Cod.10A08190

Expert workshop

Small scale biomass co-generation
Technology status and market opportunities

STATE OF THE ART OF ORC TECHNOLOGY FOR BIOMASS PLANTS

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Copenhagen, October 7th 2010

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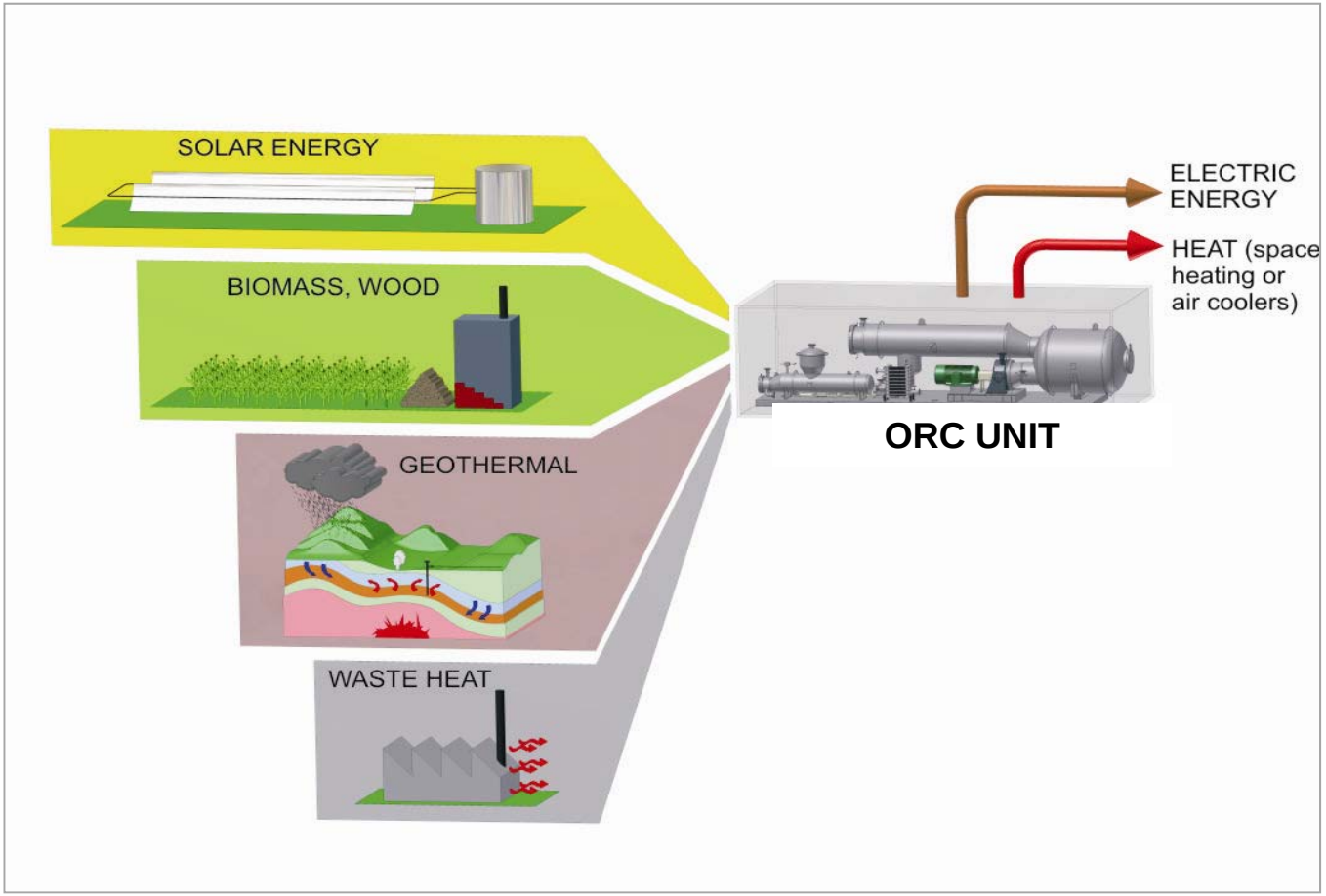
ORC application



