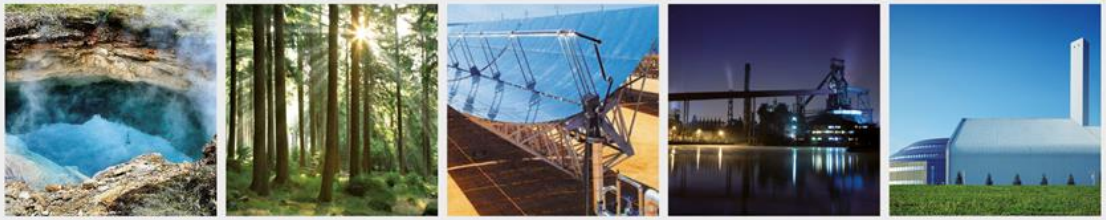

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Turboden Biomass solutions

LLOYD'S REGISTER · LRQA
ISO 9001

Doc.: 11-COM.P-1-rev.57

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

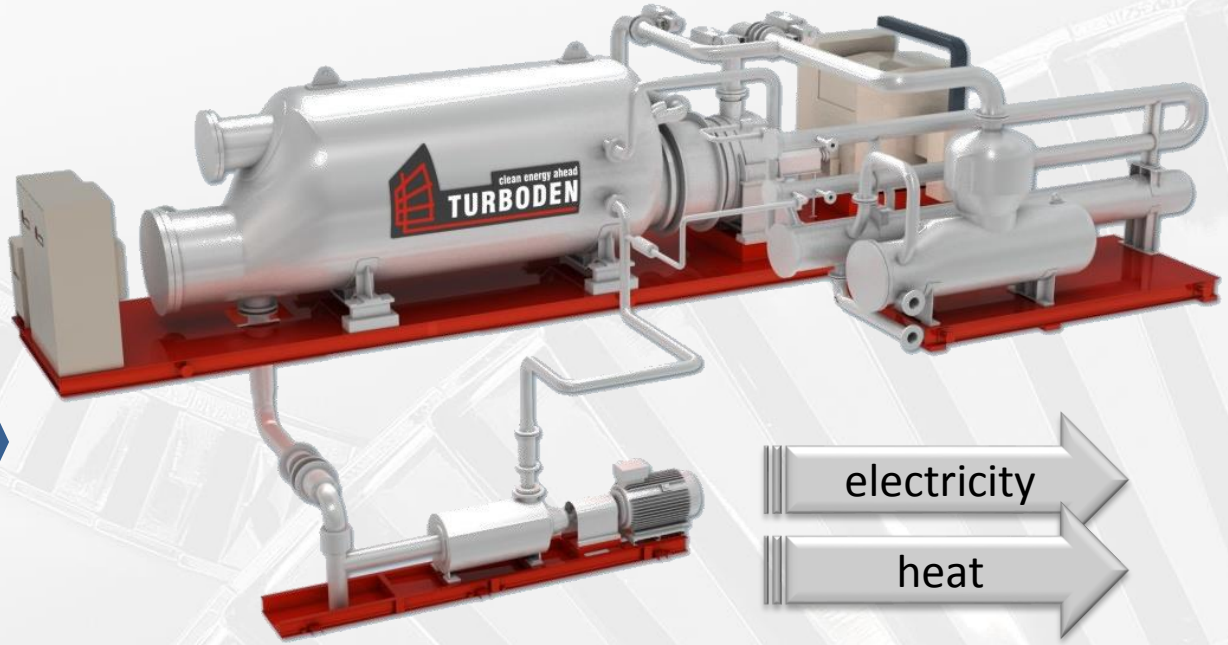
Biomass

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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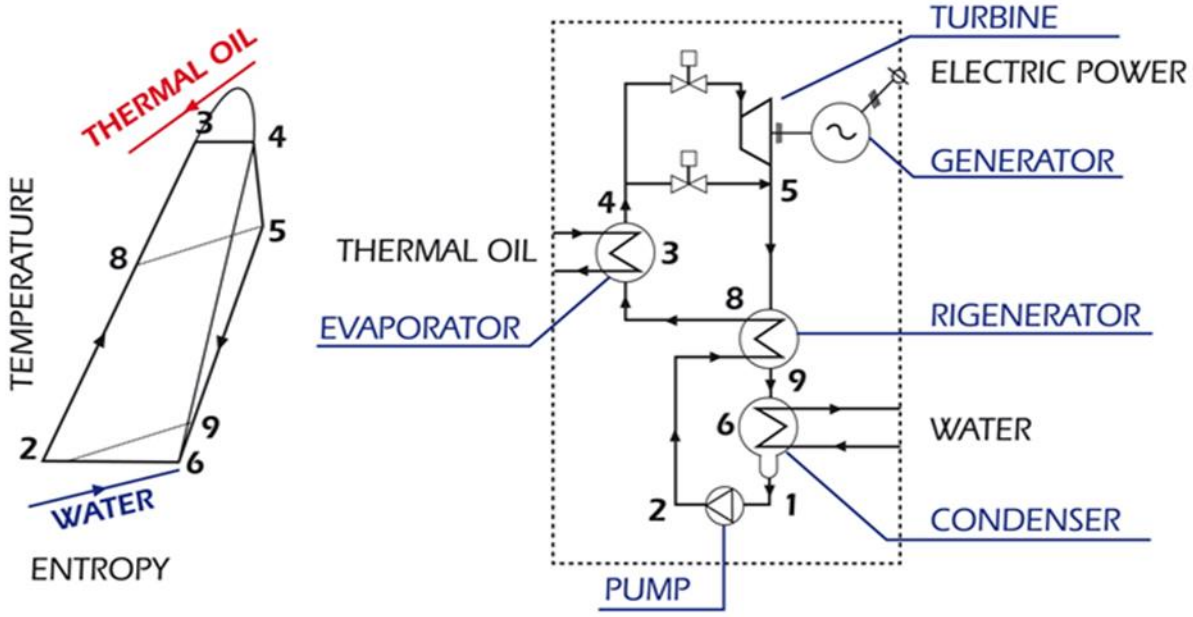
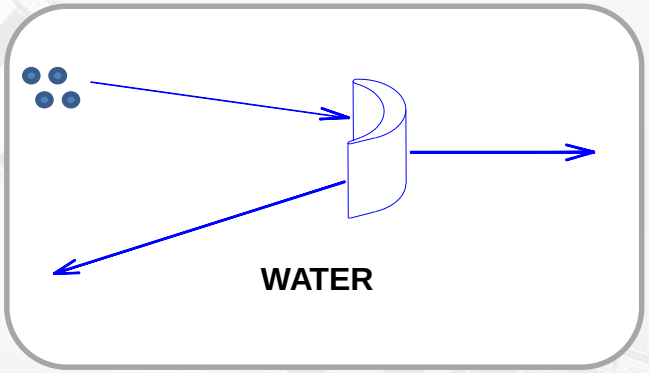
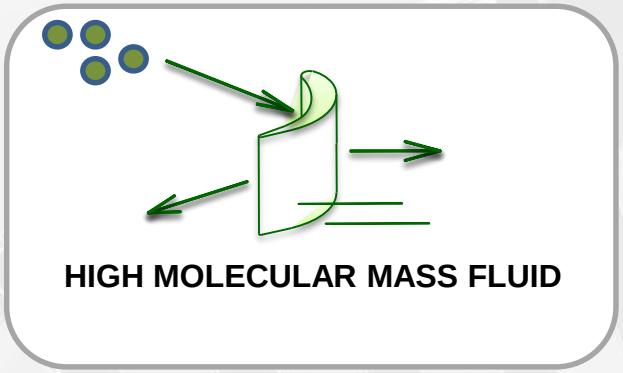
The Thermodynamic Principle: The ORC Cycle



