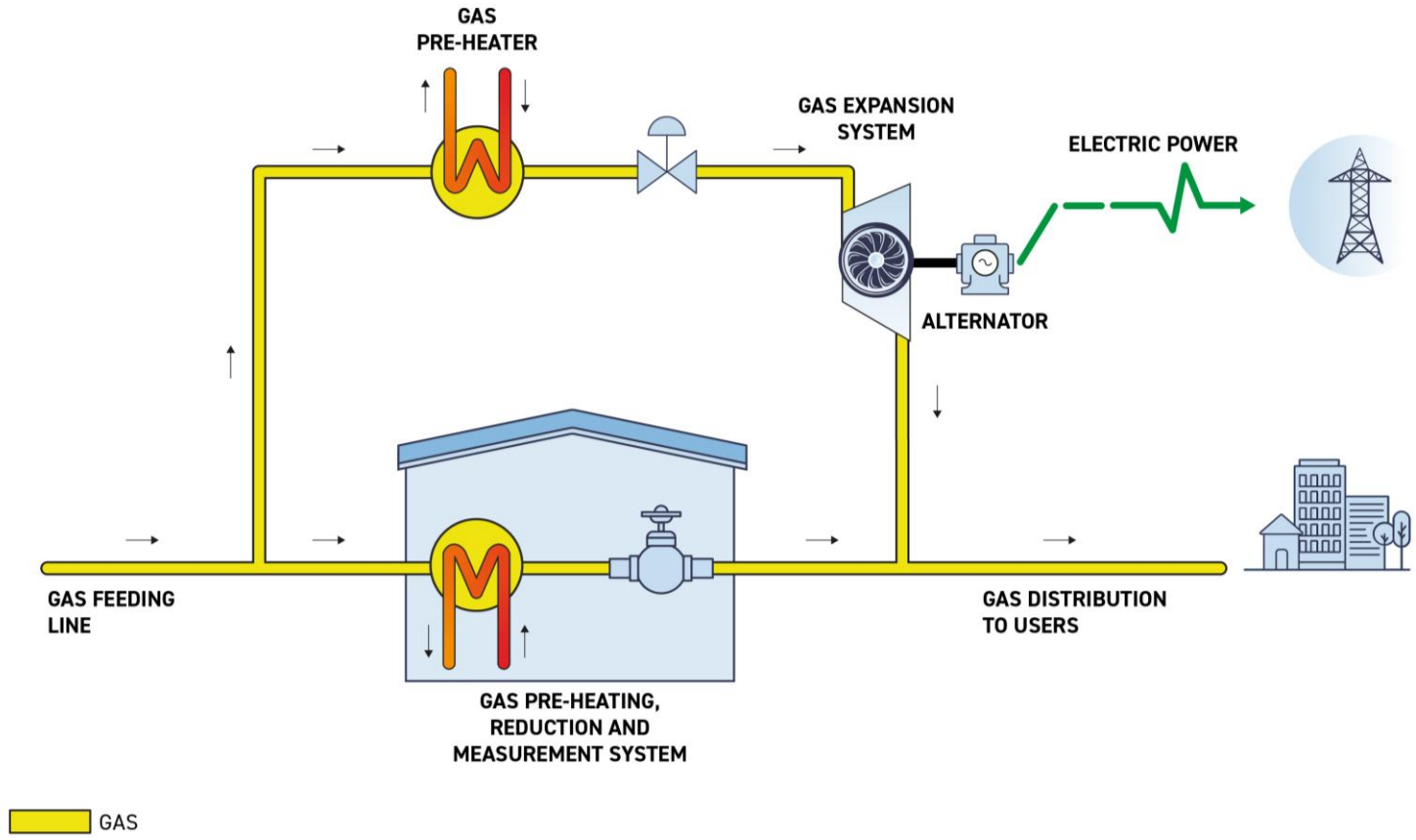
KEY POINTS

- Design based on 40+ years of experience, leveraging Mitsubishi Heavy Industries support
- Long experience in the energy efficiency sector
- Profit generation while reducing the gas pressure
- Solution for natural gas network decarbonisation
- Unmanned installations, thanks to specific technology features
- Turn-key equipment capabilities
- Over 60 Turboden turbine models within the 460+ power plants fleet

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The Configuration



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Turboden Rating

EXPANDERS SIZES	EXP 300	EXP 600	EXP 900	EXP > 1 MW
✓ Turbine stages/admission	Single stage radial turbine	Multi stages axial turbine		
✓ Flow rate	> 8,000 Sm3/h	20,000 – 150,000+ Sm3/h		
✓ In - out gas pressure range	50 - 1 bar(g)			
✓ Bearings	Self-lubricated rolling bearings	Rolling bearings		
✓ Seals	Single tight casing for impeller and generator	Double mechanical		
✓ Generator	Permanent Magnet Generator	A/Synchronous LV - Eff. 97%		
✓ Containerization	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.			
✓ Gas pre-heating	Custom based on project specific features (e.g. gas fired boilers, waste heat, heat pump...)			