- **standard size Turbogenerators: from 200 kW to 3 MW**
- **customized products: up to 10 MW**

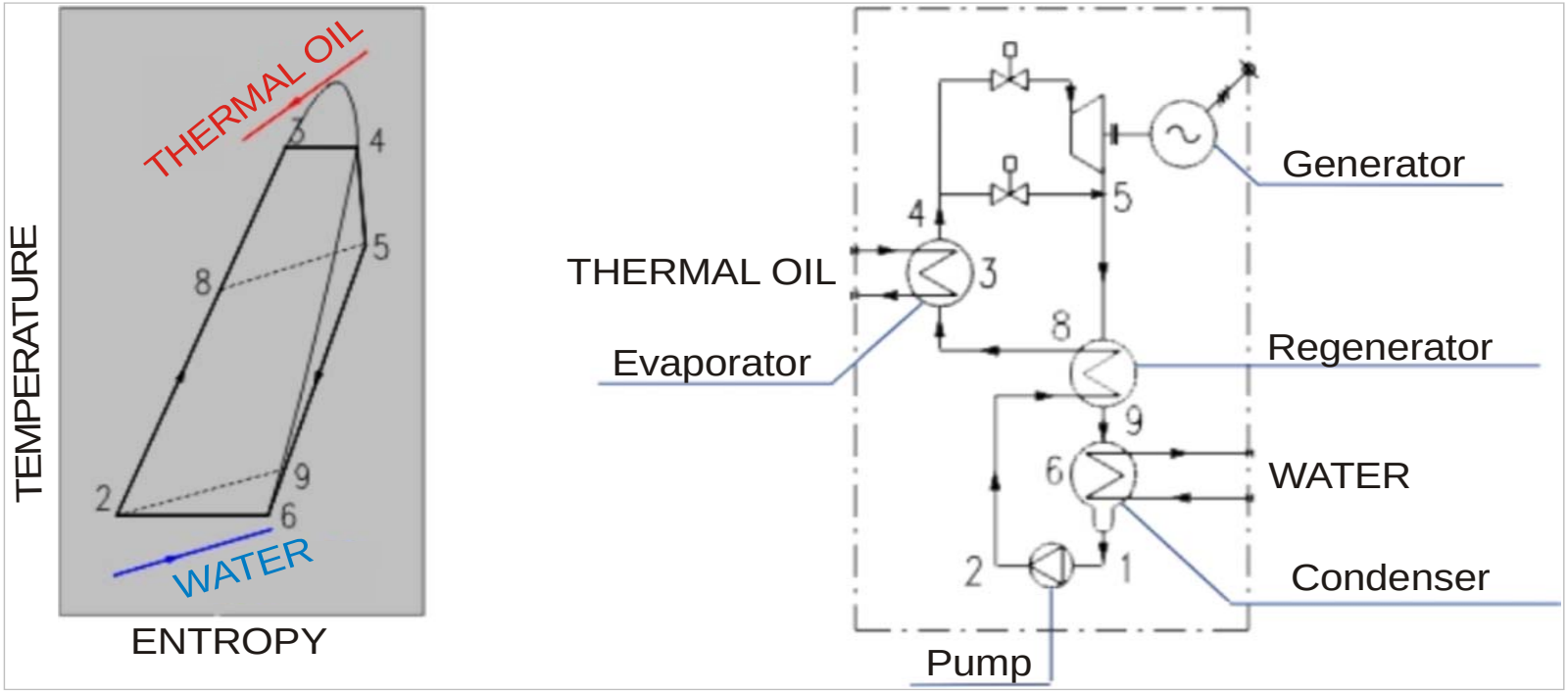
First ORC unit for biomass application. Turboden -1987