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

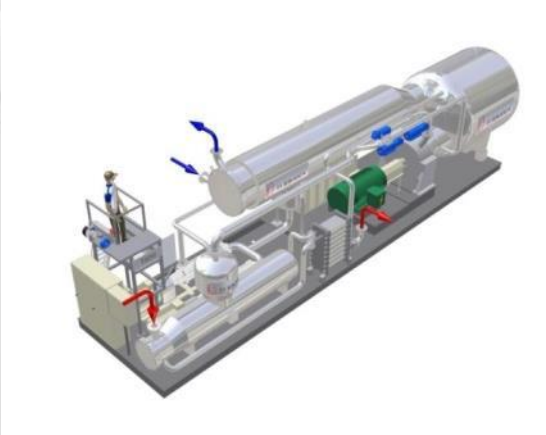
Technical advantages

- 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

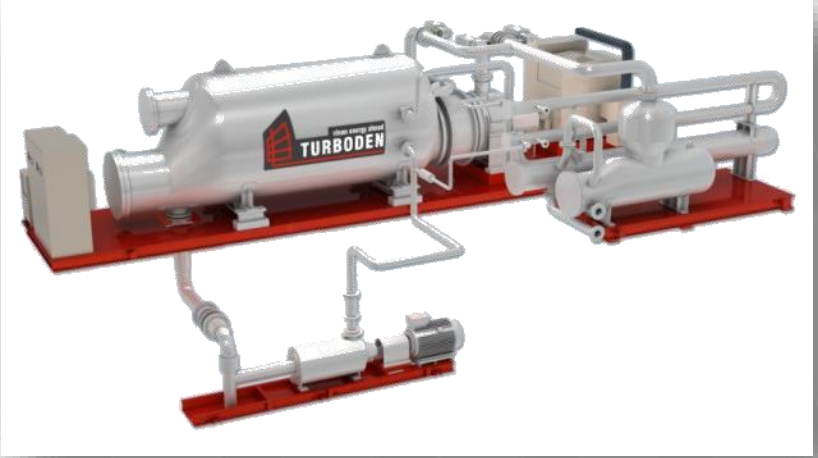
Operational advantages / results

- 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

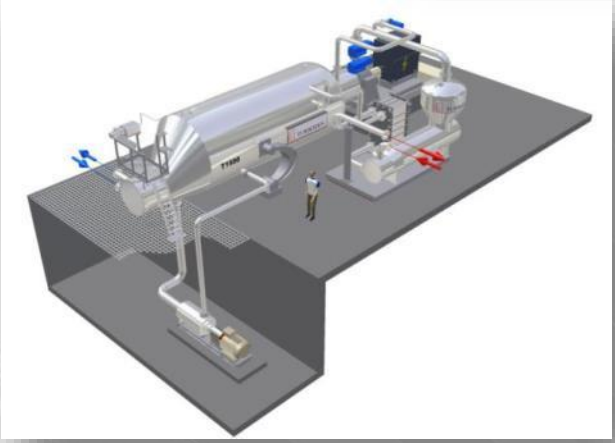
Layout – Some Examples



TURBODEN 7 layout

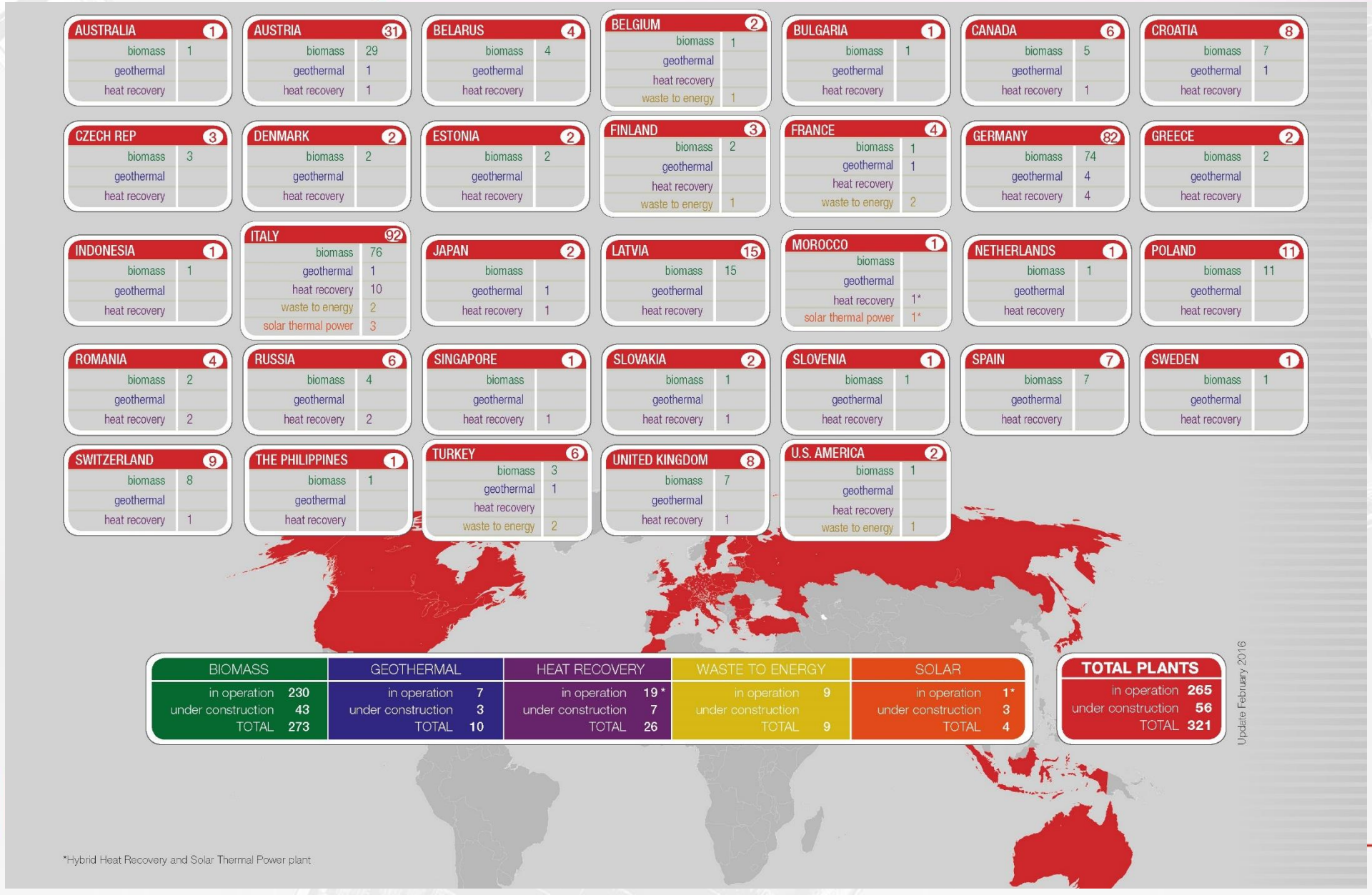


TURBODEN 10 layout



TURBODEN 18 layout

Turboden ORC Plants in the World



*Hybrid Heat Recovery and Solar Thermal Power plant

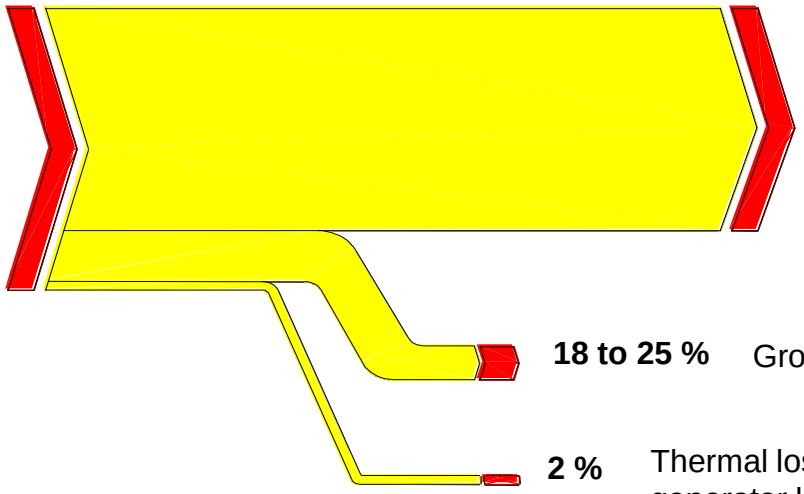
ORC Applications - Biomass

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

Biomass

