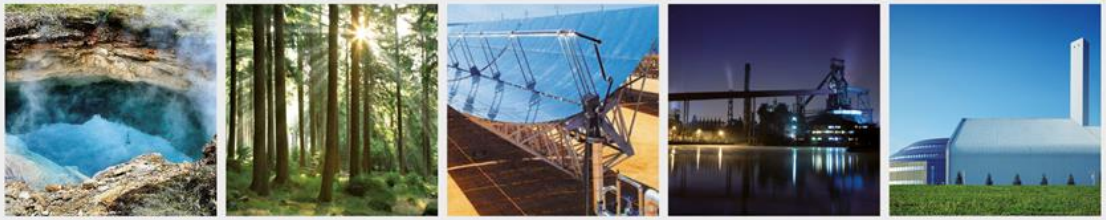

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Turboden Solar Thermal Power Applications

ISO 9001

Doc.: 11-COM.P-6-rev.42
Update: 03/02/2016

About Us

Turboden is a leading European company in development and production of ORC (Organic Rankine Cycle) turbogenerators. This state-of-the-art equipment generates heat and power from renewable sources and heat recovery in industrial processes.

The company was founded in 1980 in Milan by Mario Gaia, Associate Professor at *Politecnico di Milano*, teaching Thermodynamics, Renewable Energy and specifically studying ORC systems. At present Prof. Gaia is Honorary Chairman. A number of his former students are key persons in the Company and the whole Company is permeated by innovative and research oriented spirit.

Turboden has always had a single mission: to design ORC turbogenerators for the production of heat and electrical power from renewable sources, while constantly striving to implement ORC technical solutions.

In 2009, Turboden became part of UTC Corp., a worldwide leader in development, production and service for aero engines, aerospace drive systems and power generation gas turbines, to develop ORC solutions from renewable sources and waste heat worldwide.

In 2013 UTC exits the power market forming strategic alliance with Mitsubishi Heavy Industries.

In 2013 Mitsubishi Heavy Industries acquires from UTC Pratt & Whitney Power Systems (now PW Power Systems, Inc.) and the affiliate **Turboden.**
Today Turboden S.r.l. and PW Power Systems, Inc. are MHI group companies to provide a wider range of products and services for thermal power generation systems.

In 2013 Turboden's Quality Management System gets certified to ISO 9001:2008.

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35 Years of Experience

’60-’70

- Prof. Mario Gaia makes experience in the field of ORC within his research group at *Politecnico di Milano*
- 1976 – First prototype of a solar thermodynamic ORC

1980-1999

- 1980 – Prof. Mario Gaia founds Turboden to design and manufacture ORC turbogenerators
- Turboden develops research projects in solar, geothermal and heat recovery applications
- 1998 – First ORC biomass plant in Switzerland (300 kW)

2000-2009

- Turboden installs ORC biomass plants, especially in Austria, Germany and Italy
- Turboden plans to enter new markets, with focus on North America
- First heat recovery applications

2009-2013

- **2009 – Turboden achieves 100 plants sold**
- United Technologies Corp. (UTC) acquires the majority of Turboden’s quota. PW Power Systems supports Turboden in new markets beyond Europe
- UTC exits the power market forming strategic alliance with **Mitsubishi Heavy Industries**
- PW Power Systems becomes an MHI group company

2016…

- **2013 - MHI acquires the majority of Turboden. Italian quotaholders stay in charge of management**
- **Today - Over 300 ORC plants in the world, over 240 in operation**

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35 Years of Experience

1984 – 40 kW_{el} ORC turbo-generator for a solar plant in Australia

1987 – 3 kW_{el} ORC turbo-generator for a biomass plant in Italy

1988 – 200 kW_{el} ORC geothermal plant in Zambia

2008 – 3 MW_{el} ORC turbo-generator for heat recovery on a waste incinerator in Belgium

2009 – First 100 plants and first installed 100 MW_{el}

2010 – First plant overseas

2016 – Over 300 ORC plants in the world

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Turboden – a Group Company of MHI

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Energy & Environment

the largest segment of MHI

over $13 billion (in fiscal 2014)

Energy & Environment

Providing optimal solutions in the energy-related fields of thermal power, nuclear energy and renewable energy in different environmental areas and for Chemical plants & other industrial infrastructures elements.

Machinery, Equipment & Infrastructure

Providing a wide range of products that form the foundation of industrial development, such as machine tools, material handling, construction machinery, air-conditioning and refrigeration systems.

MITSUBISHI HEAVY INDUSTRIES, LTD.

Mitsubishi Heavy Industries is one of the world's leading heavy machinery manufacturers, with consolidated sales of over $33 billion (in fiscal 2014).

Foundation July 7, 1884

Commercial Aviation & Transport Systems

Delivering advanced land, sea and air transportation systems, including civilian aircraft, commercial ships and transit networks.

Integrated Defense & Space Systems

Providing advanced land, sea and air defense systems, including naval ships, defense aircraft, launch vehicles and special vehicles, as well as space-related services.