1987: A 3 kW_{el} CHP biomass ORC turbogenerator prototype in Milan

Single skid ORC Turbogenerators

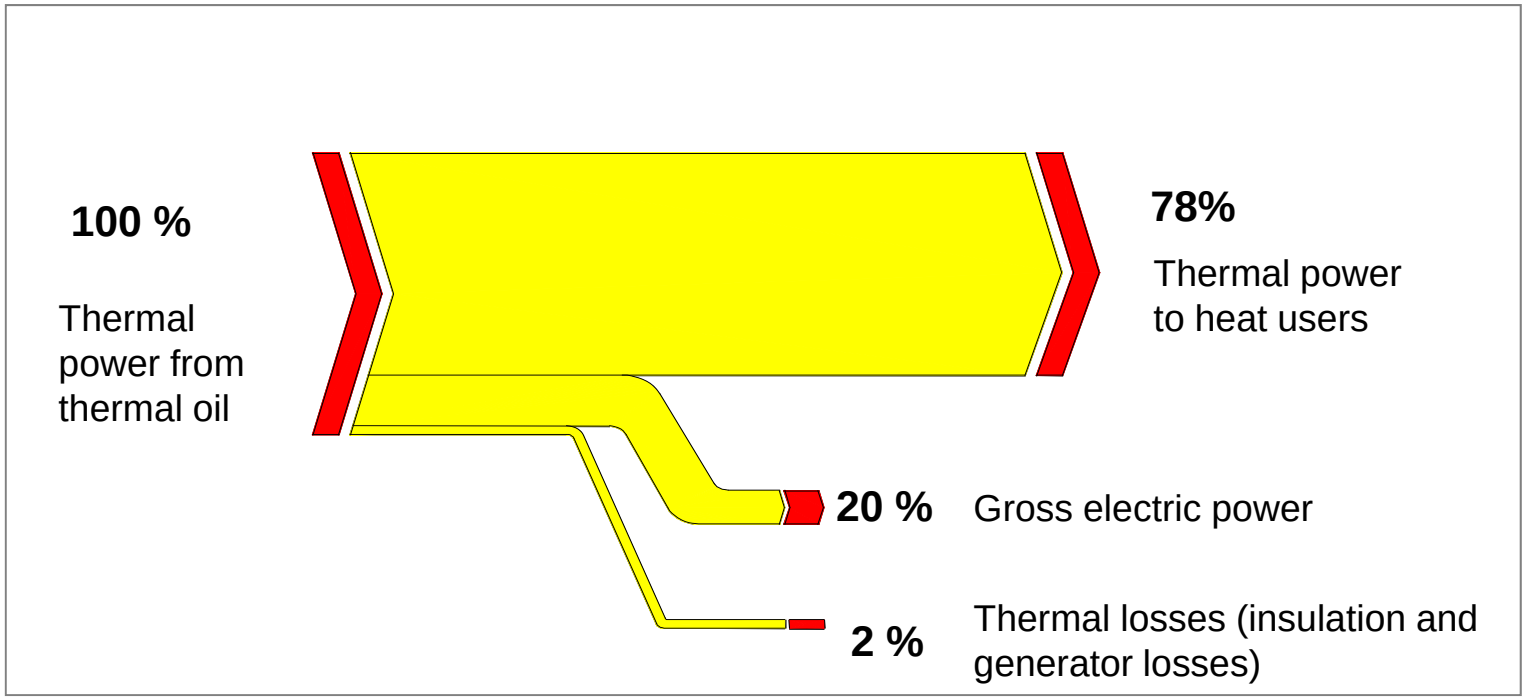
Typical single skid ORC unit for biomass cogeneration (~ 700 kWel)

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.