Cogeneration plants with Turboden ORC can produce heat and electrical power from biomass with high efficiency and user friendly operation. The generated power usually ranges between 200 kW and 15 MW electric.

ORC Plant – Performances



100 %

Thermal power from thermal oil (or other heat carrier)

80 to 73%

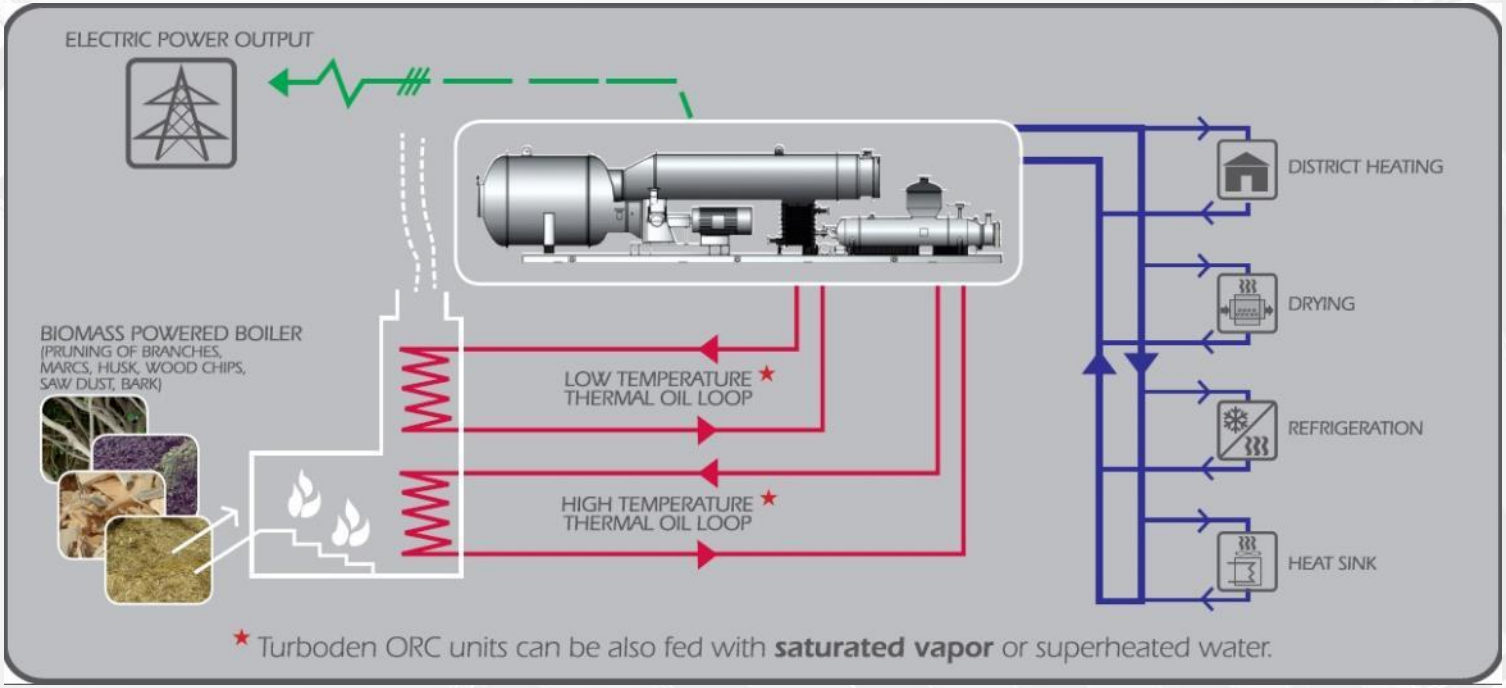
Thermal power to heat users

18 to 25 % Gross electric power

2 % Thermal losses (insulation and generator losses)

- **Gross electric efficiency: up to 25%**
- **Overall energy efficiency: 98%**

ORC Plant in a Process of Cogeneration from Biomass



Combined Heat & Power (CHP) with Split system
Standard Sizes and Typical Performances