What We Do

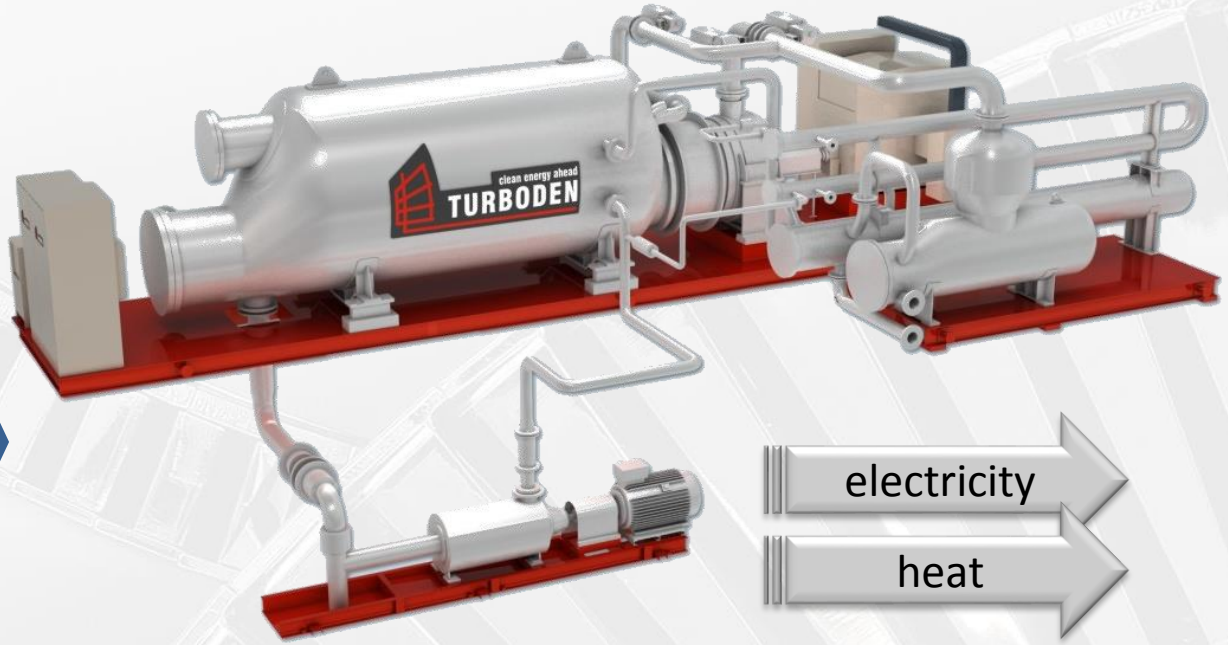
Biomass

Heat recovery

Waste to energy

Geothermal

Solar



Turboden designs, develops and maintains turbogenerators based on the Organic Rankine Cycle (ORC), a technology for the combined generation of electric power and heat from various renewable sources, particularly suitable for distributed generation.

➢ **Turboden solutions** from 200 kW to 15 MW electric per single unit

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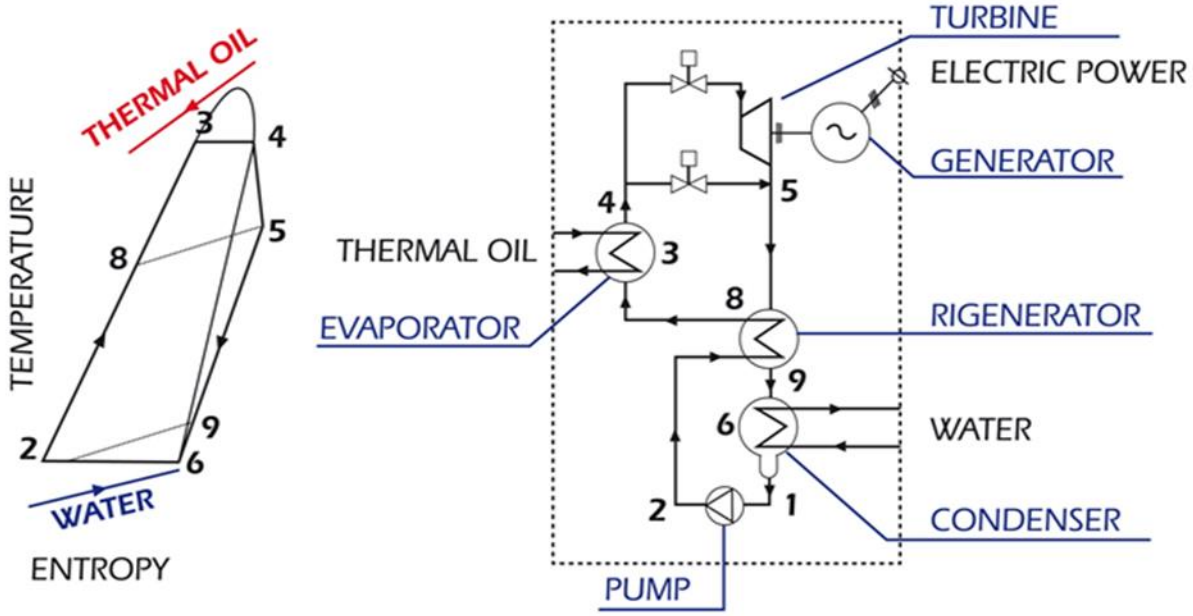
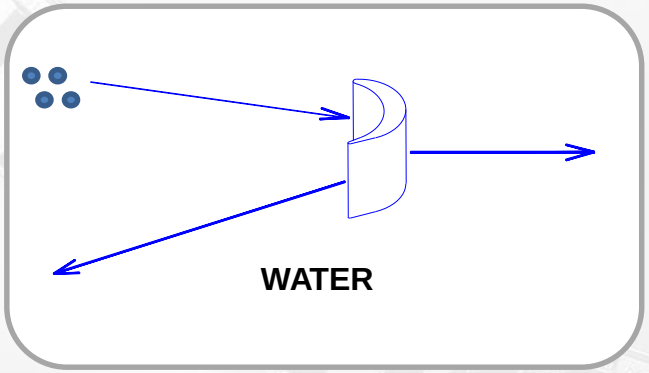
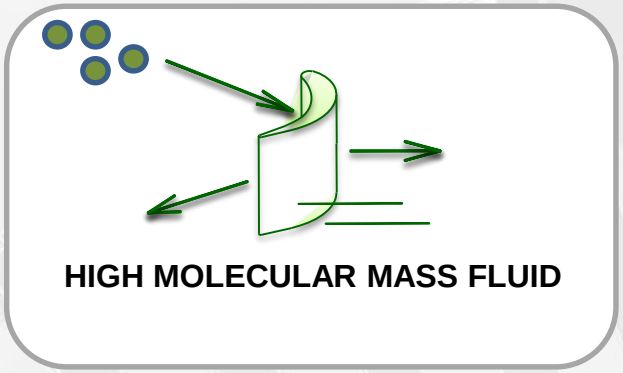
The Thermodynamic Principle: The ORC Cycle



The turbogenerator uses the hot temperature thermal oil to pre-heat and vaporize a suitable organic working fluid in the evaporator (8→3→4). The organic fluid vapor powers the turbine (4→5), which is directly coupled to the electric generator through an elastic coupling. The exhaust vapor flows through the regenerator (5→9) where it heats the organic liquid (2→8). The vapor is then condensed in the condenser (cooled by the water flow) (9→6→1). The organic fluid liquid is finally pumped (1→2) to the regenerator and then to the evaporator, thus completing the sequence of operations in the closed-loop circuit.

Why High Molecular Mass Working Fluid Instead of Water?