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Turboden Gas Expander References

PLANT	COUNTRY	START UP	GAS FLOW RATE Sm3/h	GAS PRESSURE bar(g) - in/out	APPLICATION	EXP GROSS EL. POWER (kW)
ITALGAS RETI	Italy	2022	2 x 80,000	50 – 24	pressure reduction in distribution network	1,300
A2A CALORE E SERVIZI	Italy	2024	25,000	12 - 6	pressure reduction in distribution network	300
PIETRO FIORENTINI/ ITALGAS RETI	Italy	2025	9,000	24 - 6	pressure reduction in distribution network	300
HERATECH	Italy	2024	25,000	45 - 5	pressure reduction in distribution network	700
UNARETI	Italy	under construction	40,000	14 – 4,5	pressure reduction in distribution network	1,000
UNARETI	Italy	under construction	115,000	50 – 13	pressure reduction in distribution network	3,000

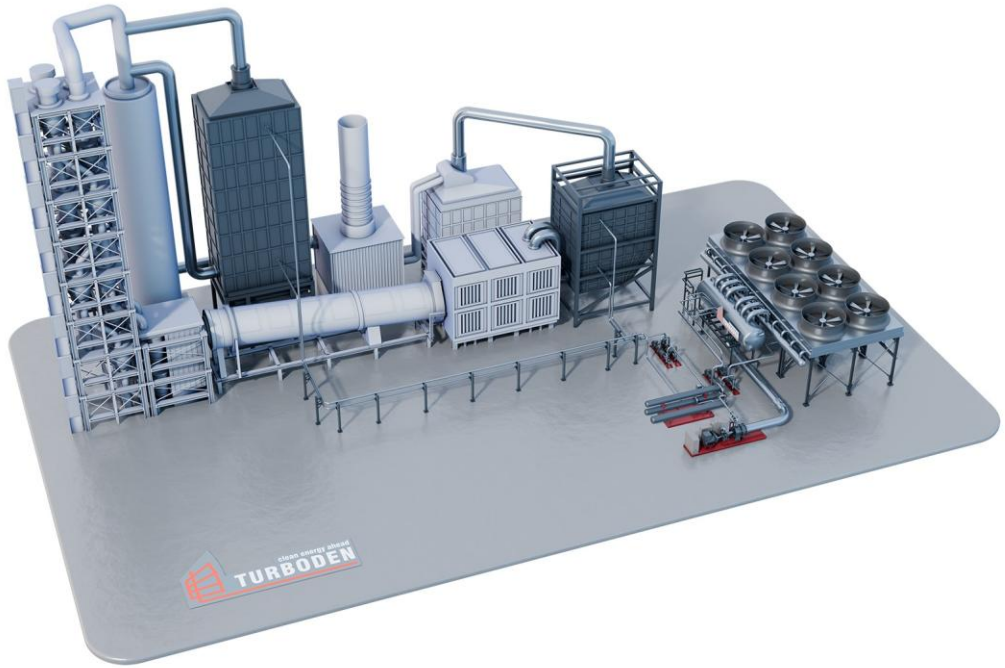
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CEMENT



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 the production process.

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Turboden References in Cement

PLANT	COUNTRY	START UP	KILN CAPACITY (ton/day)	HEAT SOURCE	HEAT CARRIER	ORC GROSS EL. POWER (kW)
CIMENTS DU MAROC (Heidelberg Materials)	Morocco	2010	5,000	PH	thermal oil	2,000
HOLCIM ROMANIA (Holcim Group)	Romania	2012	4,000	PH + CC	thermal oil + superheated water	4,000
CRH SLOVAKIA	Slovakia	2014	3,600	PH + CC	thermal oil	5,000
CARPATCEMENT (Heidelberg Materials)	Romania	2015	3,500	PH + CC	thermal oil	3,800
JURA-CEMENT-FABRIKEN (CRH Group)	Switzerland	2016	3,000	PH	superheated water	2,300
CEMENTI ROSSI	Italy	2018	3,500	PH + CC	none - direct exchange	2,000
ÇİMKO (Sanko Group)	Turkey	2019	9,500	CC	thermal oil	7,000
HOLCIM SUISSE ECLÉPENS (Holcim Group)	Switzerland	2020	2,300	PH + CC	thermal oil	1,300

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Turboden References in Cement

PLANT	COUNTRY	START UP	KILN CAPACITY (ton/day)	HEAT SOURCE	HEAT CARRIER	ORC GROSS EL. POWER (kW)
SÖNMEZ ÇIMENTO	Turkey	2020	6,000	PH + CC	thermal oil	7,300
SECIL	Portugal	2025	3,800	PH + CC	thermal oil	7,200
HOLCIM UAE (Holcim Group)	UAE	2025	7,500	PH + CC	thermal oil	10,000
CIMPOR SOUSELAS	Portugal	2025	4,200	PH + CC	thermal oil	8,000
CIMPOR ALHANDRA	Portugal	under construction	3,100	PH + CC	thermal oil	6,000
MEDCEM	Turkey	2025	10,000	CC	thermal oil	10,000
CIMSA ESKISEHIR	Turkey	2025	4,500	PH + CC	thermal oil	5,900
RIYADH CEMENT COMPANY	Kingdom of Saudi Arabia	2026	2 x 5,000	PH + CC	thermal oil	13,000