		TURBODEN 6 CHP	TURBODEN 7 CHP	TURBODEN 10 CHP	TURBODEN 14 CHP	TURBODEN 18 CHP	TURBODEN 22 CHP	TURBODEN 26 CHP	TURBODEN 28 CHP
INPUT - Thermal Oil									
Nominal temperature "HT" loop (in/out)	°C	312/252	312/252	310/250	310/250	312/252	309/249	310/250	310/245
Thermal power input "HT" loop	kW	3056	3572	4685	6130	8935	10975	12948	14302
Nominal temperature "LT" loop (in/out)	°C	252/132	252/132	250/130	250/130	252/132	249/130	250/135	245/130
Thermal power input "LT" loop	kW	283	338	450	585	855	1045	1223	1386
Overall thermal power input	kW	3339	3910	5135	6715	9790	12020	14171	15688
Nominal temperature "HT" loop (in/out)	*°F*	*594/486*	*594/486*	*590/482*	*590/482*	*594/486*	*588/480*	*590/482*	*590/473*
Thermal power input "HT" loop	*MMBtu/hr*	*10.43*	*12.19*	*15.99*	*20.92*	*30.49*	*37.45*	*44.15*	*48.76*
Nominal temperature "LT" loop (in/out)	*°F*	*486/270*	*486/270*	*482/266*	*482/266*	*486/270*	*480/266*	*482/273*	*473/266*
Thermal power input "LT" loop	*MMBtu/hr*	*0.96*	*1.15*	*1.54*	*2.00*	*2.92*	*3.57*	*4.17*	*4.73*
Overall thermal power input	*MMBtu/hr*	*11.06*	*13.02*	*17.52*	*22.91*	*33.41*	*41.01*	*48.37*	*53.53*
OUTPUT - Hot Water									
Hot water temperature (in/out)	°C	60/80	60/80	60/80	60/80	60/90	60/90	60/90	61/91
Thermal power to hot water circuit	kW	2689	3146	4095	5341	7843	9598	11589	12908
Hot water temperature (in/out)	*°F*	*140/176*	*140/176*	*140/176*	*140/176*	*140/194*	*140/194*	*140/194*	*142/196*
Thermal power to hot water circuit	*MMBtu/hr*	*9.18*	*10.73*	*13.97*	*18.22*	*26.76*	*32.75*	*39.51*	*44.04*
PERFORMANCES									
Gross active electric power	kW	619	729	1000	1317	1862	2319	2632	2833
Gross electric efficiency		18.5%	18.6%	19.5%	19.6%	19.0%	19.3%	18.6%	18.1%
Captive power consumption	kW	32	40	51	62	87	98	155	166
Net active electric power	kW	587	689	949	1255	1775	2221	2476	2667
Net electric efficiency		17.6%	17.6%	18.5%	18.7%	18.1%	18.5%	17.5%	17.0%
Electric generator**		50Hz, 400V	50Hz, 400V	50Hz, 400V 60Hz, 480V	50Hz, 400V	50Hz, 660V 60Hz, 4160V	50Hz, 660V 60Hz, 4160V	50Hz, 6kV 60Hz, 4160V	50Hz, 6kV 60Hz, 4160V
Plant size		Single Skid	Single Skid	Multiple Skid	Multiple Skid	Multiple Skid	Multiple Skid	Multiple Skid	Multiple Skid
Biomass consumption***	kg/h	1459	1709	2244	2935	4279	5253	6194	6857
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.
The thermal oil boiler is not included in the Turboden scope of supply.

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Combined Heat & Power (CHP)
Standard Sizes and Typical Performances

		TURBODEN 6 CHP	TURBODEN 7 CHP	TURBODEN 10 CHP	TURBODEN 14 CHP	TURBODEN 18 CHP	TURBODEN 22 CHP	TURBODEN 30 CHP
INPUT - Thermal Oil								
Nominal temperature "HT" loop (in/out)	°C	302/242	302/242	300/240	300/240	300/240	300/240	310/231
Overall thermal power input	kW	3340	3895	5140	6715	9790	12020	17571
Nominal temperature "HT" loop (in/out)	*°F*	*576/468*	*576/468*	*572/464*	*572/464*	*572/464*	*572/464*	*590/448*
Overall thermal power input	*MMBtu/hr*	*11.4*	*13.29*	*17.54*	*22.91*	*33.4*	*41.01*	*59.95*
OUTPUT - Hot Water								
Hot water temperature (in/out)	°C	60/80	60/80	60/80	60/80	60/90	60/90	65/95
Thermal power to hot water circuit	kW	2664	3117	4081	5313	7834	9601	14499
Hot water temperature (in/out)	*°F*	*140/176*	*140/176*	*140/176*	*140/176*	*140/194*	*140/194*	*149/203*
Thermal power to hot water circuit	*MMBtu/hr*	*9.09*	*10.64*	*13.92*	*18.13*	*26.73*	*32.76*	*49.47*
PERFORMANCES								
Gross active electric power	kW	643	739	1016	1339	1863	2304	3143
Gross electric efficiency		19.3%	19.0%	19.8%	19.9%	19.0%	19.2%	17.9%
Captive power consumption	kW	32	37	48	58	79	97	197
Net active electric power	kW	611	702	968	1281	1784	2207	2946
Net electric efficiency		18.3%	18.0%	18.8%	19.1%	18.2%	18.4%	16.8%
Electric generator*		50Hz, 400V	50Hz, 400V	50Hz, 400V 60Hz, 480V	50Hz, 400V	50Hz, 660V 60Hz, 4160V	50Hz, 660V 60Hz, 4160V	50Hz, 6kV 60Hz, 4160V
Plant size		Single Skid	Single Skid	Multiple Skid	Multiple Skid	Multiple Skid	Multiple Skid	Multiple Skid
Biomass consumption**	kg/h	1606	1873	2471	3228	4707	5779	8448
Typical delivery time (EXW)	Months	9-11	9-11	9-11	9-11	9-11	9-11	11-13

* 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 = 0.80.
The thermal oil boiler is not included in the Turboden scope of supply.

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Turboden 200/300 kW Units
Typical Performances

		TURBODEN 2 Dual mode*		TURBODEN 3 Dual mode*		TURBODEN 3 CHP	
THERMAL INPUT		Saturated steam ~16 bar(a)	Saturated steam ~26 bar(a)	Saturated steam ~23 bar(a)	Saturated steam ~30 bar(a)	Thermal Oil	
		Max electric efficiency mode	**CHP mode**	**Max electric efficiency mode**	**CHP mode**	**80 °C water output**	**90 °C water output**
Saturated steam / Thermal Oil inlet temperature "HT" Loop (in)	°C	200	226	220	234	310	310
Water condensate / Thermal Oil outlet temperature "HT" Loop (out)	°C	181	209	201	216	221	227
Overall thermal power input	kW	1234	1624	1708	1971	1817	1835
Heat source flow rate**	t/h	2.2	3.1	3.2	3.8	30.2	32.4
Saturated steam / Thermal Oil inlet temperature "HT" Loop (in)	*°F*	*392*	*439*	*428*	*453*	*590*	*590*
Water condensate / Thermal Oil outlet temperature "HT" Loop (out)	*°F*	*358*	*408*	*394*	*421*	*437*	*441*
Overall thermal power input	*MMBtu/hr*	*4.21*	*5.54*	*5.83*	*6.73*	*6.21*	*6.26*
*Heat source flow rate**	*lb/min*	*81*	*114*	*118*	*140*	*309*	*331*
THERMAL OUTPUT - Hot water							
Hot water temperature (in/out)	°C	35/55	75/95	35/55	55/75	60/80	75/90
Thermal power to the cooling water circuit	kW	1002	1402	1380	1647	1491	1505
Hot water temperature (in/out)	*°F*	*95/131*	*167/203*	*95/131*	*131/167*	*140/176*	*167/194*
Thermal power to the cooling water circuit	*MMBtu/hr*	*3.42*	*4.78*	*4.71*	*5.62*	*5.09*	*5.13*
PERFORMANCES							
Gross active electric power	kW	200	200	300	300	300	300
Captive consumption	kW	12	22	18	26	20	23
Net active electric power	kW	188	178	282	274	280	277
Gross electric efficiency	%	16.2	12.3	17.5	15.5	16.5	16.3
Electric generator		Asynchr.; 400V; 50Hz	Asynchr.; 400V; 50Hz	Asynchr.; 400V; 50Hz	Asynchr.; 400V; 50Hz	Asynchr.; 400V; 50Hz	Asynchr.; 400V; 50Hz
Biomass consumption***	Kg/h	558	735	775	880	825	830
Typical delivery time (EXW)	Months	9	9	9	9	9	9

* Dual mode: the same ORC module (fed with saturated steam) can be operated either in "max electric efficiency" mode or in "CHP" mode.