Water

- Small, fast moving molecules
- Metal parts and blade erosion
- Multistage turbine and high mechanical stress

Organic Fluid

- Very large flow rate
- Larger diameter turbine
- No wear of blades and metal parts

Advantages of Turboden ORC Turbogenerators

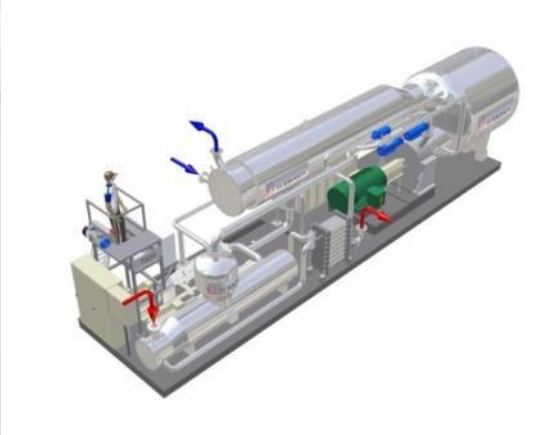
Technical advantages

- High cycle efficiency
- Very high turbine efficiency (up to 90%)
- Low mechanical stress of the turbine due to the low peripheral speed
- Low RPM of the turbine allowing the direct drive of the electric generator without reduction gear
- No erosion of blades, thanks to the absence of moisture in the vapor nozzles

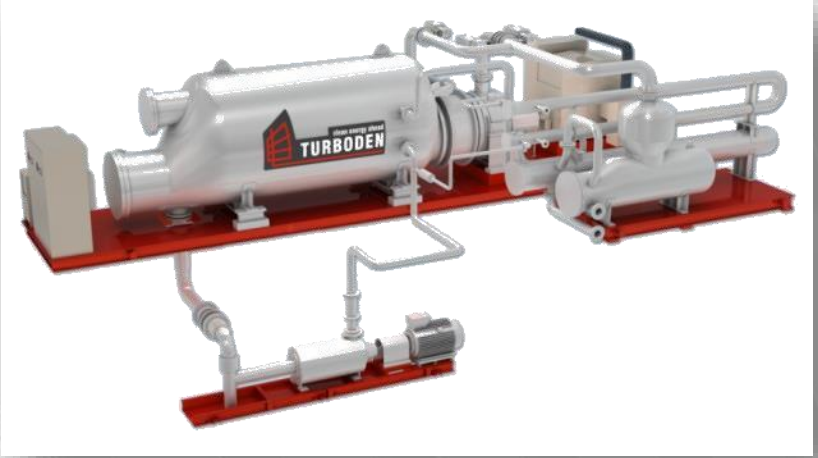
Operational advantages / results

- Simple start-stop procedures
- Automatic and continuous operation
- No operator attendance needed
- Quiet operation
- High Availability
- Partial load operation down to 10% of nominal power
- High efficiency even at partial load
- Low O&M requirements: about 3-5 hours / week
- Long life