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Turboden References in Cement

PLANT	COUNTRY	START UP	KILN CAPACITY (ton/day)	HEAT SOURCE	HEAT CARRIER	ORC GROSS EL. POWER (kW)
HOLCIM (BELGIQUE) S.A. (Holcim Group)	Belgium	under construction	6,000	PH + CC	thermal oil	7,500
COLACEM SESTO CAMPANO	Italy	under construction	3,000	CC	thermal oil	2.000
UNDISCLOSED	Turkey	under construction	3,300	CC	thermal oil	3,500
UNDISCLOSED	Turkey	under construction	3,300	CC	thermal oil	8,000
UNDISCLOSED	Turkey	under construction	3,300	CC	thermal oil	6,000

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References



Ciments du Maroc / Heidelberg Materials

Morocco

ORC ELECTRIC POWER: 2 MW

STATUS: in operation since 2010

CLINKER PRODUCTION CAPACITY: ≈ 5,000 ton/day

HEAT SOURCE: pre-heater exhaust gas

HEAT CARRIER: thermal oil

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



Holcim Romania (Holcim Group)

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)

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References



CHR Slovakia

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)



Sönmez Çimento

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)

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References



Riyadh Cement Company

Kingdom of Saudi Arabia

ORC ELECTRIC POWER: 13 MW

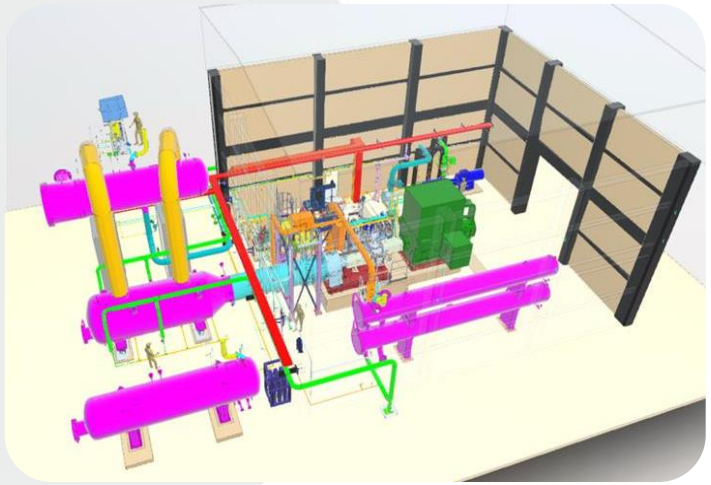
STATUS: in operation since 2026

CLINKER PRODUCTION CAPACITY: ≈ 2 x 5,000 ton/day

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

HEAT CARRIER: thermal oil

COOLING SYSTEM: air cooled condenser (no water consumption)



Holcim (Belgique) S.A.

Belgium

ORC ELECTRIC POWER: 7.5 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: water cooled condenser + hybrid cooling towers

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STEEL & METALS

Main Heat Sources

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

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Turboden References in Steel & Metal

PLANT	COUNTRY	START UP	TYPE	CHARGE	CAPACITY	HEAT CARRIER	ORC GROSS EL. POWER (kW)
NATSTEEL	Singapore	2013	steel rolling mill billet reheating furnace	billet	125 ton/h	none - direct exchange	700
ELBE STAHLWERKE FERALPI	Germany	2013	steel electric arc furnace	scrap	100 ton	saturated steam	2,700
ORI MARTIN	Italy	2016	steel electric arc furnace	scrap - consteel	85 ton	saturated steam	2,200
FONDERIA DI TORBOLE	Italy	2016	iron cupola furnace	scrap, pigs	30 ton/h	thermal oil	700
ARVEDI	Italy	2018	steel electric arc furnace	scrap	250 ton	saturated steam	10,000
SAFRAN	Malaysia	2019	chemical vapor infilatration furnace	n.a.	n.a.	thermal oil	1,900
POSCO ICT	South Korea	2019	Fe-Mn submerged arc furnace	raw materials	150 ton/d	thermal oil	1,200
SACAL	Italy	2019	aluminum rotative furnaces	scrap	n.a.	thermal oil	2,100

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References



ESF Elbe-Stahlwerke Feralpi GmbH

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

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)

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References



Arvedi S.p.A.