ORC Plants – Perfomances



➢**Gross electric efficiency: nearly 20%, Overall energy efficiency: 98%**

Starting from biomass and considering boiler efficiency, the overall electric efficiency becomes about 16%

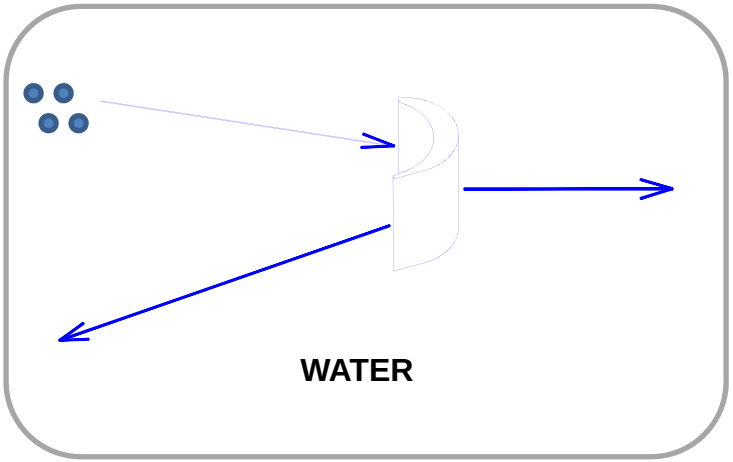
Why High Molecular Mass Working Fluid Instead of Water?