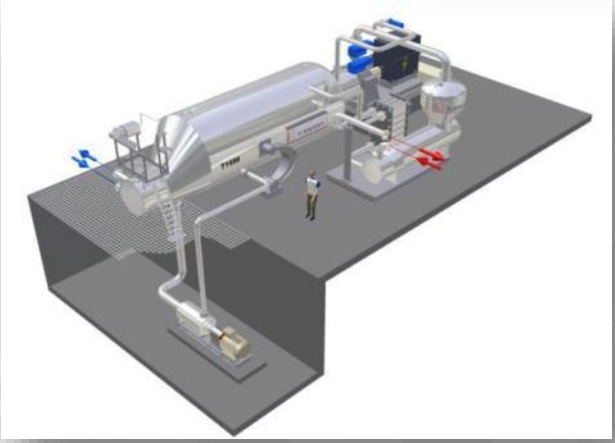
Layout – Some Examples



TURBODEN 7 layout



TURBODEN 10 layout



TURBODEN 18 layout

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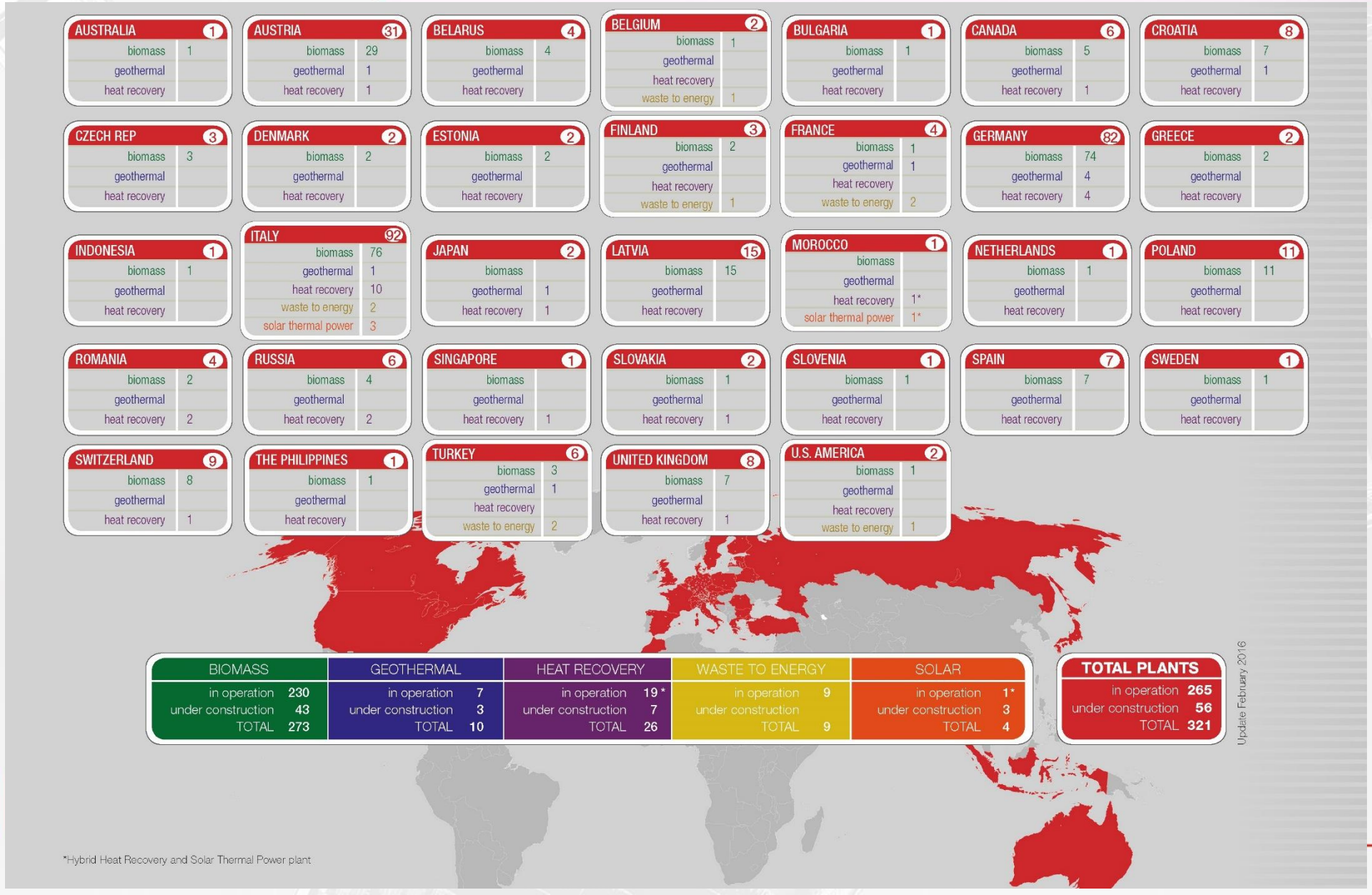
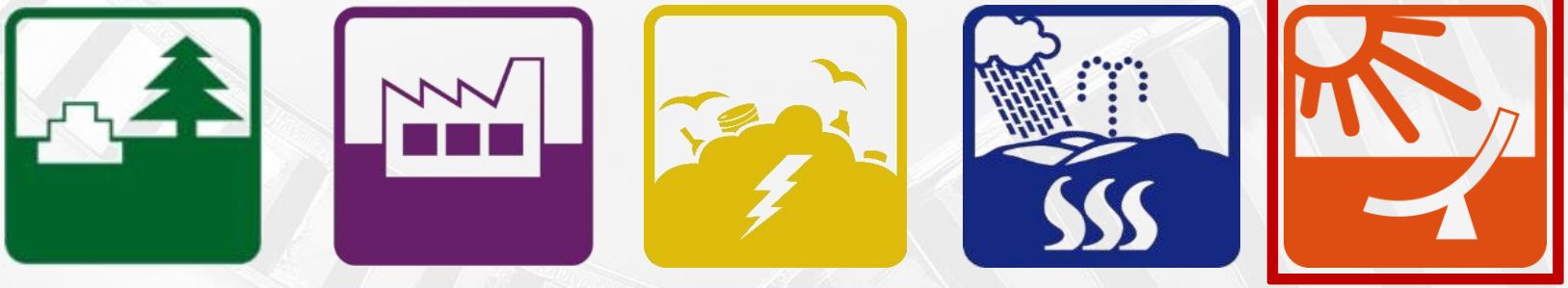
Turboden ORC Plants in the World



*Hybrid Heat Recovery and Solar Thermal Power plant

ORC Applications - Solar Thermodynamic



Biomass | Heat Recovery | Waste to energy | Geothermal | Solar Thermal Power

Solar Thermal Power

Turboden units allow to convert the heat collected by solar collectors into electricity through an efficient thermodynamic cycle. Concentrating Solar Power systems with ORC Turboden can be cost-effective in the range between 200 kW and 15 MW electric.

Solar Energy Market

Solar energy can be harnessed by different technologies. Each of the technologies covers the part of the market where it can bring the highest cost-effectivness rate.

Turboden ORC mostly finds its place in industrial scale sector from 1 to 10 MWel.

Italian Decree July 6th, 2012

Feed in tariff is paid for 25 years from date of commercial operation of the plant.

Plants will also be paid the market price for electricity sold

Feed in tariff in table are referred to plants that will be started up by 31st December 2015.

Feed in tariff [€/kWh el]			
Integration rate	**Up to 0.15**	**Between 0.15 and 0.50**	**Above 0.50**
Tariff added to the price of sale for plants with collecting surface up to 2500 m²	0.36	0.32	0.30
Tariff added to the price of sale for plants with collecting surface above 2500 m²	0.32	0.30	0.27

Feed in tariff will be reduced by 5% in 2016 and a further 5% in 2017.

A minimum thermal storage capacity is required:

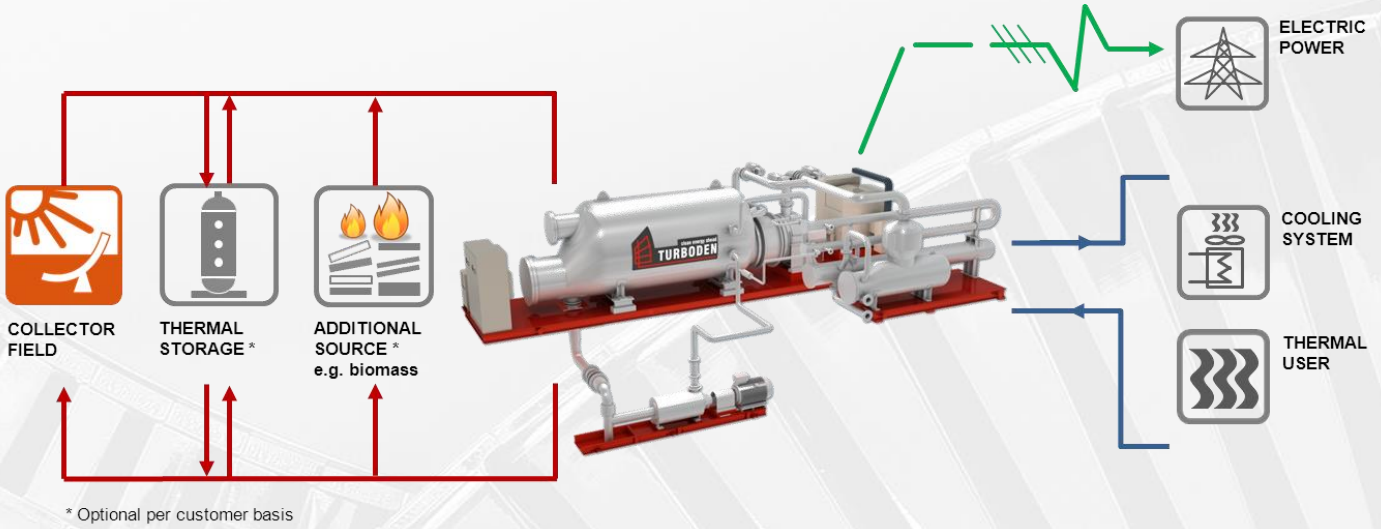
- 1.5 kWh_{th}/m^2 of collecting surface (for plants with a collecting surface bigger than 50,000 m^2)
- 0.4 kWh_{th}/m^2 of collecting surface (for plants with a collecting surface between 10,000 and 50,000 m^2)

In those plants where hibridization source is renewable, integration rate is conventionally zero.