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

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)

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GLASS

Turboden References in Glass Industry

PLANT	COUNTRY	START UP	KILN CAPACITY (ton/day)	HEAT SOURCE	HEAT CARRIER	ORC GROSS EL. POWER (kW)
AGC FLAT GLASS CUNEO	Italy	2012	float glass	600 ton/d	thermal oil	1,300
UNDISCLOSED	Italy	2015	container glass	500 ton/d	thermal oil	500
DÜZCE CAM (Çalbıyık Grup)	Turkey	2018	float glass	2 x 600 ton/d	thermal oil	6,200
SAINT-GOBAIN CHENNAI	India	2019	float glass	600 ton/d	thermal oil	1,200
SAINT-GOBAIN PISA	Italy	2019	float glass	600 ton/d	thermal oil	1,200 (turbine coupled with an air compressor)
VETRERIE DEL NORD	Italy	2025	container glass	500 ton/d	thermal oil	1,100
VETRERIA COOPERATIVA PIEGARESE	Italy	under construction	container glass	700 ton/d	thermal oil	2,000

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Turboden References in Glass Industry

PLANT	COUNTRY	START UP	KILN CAPACITY (ton/day)	HEAT SOURCE	HEAT CARRIER	ORC GROSS EL. POWER (kW)
AGC FLAT GLASS THAILAND	Thailand	2026	float glass	600 ton/d	thermal oil	1,900
AGC SEINGBOUSE	France	2023	float glass	600 ton/d	thermal oil	1,200
UNDISCLOSED	Poland	2025	container glass	2 x 300 ton/d	thermal oil	800
EUROGLAS POLSKA	Poland	2025	float glass	1 x 1,000 ton/d 1 x 750 ton/d	thermal oil	5,000
ASAHI INDIA GLASS	India	under construction	float glass	600 ton/d	thermal oil	1,500
ASAHI INDIA GLASS	India	under construction	float glass	600 ton/d	thermal oil	1,700

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References



AGC Flat Glass Cuneo

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



Undisclosed

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

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References



Calbıyık Grup / Düzce Cam

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)



AFT Flat Glass Thailand

Thailand

STATUS: under construction

ORC ELECTRIC POWER: 1.8 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

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COMBINED CYCLES



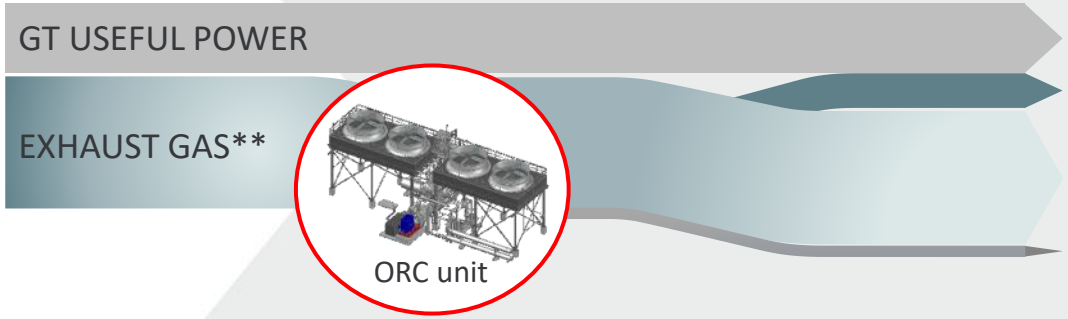
POWER GENERATION WASTE HEAT TO POWER

Potential Power Augmentation

GAS TURBINES

30÷40% ORC additional power*



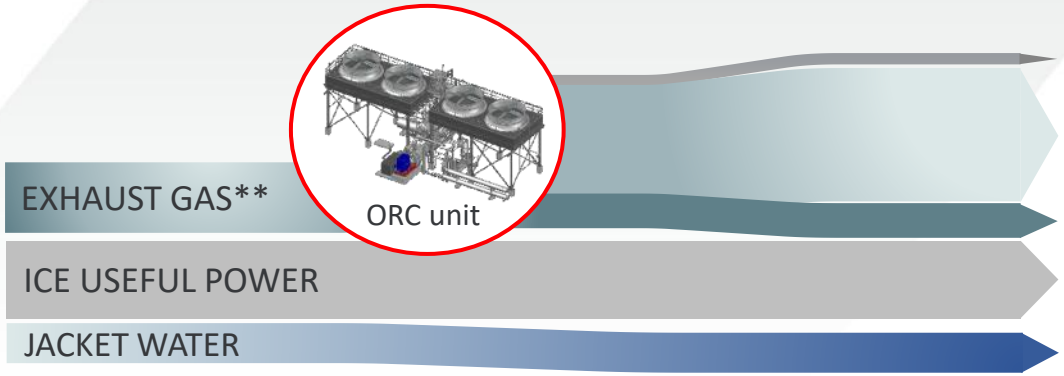


18 ÷ 30%	Useful power ***
80 ÷ 68%	Thermal power
2%	Thermal losses

INTERNAL COMBUSTION ENGINES

10% ORC additional power*





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.