** In case of thermal oil the flow rate was calculated assuming "Therminol 66" properties.

*** Assuming a low heating value of biomass = 2.6 kWh/kg and a boiler efficiency = 0.85.

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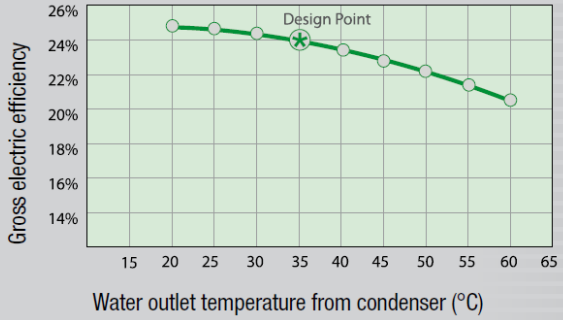
HRS – High Electrical Efficiency Units

HRS for electricity generation and cogeneration from biomass

Gross Performance of the Turboden HRS Modules at Various Condensation Water Temperatures

(*) Value of gross electrical efficiency calculated as the ratio of electric power output at generator terminals to the thermalpower input to the ORC at the design point



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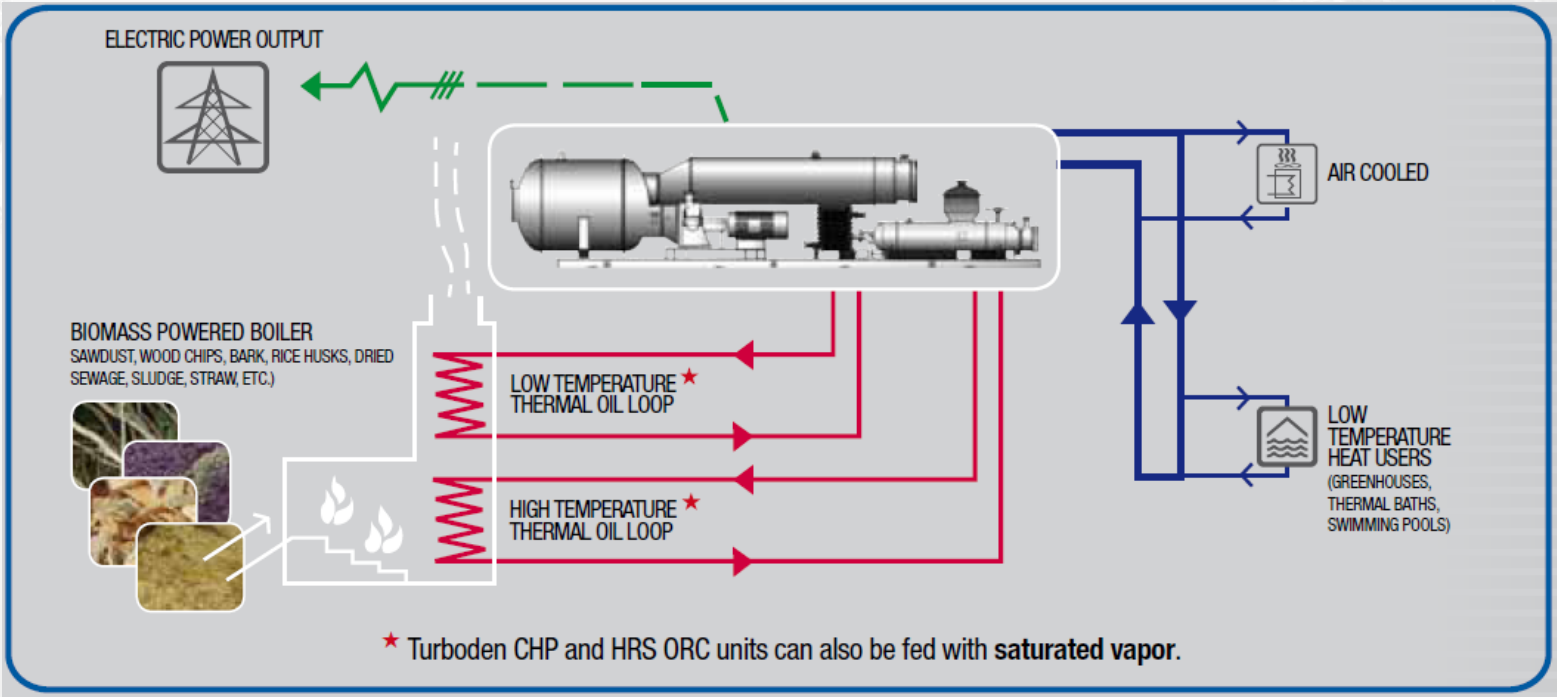
HRS – High Electrical Efficiency Units



HRS – High Electrical Efficiency 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.

HRS – High Electrical Efficiency 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.

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Biomass – Fuels & Applications

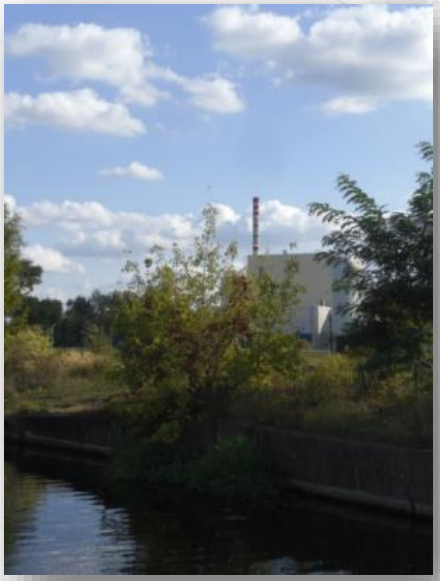
Fuels

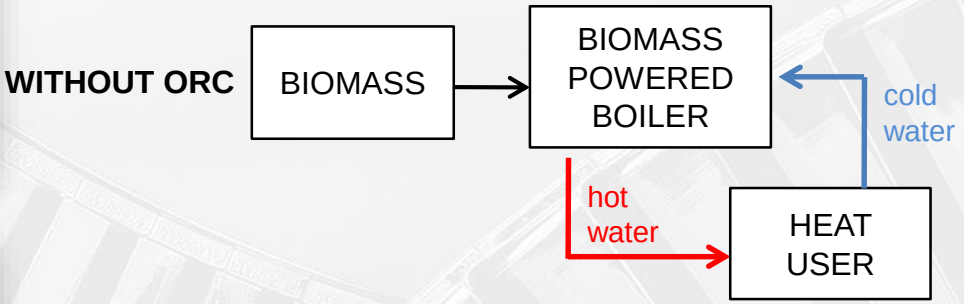
- Wood biomass: sawdust, woodchips, bark, treated wood
- Other biomass: dried sewage sludge, green cuttings, rice husk, vinasse and vine cuttings, wood industry waste material etc …
- Waste material