Solar Thermal Power Plant with ORC unit

The ORC power block uses **organic fluid to drive the turbine** instead of a traditional high pressure steam.

This results in a **reliable**, **efficient** and **user friendly** solar thermal power plant



Turboden ORC strenghts in CSP plants

Electrical efficiency up to 26%

Capability to adapt to load variation easily and quickly

Partial load operation down to 10% of the nominal load

Direct air condenser. No water consumption

Synchronous or asynchronous generation

Remote Control operation
No operator needed on site

Low O&M requirements

Ease of hybridization with biomass or heat recovery plants

Possibility to couple to low cost/medium scale solar collectors

Possibility to use mineral/synthetic oils or saturated steam as heat transfer fluid

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Different Heat Transfer Fluids

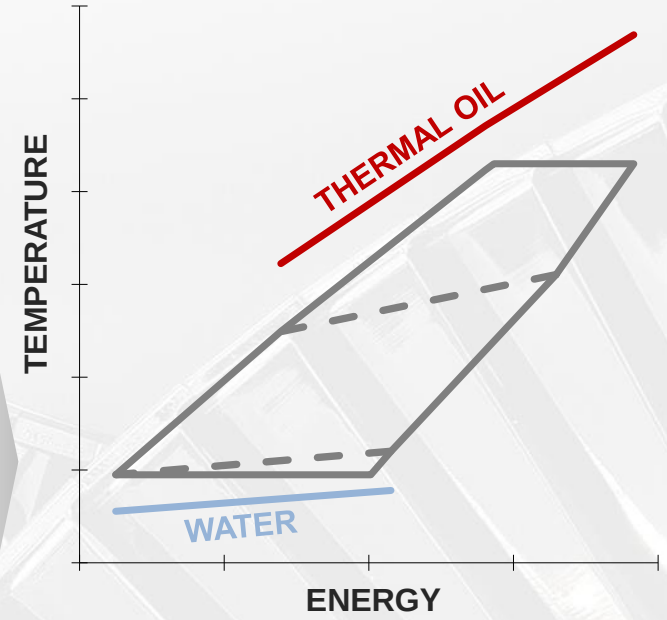
Th. oil parabolic trough system

***Figure 1**: Eurotrough solar collectors*

Th. oil linear Fresnel reflectors

***Figure 2**: FERA Fresnel solar collectors*

Turboden solution



Thermal oil (mineral or synthetic) between **250-300°C** feeds **Turboden HR** (20% electrical efficiency) or **Turboden HRS** units (24% electrical efficiency).

Partial load down to 10% of thermal power input

→ Non-harmful mineral or synthetic oil

→Thermal oil also as storage medium

→ Higher equivalent working hours considering storage

→ Heat transfer fluid working at ambient pressure

→ High ORC efficiency

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Different Heat Transfer Fluids

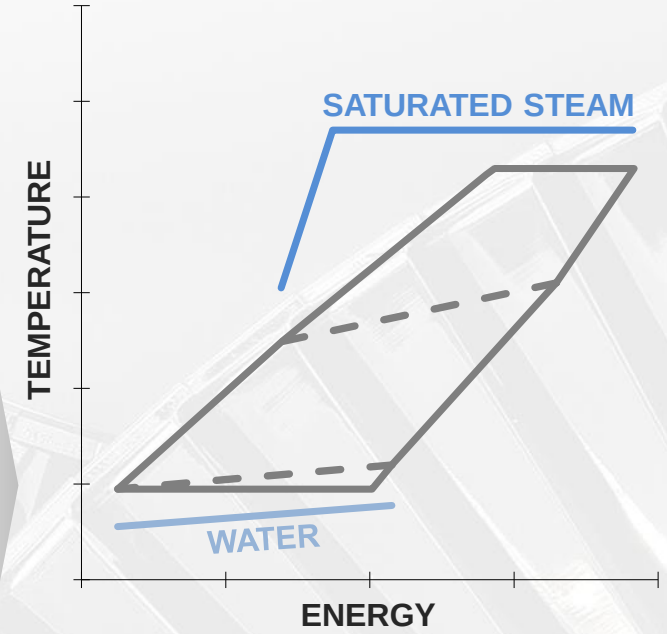
DSG linear Fresnel reflectors

***Figure 3**: AUSRA Fresnel collectors*

DSG parabolic trough system

***Figure 4**: Solarlite solar collectors*

Turboden solution



Saturated steam at **~20 barA** can feed **Turboden HR** units (20% electrical efficiency)

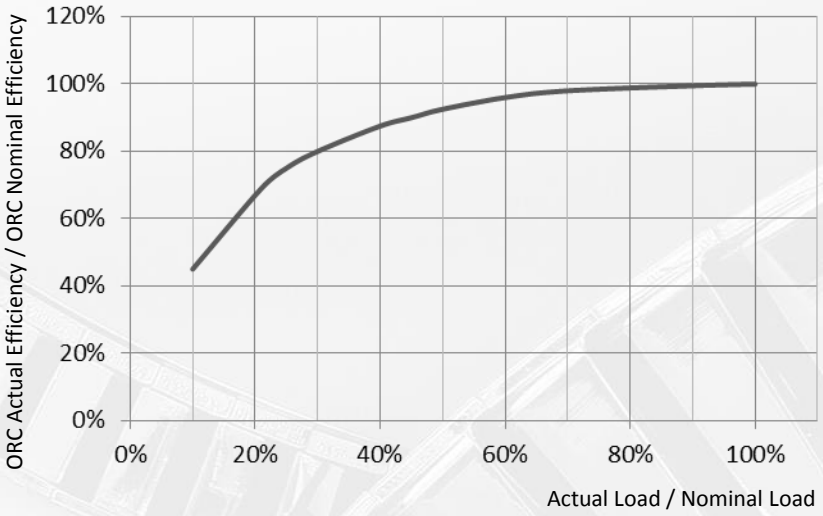
Saturated steam at **~60-70 barA** can feed **Turboden HRS** units (25% electrical efficiency)