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Exhaust Gas Waste Heat Recovery Unit Configuration

- WHRU installed in **by-pass** to the main exhaust gas ducting in order to **avoid any impact on the gas turbines operation** in any circumstance.
- **WHRU completely isolable** with a diverter prior to the WHRU and an insulation valve right after it. Diverter equipped with air sealing to ensure 100% insulation. This permits to insulate **the WHRU, ensuring gas turbines operation** even in case of major issues on the WHRU.
- Pneumatic **safety-closed** diverter to avoid any impact on gas turbines operation even during emergency situation.
- WHRU 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 WHRU temperature at acceptable level even in case of gas turbines particular operation cases.





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Turboden References in Combined Cycles

PLANT	COUNTRY	START UP	HEAT SOURCE	HEAT CARRIER	ORC GROSS EL. POWER (kW)
TRANSGAS	Canada	2011	1 x Solar Centaur 40 gas turbine in gas compressor station	thermal oil	1,000
UZTRANSGAZ	Uzbekistan	2021	3 x GE LM 1600 gas turbines in gas compressor station	thermal oil	1,000
ULM	Germany	2012	2 x 2 MW Jenbacher gas engines (+ additional heat from process)	thermal oil	700
PISTICCI I	Italy	2010	3 x 8 MWe Wärtsilä diesel engines	thermal oil	1,800
TERMOINDUSTRIALE	Italy	2008	1 x 8 MWe MAN diesel engine	thermal oil	500
PISTICCI II	Italy	2012	2 x 17 MWe Wärtsilä diesel engines	thermal oil	4,000
CEREAL DOCKS	Italy	2012	1 x 7 MWe Wärtsilä diesel engine	none - direct exchange	500
BIOGASTECH	Belgium	2019	4 x 3.3 MWe Jenbacher gas engines	none - direct exchange	700

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Turboden References in Combined Cycles

PLANT	COUNTRY	START UP	HEAT SOURCE	HEAT CARRIER	ORC GROSS EL. POWER (kW)
E&S ENERGY	Italy	2010	2 x 1 MWe Jenbacher gas engines + 3 x 800 kWe Jenbacher gas engines + 1 x 600 kWe Jenbacher gas engin	thermal oil	600
GASCO DASHUR	Egypt	Under commissioning	5 X 30 MWe gas turbines (4 in operation, 1 in stand-by) in gas compressor station	thermal oil	25,000
MONDO POWER	Italy	2012	1 x 17 MWe Wärtsilä diesel engine	thermal oil	1,000
HSY	Finland	2011	4 x 4 MWe MWM gas engines - landfill gas	thermal oil	1,300
ORTADOGU I	Turkey	2023	28 x 1.4 MWe Jenbacher engines + 4 x 1.2 MWe MWM engines - landfill gas	thermal oil	4,600
ORTADOGU II	Turkey	2020	12 x 1.4 MWe Jenbacher engines - landfill gas	thermal oil	2,300
TALLGRASS Washington Court House	Ohio	under construction	1 x Solar Mars 100 gas turbine + 2 Solar Mars 90 gas turbines in gas compressor station	thermal oil	10,000

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Turboden References in Combined Cycles

PLANT	COUNTRY	START UP	HEAT SOURCE	HEAT CARRIER	ORC GROSS EL. POWER (kW)
UNDISCLOSED	Ohio	under construction	3 x Solar Mars 100 gas turbines in gas compressor station	thermal oil	11,000
UNDISCLOSED	Indiana	under construction	3 x Solar Mars 100 gas turbines in gas compressor station	thermal oil	11,000
UNDISCLOSED	Ohio	under construction	4 x Solar Mars 100 gas turbines in gas compressor station	thermal oil	14,000

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References



TransGas

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%



Uztransgaz

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

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References



Cereal Docks

Italy

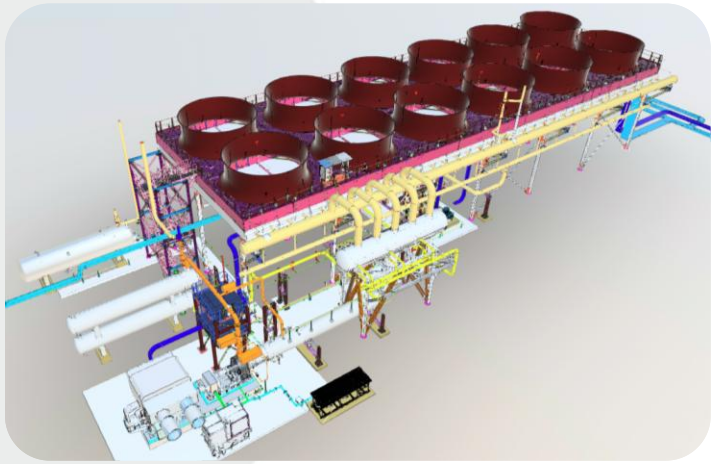
STATUS: in operation since 2012

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)