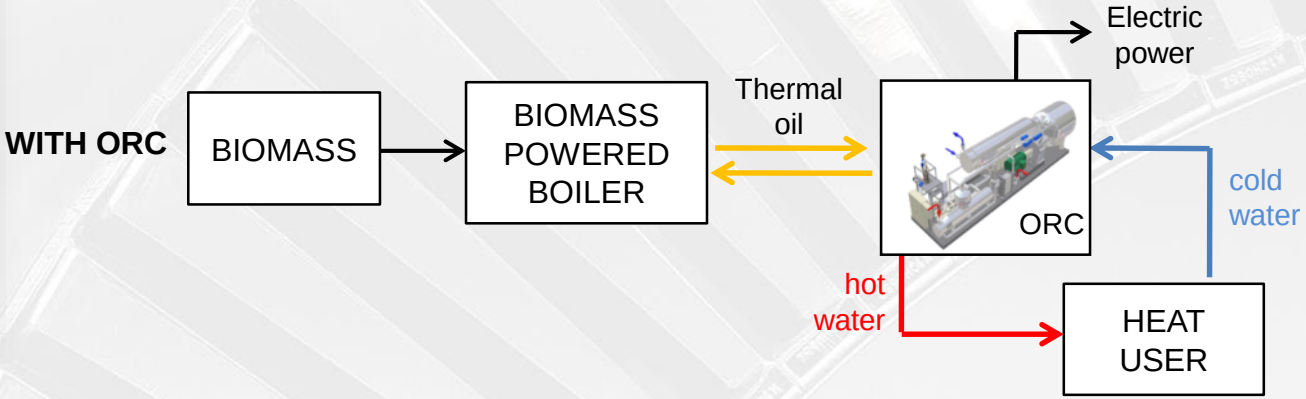
Heat Consumers

- District Heating networks
- Timber drying in sawmills
- Sawdust drying in wood pellet factories
- MDF/PB Producers
- Refrigeration
- Greenhouses
- Wine industry

District Heating Networks







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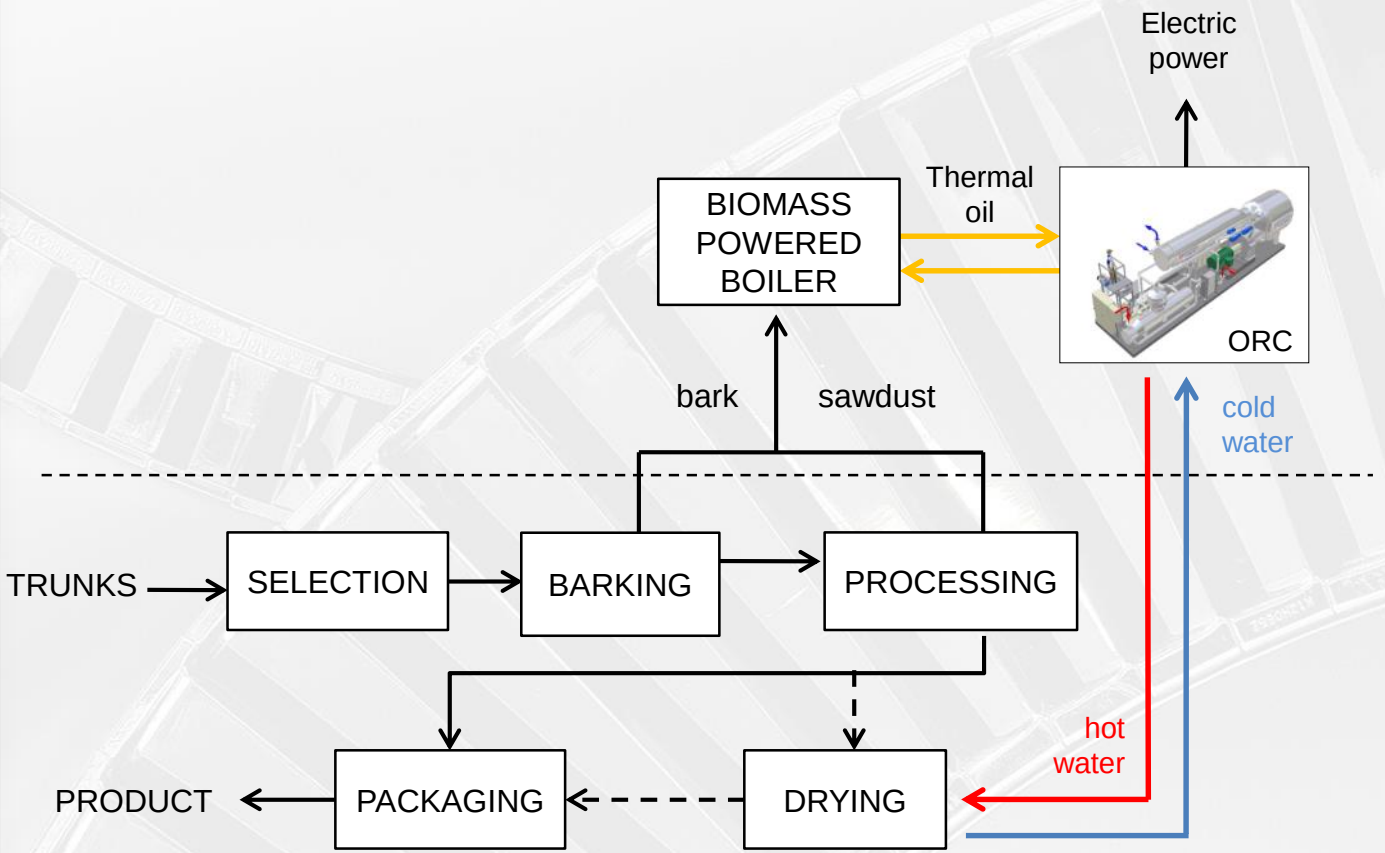
Sawmills