- → **Lean configuration**
- → **Lower CAPEX**
- → **Environment friendly**
- → **Partial load with saturated steam inlet even below 5 barA**

Flexible and Automatic

"One of the key points in the the success of ORC technology is the capability to adapt to load variation easily and quickly"

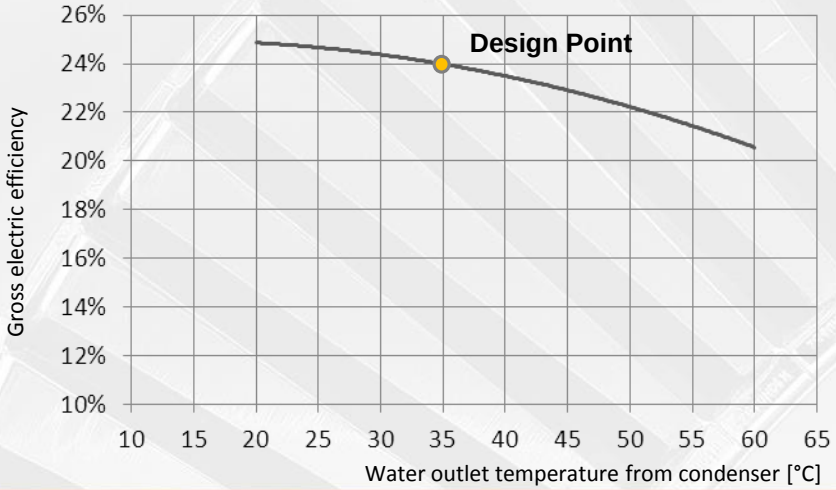
ORC Partial Load Efficiency



Part load operation down to 10% of nominal load.

Mantains 90% of cycle efficiency down to 50% of loading

Cooling water temperature effect on cycle efficiency (HRS Units)



Turboden ORC units automatically adapt the cycle at the ambient temperature variations

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Turboden Solutions: HR Units

		TURBODEN 6/7 HR DE		TURBODEN 10 to 14 HR DE		TURBODEN 18 to 24 HR DE		TURBODEN 27 to 40 HR DE		TURBODEN 50 to 100 HR DE	
		Range of Operation	Reference Case TD 6 HR	Range of Operation	Reference Case TD 10 HR	Range of Operation	Reference Case TD 22 HR SPLIT	Range of Operation	Reference Case TD 40 HR SPLIT	Range of Operation	Reference Case TD 70 HR
INPUT* - Thermal Oil											
Thermal Oil inlet temperature	°C	240-300	270	240-310	290	240-310	285	250-315	315	240-310	290
Thermal Oil outlet temperature	°C	170-120	140	170-120	145	170-120	120	170-120	130	150-110	115
Thermal power input	MW	2.5-4.0	3.0	5.0-7.0	5.54	8.0-12.0	11.21	13.0-22.0	21.40	24.0-50.0	32.00
Thermal Oil inlet temperature	*°F*	*464-572*	*518*	*464-590*	*554*	*464-590*	*545*	*482-599*	*599*	*464-590*	*554*
Thermal Oil outlet temperature	*°F*	*338-248*	*284*	*338-248*	*293*	*338-248*	*248*	*338-248*	*266*	*302-230*	*239*
Thermal power input	*MMBtu/hr*	*8.53-13.65*	*10.24*	*17.06-23.88*	*18.90*	*27.30-40.95*	*38.25*	*44.36-75.07*	*73.02*	*81.89-170.61*	*109.00*
OUTPUT - Cooling Water**											
Typical cooling water temperature (in/out)	°C	25/35	25/35	25/35	26/38	25/40	22/40	20/45	22/54	25/40	20/27
Thermal power to condenser	MW	2.0-3.5	2.4	4.0-5.0	4.4	6.0-9.5	9.0	10.0-17.5	17.2	19.2-40.0	25.2
Typical cooling water temperature (in/out)	*°F*	*77/95*	*77/95*	*77/95*	*79/100*	*77/104*	*72/104*	*68/113*	*72/129*	*77/104*	*68/81*
Thermal power to condenser	*MMBtu/hr*	*6.82-11.94*	*8.19*	*13.65-17.06*	*15.01*	*20.47-32.42*	*30.71*	*34.12-59.71*	*58.69*	*65.51-136.49*	*86.00*
PERFORMANCES											
Gross electric power	kW	500-800	600	900-1600	1108	1700-2500	2120	2600-4500	4000	4800-10500	6800
Gross electric efficiency***		17%-20%	20%	17%-22%	20%	17%-22%	19%	17%-21%	19%	17%-22%	21%
Captive power consumption	kW	18-36	25	36-70	46	60-100	80	100-200	200	200-800	465
Net active electric power output	kW	480-760	575	850-1550	1062	1650-2400	2040	2500-4000	3800	4500-9800	6335
Net electric efficiency***		16%-19%	19%	16%-21%	19%	16%-21%	18%	16%-20%	18%	16%-21%	20%
Electric generator****		50Hz, 400V 60Hz, 480V	50Hz, 400V 60Hz, 480V	50Hz, 400V 60Hz, 480V	50Hz, 400V 60Hz, 480V	50Hz, 660V 60Hz, 4160V	50Hz, 660V 60Hz, 4160V	50Hz, 6kV 60Hz, 4160V	50Hz, 6kV 60Hz, 4160V	50Hz, 6kV 60Hz, 4160V	60Hz, 4160V
Cooling systems		closed loop water cooling or wet tower		closed loop water cooling or wet tower		closed loop water cooling or wet tower		closed loop water cooling or wet tower		wet tower or air condenser	
Typical delivery time (EXW)	Months	9-11		9-11		9-11		11-13		12-14	

* Turboden units up to TURBODEN 40 HR can be equipped with the "Split System", a heat exchanger allowing additional low temperature heat recovery to increase the power production. The "Split System" heat exchager may use thermal oil / pressurized water as heat transfer fluid.