Tallgrass Energy Washington Court House

Ohio

STATUS: under construction

DESCRIPTION: power generation from exhaust gas of 1 x Solar Mars 100 gas turbine + 2 Solar Mars 90 gas turbines in a gas compressor station

ORC ELECTRIC POWER: 10 MW

HEAT CARRIER: thermal oil

COOLING SYSTEM: solution with air-cooled condenser, no water needed

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References

Gasco Dashur

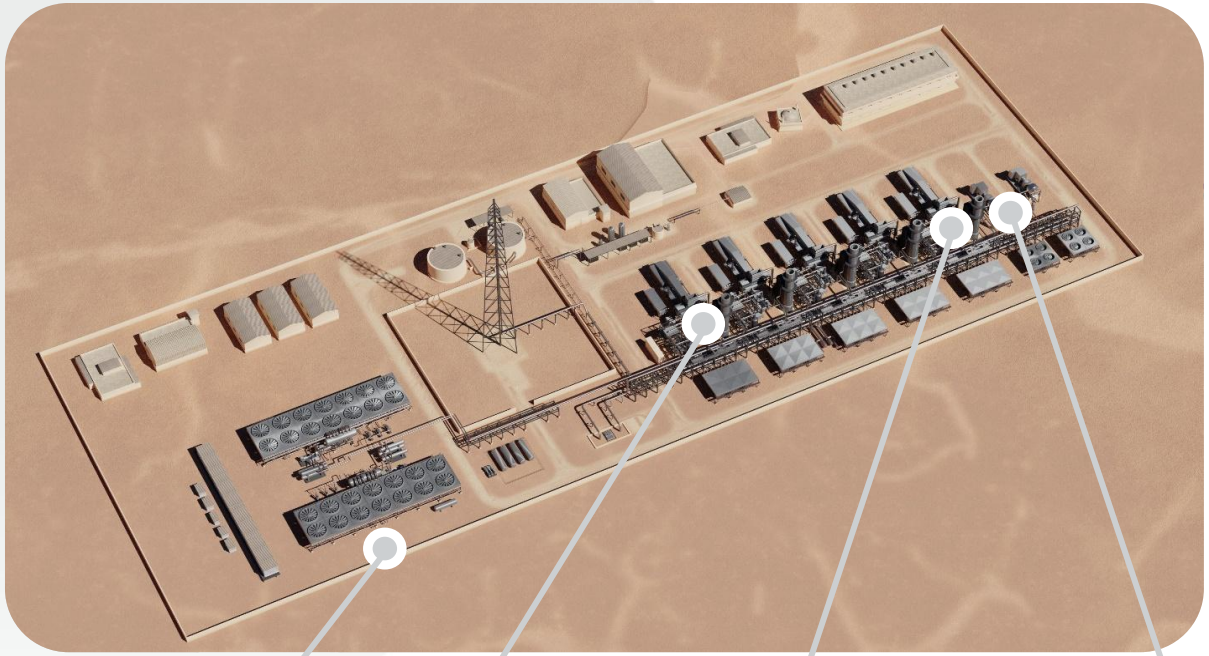
Egypt

STATUS: under commissioning

DESCRIPTION: power generation from waste heat from 5 open cycle GTs (4 in operation 1 in stand-by) in gas compressor station

ORC ELECTRIC POWER: 25 MWe to feed 2 electrical motor-driven compressors of 10 MW each that will empower compressor station pumping capacity





25 MWe ORC SYSTEM
(two ORCs designed for 14 MWe each)

WASTE HEAT RECOVERY SYSTEM
one WHRU for each GT
(4 existing GTs + 1 new GT)

NEW GAS TURBINE COMPRESSION TRAIN
50 MW GT driven train

ELECTRICAL MOTOR DRIVEN TRAINS
(two trains of 10 MW each)

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DATA CENTERS

From Cooling to Power Generation

Selective Catalytic Reduction (SCR) + Water-Free Combined Cycle Solution for Gas Turbines

Energy waste:

The Selective Catalytic Reduction (SCR) system decreases emissions from gas turbines but requires the exhaust gases to be cooled. Traditionally, this cooling is achieved using electric fans that consume energy, increasing operating costs and generating waste.



The recovery of heat:

Utilize the drop in gas turbine exhaust upstream the SCR for power generation in a water-free combined cycle solution otherwise known as Organic Rankine Cycle (ORC).

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Starting Point

Reducing the exhaust gas temperature before SCR requires high energy consumption.

→ **Cooling exhaust gases requires a lot of energy**

Selective Catalytic Reduction (SCR) systems require that gas turbine exhaust gases be cooled prior to treatment to function properly.