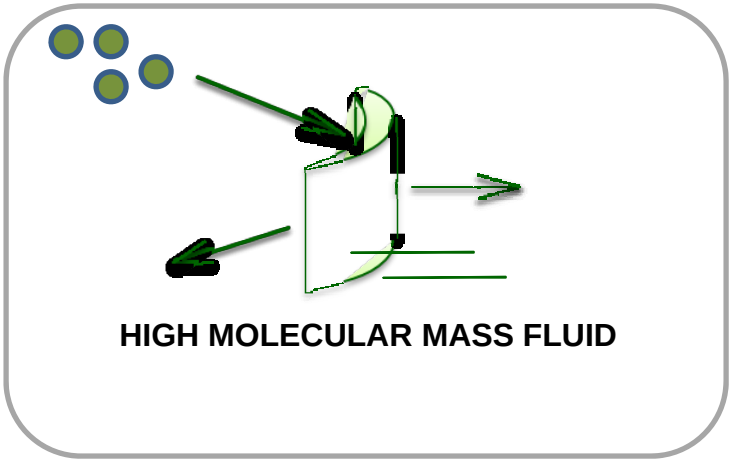
Water

- 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 ORC Turbogenerators

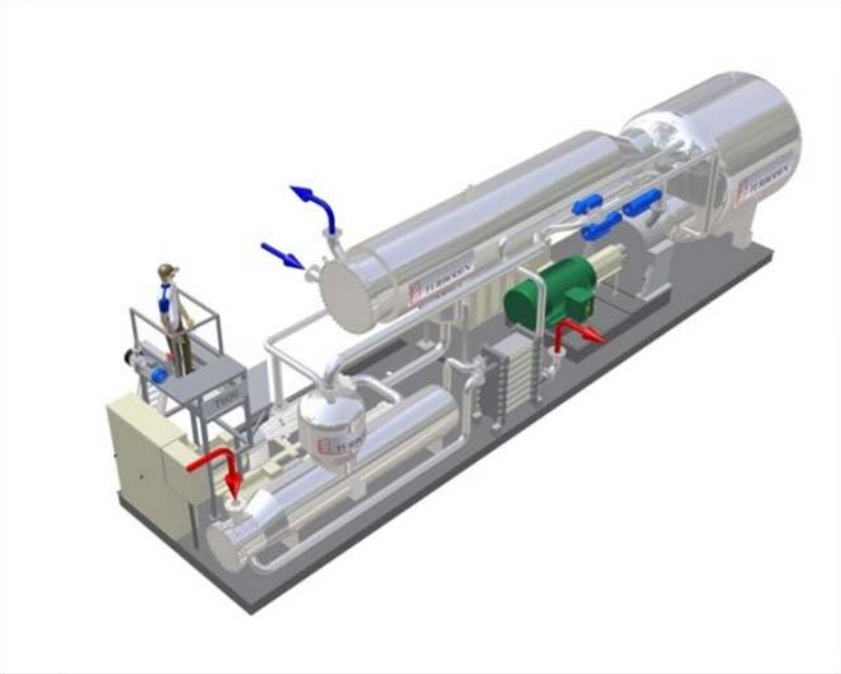
Technical advantages

- 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

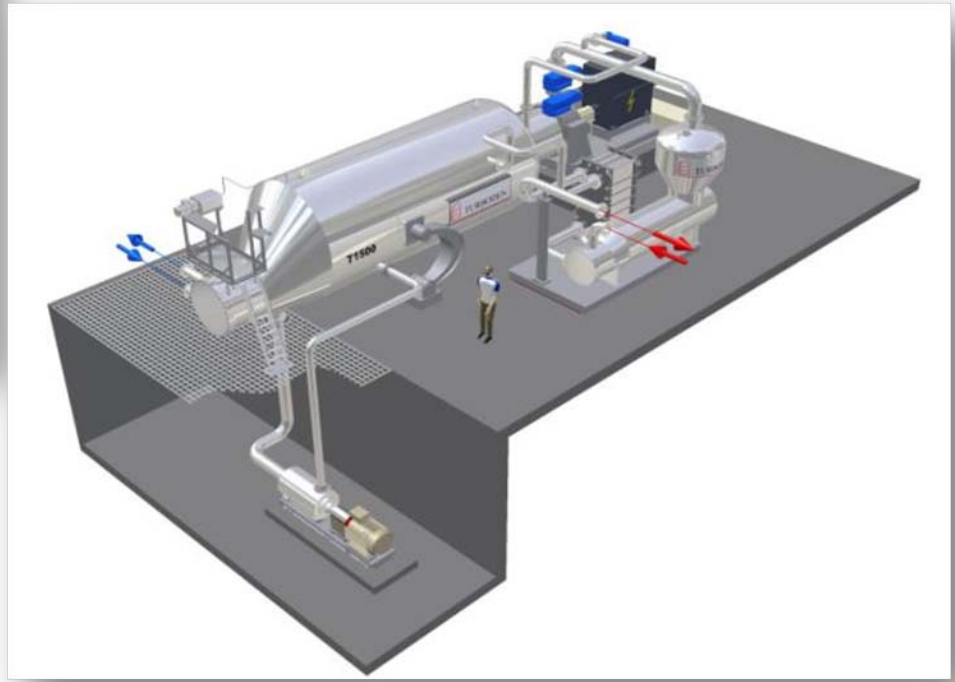
Operational advantages / results

- Simple start-stop procedures
- Automatic and continuous operation
- No operator attendance needed
- Quiet operation
- High Availability (Admont – over 50,000 hours of operation, availability > 98%)
- 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



Single skid layout (< 700kWel)