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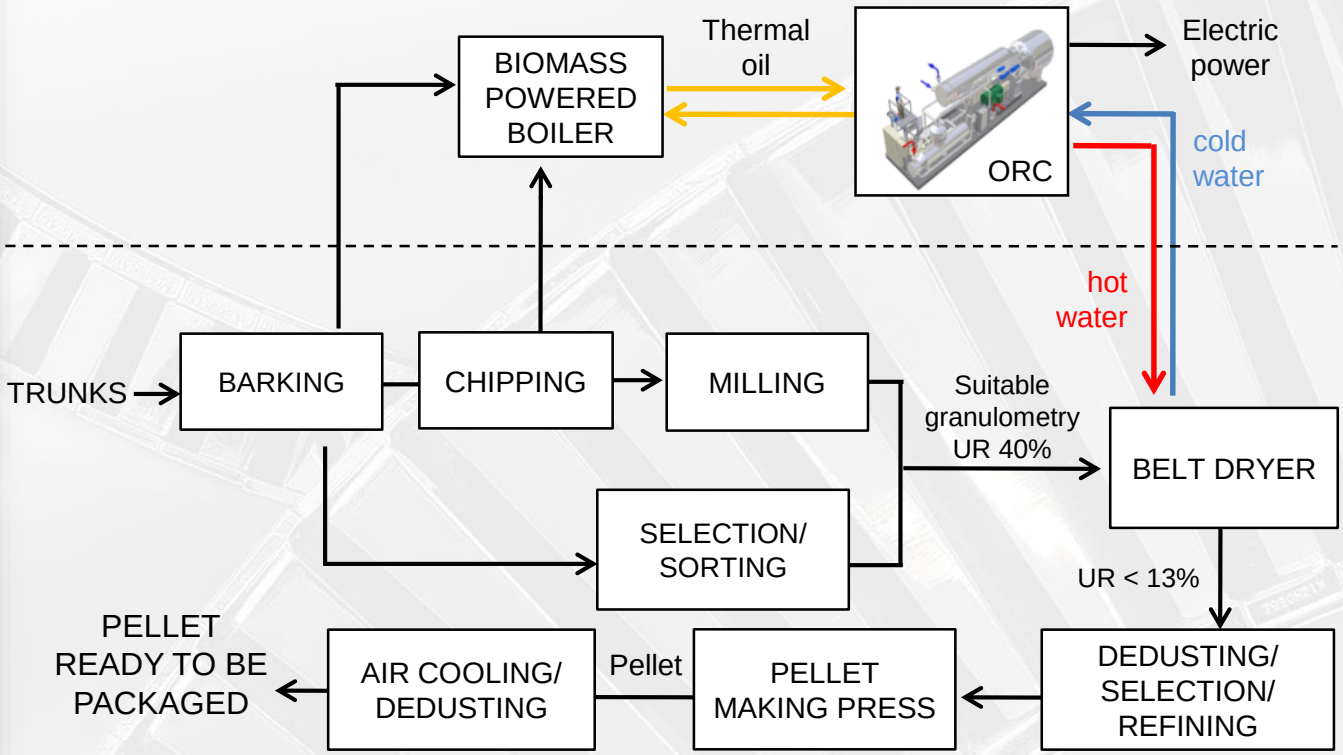
Wood Pellet Production



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MDF Production

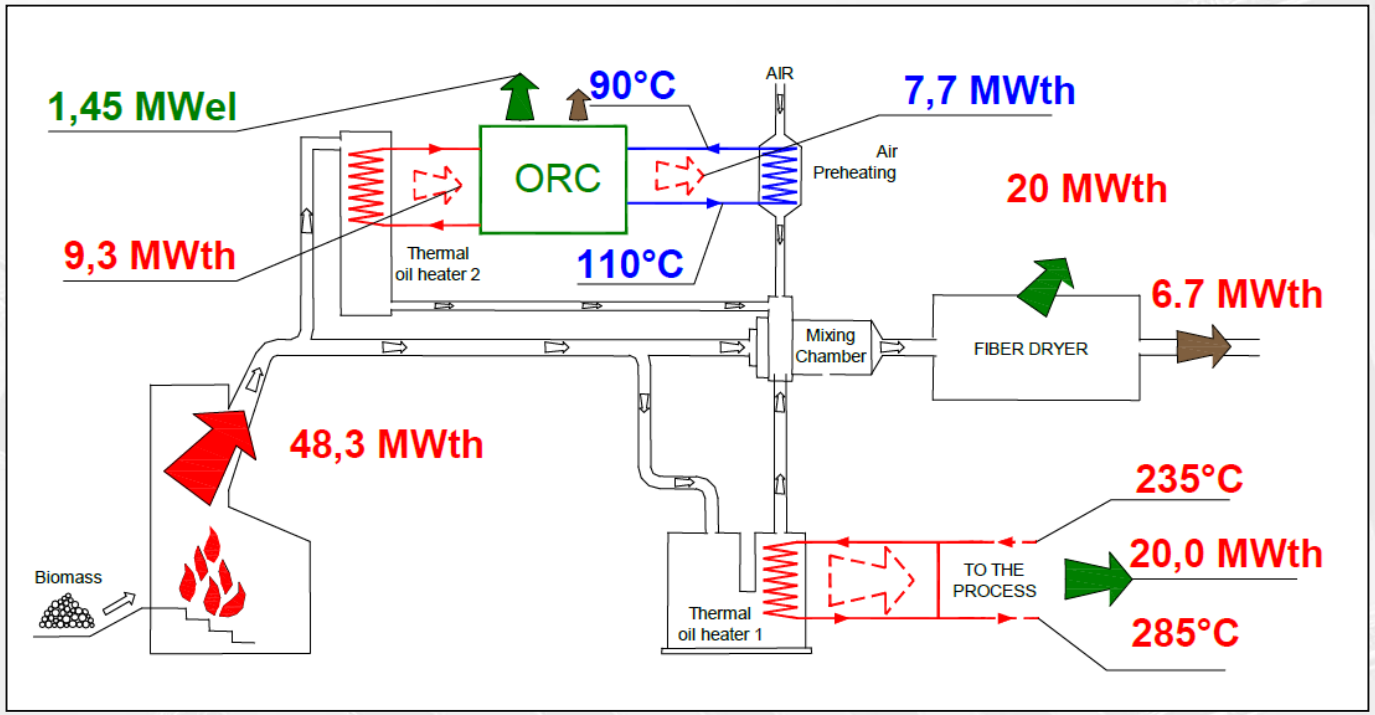
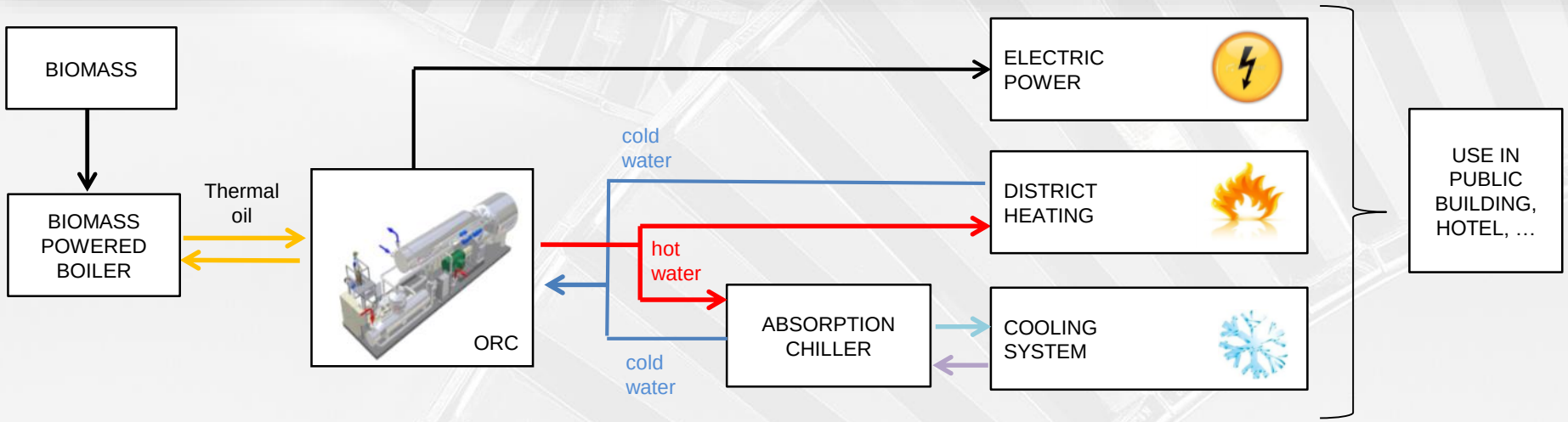