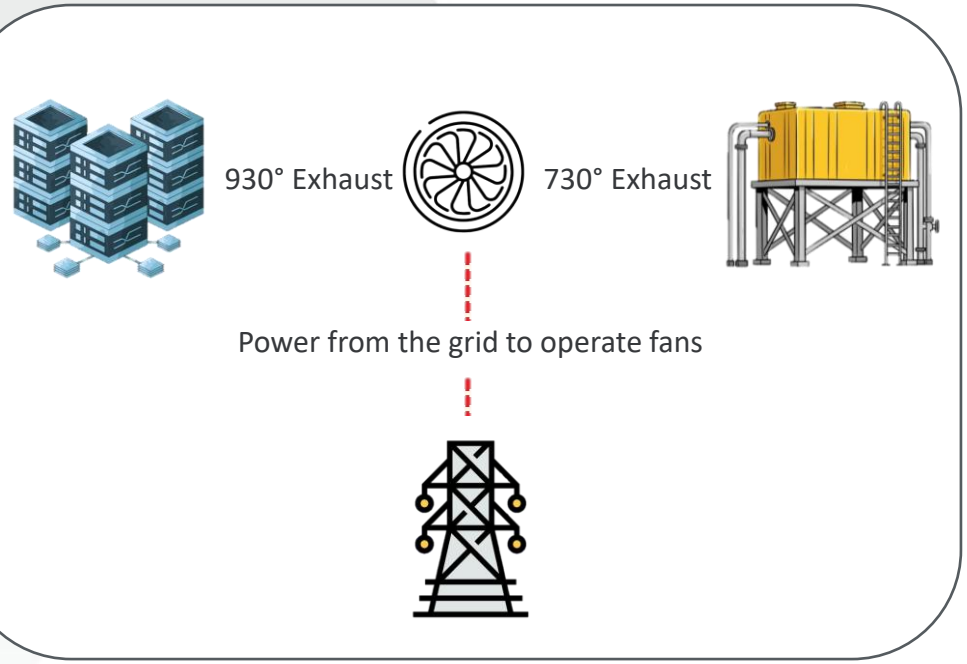
Today, this cooling is normally achieved by electric fans, which lower the temperature of the gases to levels compatible with the catalyst.

→ **Increased costs and less energy available**

Although technically effective, this solution has some consequences:

- additional electricity consumption due to large ventilation systems;
- a reduction in net available power, when energy is used internally instead of fed into the grid or destined for the data centre.

→ In both cases, the result is an increase in operating costs or a reduction in potential revenues.



An unexploited opportunity

For power plants serving data centers, where efficiency, business continuity, and cost control are essential, dissipating energy just to cool down represents a missed opportunity. That heat could be enhanced, instead of simply being dispersed.

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The Turboden Solution

How It Works

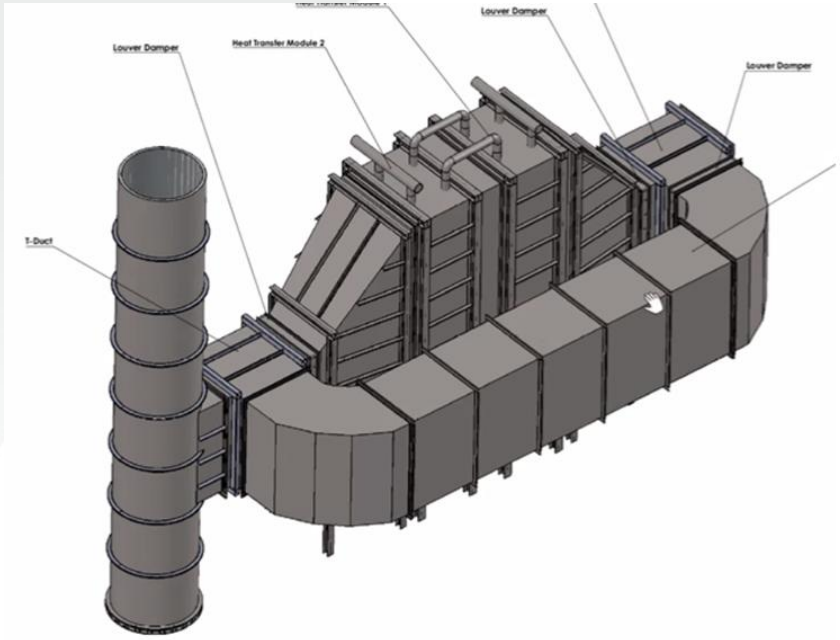
Turboden and its SCR partner offer a waterless combined cycle solution, placing the Turboden Heat to Power system upstream of the SCR to recover energy from turbine exhaust.

→ Benefits

- Reduces or eliminates the energy load of fans;
- Recover thermal energy and convert it into clean electricity;
- Provides exhaust gas to the SCR at the optimum temperature.

→ Results

- Additional power of several MW from energy that would be wasted;
- Lower operating costs due to the elimination of fans;
- Increased plant efficiency and increased revenues.