** Cooling water temperatures are selected keeping into account specific site requirements, e.g. average air temperaure, water availability (to use either dry or wet heat dissipation system), possibility of CHP mode (in this specific case water up to 90°C can be generated by the ORC).

*** Electric efficiency depends on several factors, primarely Heat and Cooling Source Temperatures and thermal media. Our sales specialists will support you to optimise the solutions, evaluating specific heat source features (thermal oil, steam, pressurized water, exhaust gas) and cooling devices (dry/wet water loops, CHP, air condensing).

**** Induction or synchronous, medium voltage available upon request. If reduction gear is required, electric power is reduced of about 1.5%.

DE: Available Direct Heat Exchange for direct heat recovery from internal combustion engines exhaust gas.

DISCLAIMER NOTE: Data provided herein are not binding and might change without prior notice.

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Turboden Solutions: HRS Units

		TURBODEN 12 HRS - 1MW		TURBODEN 12 HRS		TURBODEN 24 HRS		TURBODEN 32 HRS	
		with split*	without split	with split*	without split	with split*	without split	with split*	without split
INPUT - Thermal Oil									
Nominal temperature "HT" loop (in/out)	°C	305/209	305/204	305/210	305/206	310/215	310/212	310/215	310/214
Thermal power input "HT" loop	kW	3817	4043	4425	4817	8850	9634	12015	13075
Nominal temperature "LT" loop (in/out)	°C	209/130	-	210/130	-	215/135	-	215/135	-
Thermal power input "LT" loop	kW	338	-	392	-	784	-	1060	-
Overall thermal power input	kW	4155	4043	4817	4817	9634	9634	13075	13075
Nominal temperature "HT" loop (in/out)	*°F*	*581/408*	*581/399*	*581/410*	*581/403*	*419/275*	-	*419/275*	-
Thermal power input "HT" loop	*MMBtu/hr*	*13.02*	*13.08*	*15.09*	*16.44*	*30.17*	*32.87*	*40.01*	*44.61*
Nominal temperature "LT" loop (in/out)	*°F*	*408/266*	-	*410/266*	-	*419/275*	-	*419/275*	-
Thermal power input "LT" loop	*MMBtu/hr*	*1.15*	-	*1.34*	-	*2.68*	-	*3.62*	-
Overall thermal power input	*MMBtu/hr*	*14.18*	*13.80*	*16.44*	*16.44*	*32.87*	*32.87*	*44.61*	*44.61*
OUTPUT - Cooling Water									
Cooling water temperature (in/out)	°C	25/35	25/35	25/35	25/35	24/37	24/37	25/40	25/40
Thermal power to the cooling water circuit	kW	3151	3040	3662	3632	7256	7310	9977	9897
Cooling water temperature (in/out)	*°F*	*77/95*	*77/95*	*77/95*	*77/95*	*75/99*	*75/99*	*77/104*	*77/104*
Thermal power to the cooling water circuit	*MMBtu/hr*	*10.75*	*10.37*	*12.5*	*12.39*	*24.76*	*24.94*	*34.04*	*33.77*
PERFORMANCES									
Gross electric power	kW	1000	1000	1156	1188	2270	2336	3109	3193
Gross electric efficiency		24.1%	24.7%	24.0%	24.7%	23.6%	24.2%	23.8%	24.4%
Captive power consumption	kW	36	36	46	49	87	92	119	125
Net active electric power output	kW	964	964	1110	1139	2183	2244	2990	3067
Net electric efficiency		23.2%	23.8%	23.0%	23.6%	22.7%	23.3%	22.9%	23.5%
Electric generator**		50Hz, 400V 60Hz, 480V	50Hz, 400V 60Hz, 480V	50Hz, 400V 60Hz, 480V	50Hz, 400V 60Hz, 480V	50Hz, 660V 60Hz, 4160V	50Hz, 660V 60Hz, 4160V	50Hz, 6kV 60Hz, 4160V	50Hz, 6kV 60Hz, 4160V
Plant size		Multiple skid	Multiple skid	Multiple skid	Multiple skid	Multiple skid	Multiple skid	Multiple skid	Multiple skid
Biomass consumption***	kg/h	1816	1944	2105	2316	4211	4632	5715	6286
Net solar collector surface****	m²	-	10000-13000	-	13000	-	24000	-	33000
Typical delivery time (EXW)	Months	9-11	9-11	9-11	9-11	9-11	9-11	11-13	11-13

* The Turboden split system allows maximisation of electric power production for a given biomass consumption.

** Induction or synchronous, medium voltage available upon request. If reduction gear is required, electric power is reduced of about 1.5%.

*** Assuming a low heating value of biomass = 2.6 kWh/kg and boiler efficiency = 0.88 in case of ORC with split, = 0.80 in case of ORC without split. The thermal oil boiler is not included in the Turboden scope of supply.

**** Assuming design solar radiation = 800 W/m2, design solar collector efficiency = 0.6 and solar multiple = 1.2. The Solar field is not included in the Turboden scope of supply.

For heat recovery applications direct heat exchange can be available.

DISCLAIMER NOTE: Data provided herein are not binding and might change without prior notice.

Turboden Solutions: HRS units

		TURBODEN 50-110 HRS Range of Operation	TURBODEN 55 HRS Range Case	TURBODEN 65 HRS Range Case	TURBODEN 110 HRS Range Case
INPUT - Thermal Oil					
Thermal Oil inlet temperature	°C	300 - 320	315	315	315
Thermal Oil outlet temperature	°C	170 - 200	190	190	180
Overall thermal power input	kW	18000 - 40000	20000	25380	40023
Thermal Oil inlet temperature	*°F*	*572 - 608*	*599*	*599*	*599*
Thermal Oil outlet temperature	*°F*	*356 - 392*	*374*	*374*	*354*
Overall thermal power input	*MMBtu/hr*	*61.4 - 136.5*	*68.3*	*86.6*	*134.9*
OUTPUT - Cooling System (1)					
Cooling source		water / air	water	water	water
Design cooling system temperature (2)	°C	0 - 40	25/35	24/34	25/35
Thermal power to the cooling system	kW	13000 - 30000	14911	19376	29750
Design cooling system temperature (2)	*°F*	*32 - 104*	*77/95*	*75/93*	*77/95*
Thermal power to the cooling system	*MMBtu/hr*	*44.4 - 102.4*	*48.6*	*64.7*	*97.7*
PERFORMANCES					
Gross electric power	kW	4500 - 11000	5286	6348	10512
Gross electric efficiency		23 - 27%	26.4%	25.0%	26.3%
Captive power consumption (3)	kW	180 - 500	212	348	512
Net active electric power output	kW	4500 - 10000	5074	6000	10000
Net electric efficiency (4)		22 - 26%	25.4%	23.6%	25.0%
Electric generator		50Hz/60Hz, MV	50Hz, 6kV	60Hz, 4160V	50Hz, 6kV
Biomass consumption (5)	kg/h	9000 - 20000	9610	12200	19010
Net solar collector surface (6)	m^2	45000 - 100000	50000	63500	98900
Typical delivery time (EXW) (7)	Months	10 - 15	10 - 15	10 - 15	10 - 15

(1) Cooling water/air temperatures are selected considering specific site requirements, e.g. average air temperature, water availability (to use either dry or wet heat dissipation system), possibility of CHP mode (with hot water generation at ORC condenser).