Figure: Proposed scheme for MDF plant with ORC cogeneration unit

CCHP – Combined Cooling Heating Power



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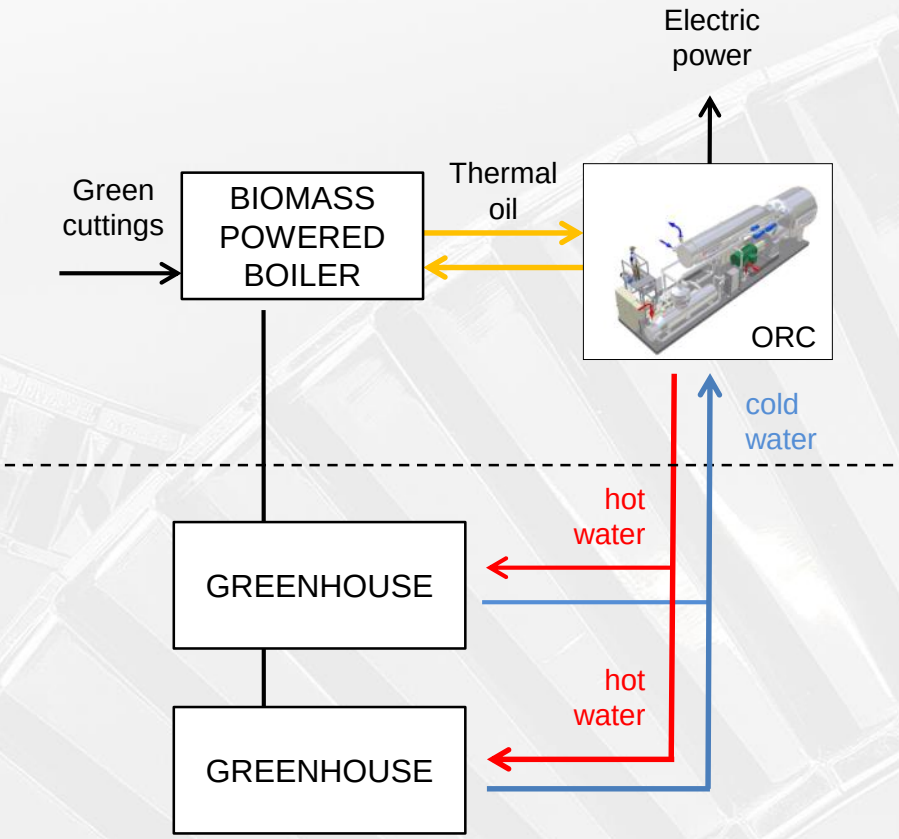
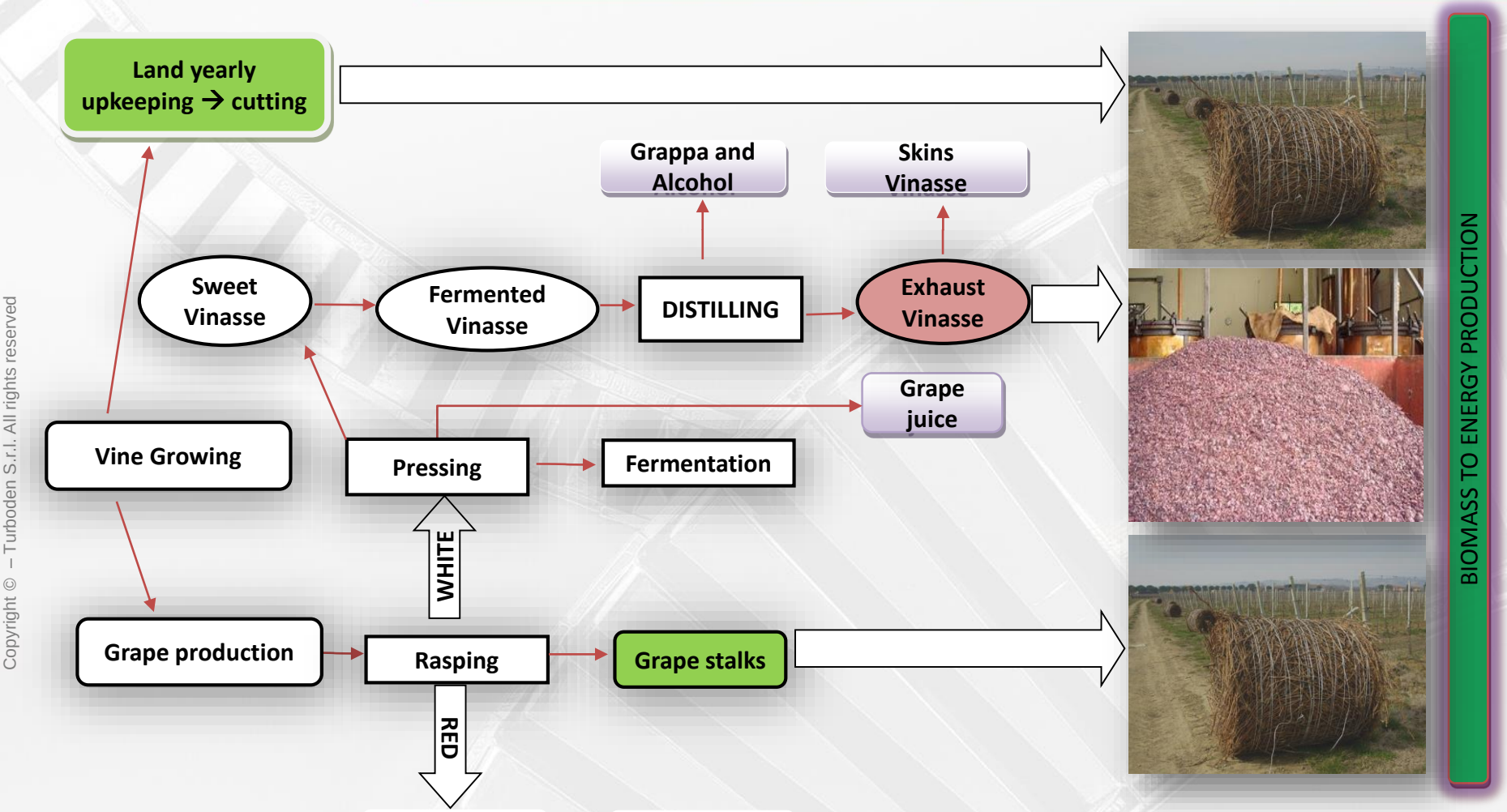
Greenhouses



Wine Production



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