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Advantages

From energy consumption to electricity production

→ **Combined cycle without water**

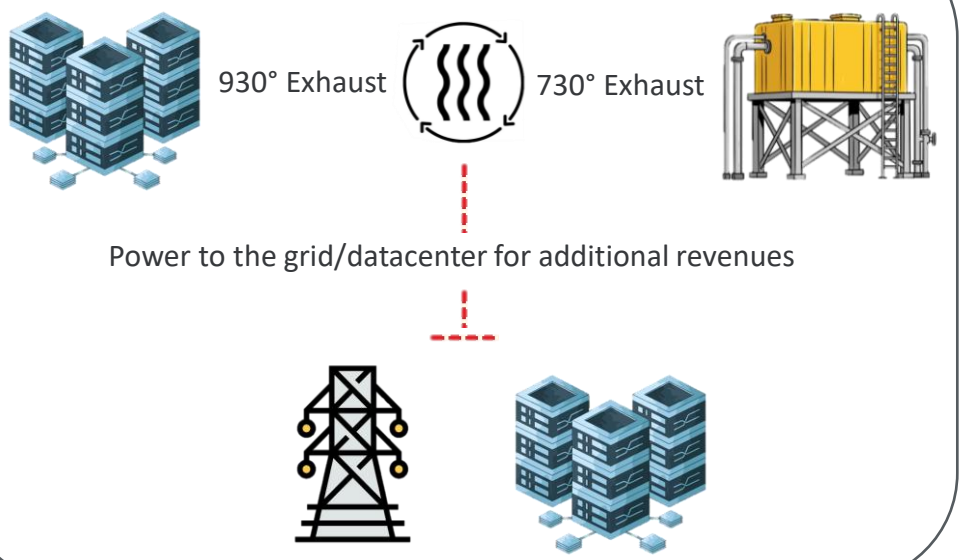
The addition of a combined cycle without water transforms the need to reduce temperature into a valuable and continuous production of electricity.

→ **Conversion of exhaust gases into electrical energy**

By integrating a water-free combined-cycle technology upstream of the SCR, thermal energy is recovered from the exhaust gases and transformed into clean, reliable electricity.

→ **Lower costs and higher revenues**

By increasing plant efficiency, producing emission-free energy, and reducing the need for fan power, the power plant increases revenues and reduces operating costs.



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Case Study– $83,000,000 in Additional Revenues*

* Assuming $100 / MWh power rates

LM2500 GT – Transforming exhaust temperature reduction into electrical power

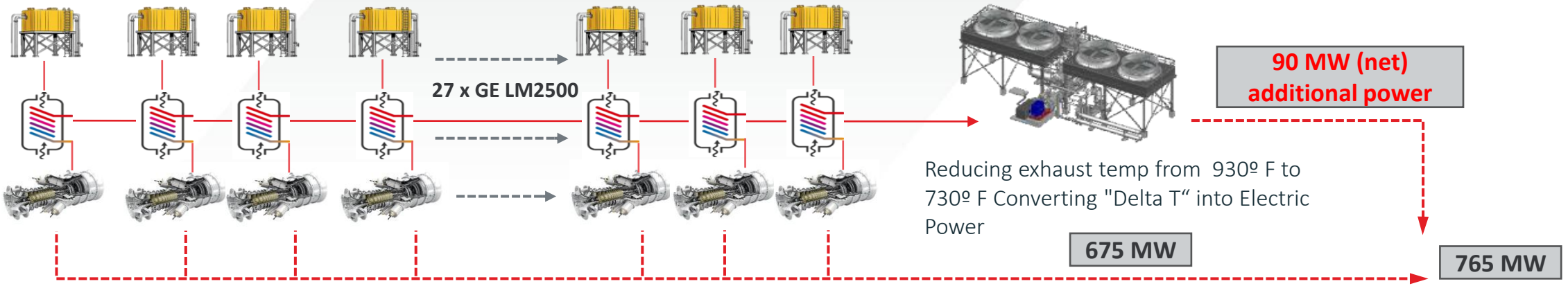
Turboden offer an **integrated combined cycle + SCR solution** to optimize **power generation in data center power plants**, maximizing efficiency and cost return.

How it works:

- → Each SCR draws exhaust gases from the LM2500 gas turbine and removes harmful pollutants, such as NOx.
- → To ensure effective treatment, the temperature of the exhaust gases must be reduced.
- → This is where the SCR Provider + Turboden solution comes in: the exhaust gases are conveyed to the ORC heat exchanger where the heat is recovered and converted into electricity.

The Results:

- → Gas temperature optimized for SCR
- → Production of additional power without extra fuel
- → Up to $83 million in incremental revenue
- → Increased overall plant efficiency and reduced emissions



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Global and Proven Experience

Supply reliable power for over four decades.

→ 25 thousand GWh produced
→ 19 million cumulative operation hours
→ 98+% average availability



50+ countries

470+ plants

In **2013** Turboden became part of **Mitsubishi Heavy Industries group** that strongly supports Turboden in the development of innovative solutions.

In **November 2024**, **Turboden America LLC** was established to support large-scale projects and promote closer collaboration with our US partners.

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