(2) IN/OUT water temperatures for water cooling.

(3) Including working fluid pump and auxiliaries consumptions. Excluding heat dissipation system and thermal oil circulation consumptions.

(4) Electric efficiency depends on several factors, primarely Heat and Cooling Source Temperatures and thermal media. Our sales specialists will support you to optimise the solutions, evaluating specific heat source features (thermal oil, steam, pressurized water, exhaust gas) and cooling devices (dry/wet water loops, CHP, air condensing).

(5) Assuming a low heating value of biomass = 2.6 kWh/kg and boiler efficiency = 0.80. The thermal oil boiler is not included in the Turboden scope of supply.

(6) Assuming design solar radiation = 800 W/m2, design solar collector efficiency = 0.6 and solar multiple = 1.2.
The Solar field is not included in the Turboden scope of supply.

(7) Delivery time is defined at the moment of order considering specific project features (e.g. customer standards) and Turboden production load at the moment of order.

For heat recovery applications direct heat exchange can be available.

DISCLAIMER NOTE: Data provided herein are not binding and might change without prior notice.

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Reference Plants

Customer:
Italcementi Group

Site:
Ait Baha, Morocco

DNI:
2,400 kWh/m^2_year

Turboden unit:
Turboden 18 HR (2 MW_{el})

Figure 5

Figure 6

Figure 7

Plant type:
hybrid – heat recovery from waste heat of cement factory plus solar collectors with pebble stone thermal storage

Solar field area:
Aperture area: 6,159 m^2
Nr. of string: 3
String length: 215 m
Thermal power: 4 MW_{th}
Storage capacity: 12 h
HTF: hot air

***Figure 5**: Turboden 18 HR in Ait Baha plant*

***Figure 6**: Airlight conctrete solar collector structure*

***Figure 7**: view of Italcementi cement factory in Ait Baha with solar field*

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ENAS project

***Figure**: FERA Fresnel solar collectors.*

- **Final Customer**: ENAS (Ente acque della Sardegna)
- **EPC**: CEIF Soc. Coop. (Cooperativa Elettricisti Installatori Forlivesi)
- **Site:** Ottana (Nuoro, Sardegna)
- **Size:** 650 kW_{el}
- **Turboden unit:** Turboden 6 HR (Nominal working conditions: thermal oil 260/150°C, cooling water 25/35°C, gross efficiency 21%)
- **Plant type**: pure solar plant with 6 loops FERA Fresnel solar collectors (about 10.000 m^2) and a direct two-tanks thermal oil storage with thermal capacity of almost 5 equivalent working hours

Archimede project

Figure: *Turboden 12 HRS*

- **Final Customer**: Archimede S.r.l. Società di Ingegneria
- **EPC**: Archimede S.r.l. Società di Ingegneria
- **Site:** Melilli (Siracusa, Sicilia)
- **Size:** 1180 kW_{el}
- **Turboden unit:** Turboden 12 HRS (Nominal working conditions: thermal oil 305/204°C, cooling water 25/35°C, gross efficiency 25%)
- **Plant type**: hybrid solar plant with about 8.000 m^2 solar collectors coupled to a 3 MW_{th} natural gas boiler.

R&D solar projects

SOLAR project

Public-Private laboratory for the development of innovative technologies for distributed power production from Solar energy. DM 593/00 art.12 DM 19447

Description:

- Study and development of new-designed concentrated solar collectors
- Study of innovative thermal fluids with nanoparticles
- Realization of a prototype scale ORC connected to solar collectors
- Master studies for qualified energy technicians

Budget: 12,3 Meuro - Grant: 9,1 MEuro

Beneficiaries:

- Università del Salento (Coordinator)
- Università degli Studi di Catania
- CNR-IMM
- Costruzioni solari Srl
- Politecnico di Bari
- STC Srl
- TCT Srl
- Turboden Srl

EUROSUNMED project

Euro-Mediterranean cooperation on research & training in sun based renewable energies. FP7-ENERGY-2013-1

Description:

- Developing new technologies in 3 energy areas: PV, CSP and grid integration,
- Establishing strong networking between EU and MPC
- Disseminating the results of the projects

Beneficiaries:

- France: CNRS, EMRS
- Norway: Sintef, Sintef Energy
- Spain: Cener, IK4 Tekniker
- Belgium: EUREC
- Italy: Turboden
- Morocco: CNESTEN, CNRST, MASCIR, Agdal University, Al Akhawayn University, MASEN
- Egypt: Helwan University, Alexandria University, Nile Valley Engineering

Turboden at a Glance

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Turboden strong points

R&D

- Participation in national & EU research programs
- Cooperation with EU Universities and Research Centres
- Thermodynamic cycle optimization
- Working fluid selection & testing
- Thermo-fluid-dynamic design and validation
- Implementation & testing of control/supervision software
- Many patents obtained

Sales/marketing

- Pre-feasibility studies: evaluation of technical & economical feasibility of ORC power plants
- Customized proposals to maximize economic & environmental targets

Design

- Complete in-house mechanical design
- Proprietary design and own manufacturing of ORC optimized turbine
- Tools
  - Thermo-fluid-dynamic programs
  - FEA
  - 3D CAD-CAM
  - Vibration analysis

Operations & manufacturing

- Outsourced components from highly qualified suppliers
- Quality assurance & project management
- In-house skid mounting to minimize site activities

Aftermarket service

- Start-up and commissioning
- Maintenance, technical assistance to operation and spare parts service
- Remote monitoring & optimization of plant operation