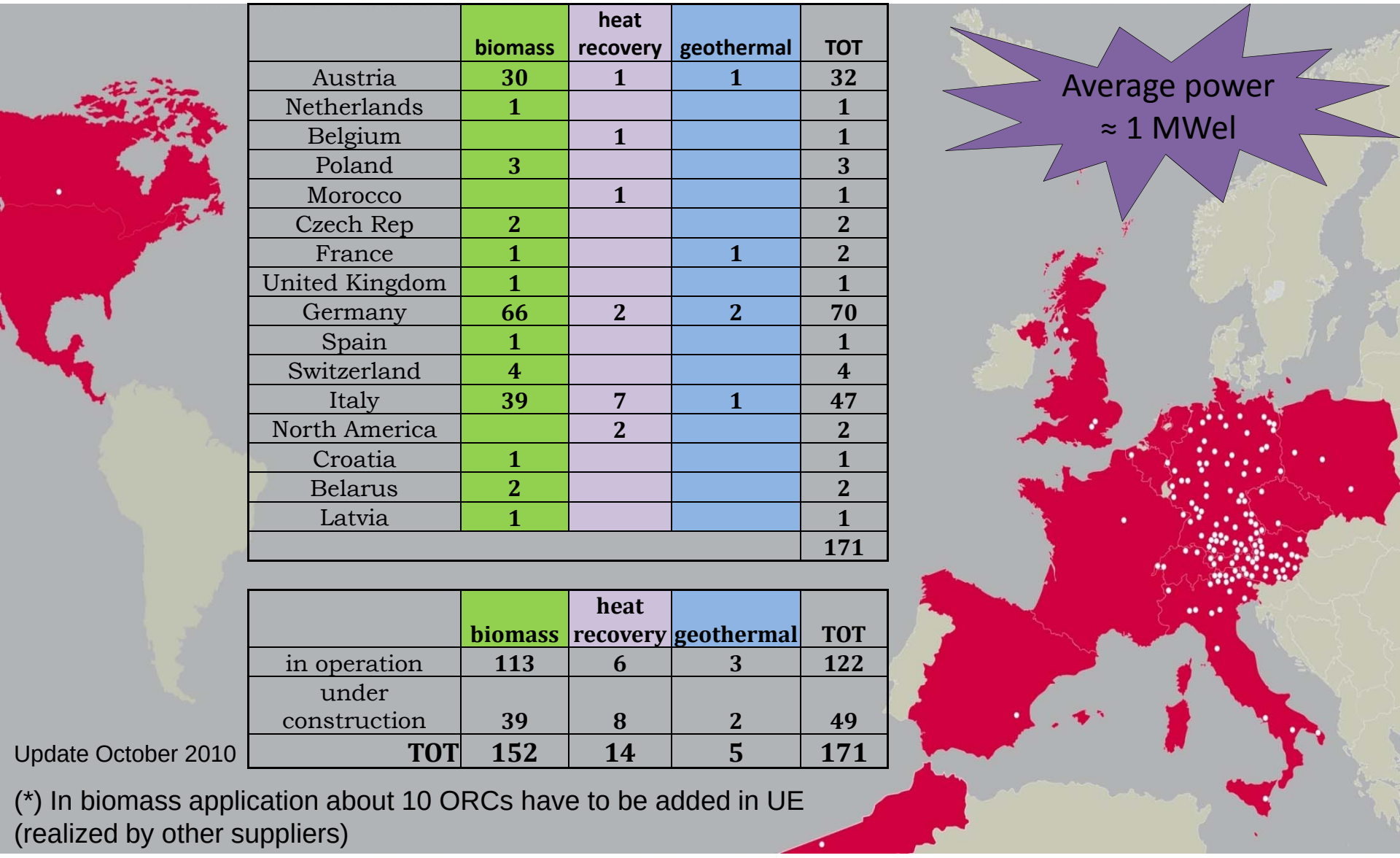
Multiple skid layout (> 700kWel)

Map of ORCs installed by Turboden (*)

	biomass	heat recovery	geothermal	TOT
Austria	30	1	1	32
Netherlands	1			1
Belgium		1		1
Poland	3			3
Morocco		1		1
Czech Rep	2			2
France	1		1	2
United Kingdom	1			1
Germany	66	2	2	70
Spain	1			1
Switzerland	4			4
Italy	39	7	1	47
North America		2		2
Croatia	1			1
Belarus	2			2
Latvia	1			1
				171

	biomass	heat recovery	geothermal	TOT
in operation	113	6	3	122
under construction	39	8	2	49
TOT	**152**	**14**	**5**	**171**

Update October 2010



(*) In biomass application about 10 ORCs have to be added in UE (realized by other suppliers)

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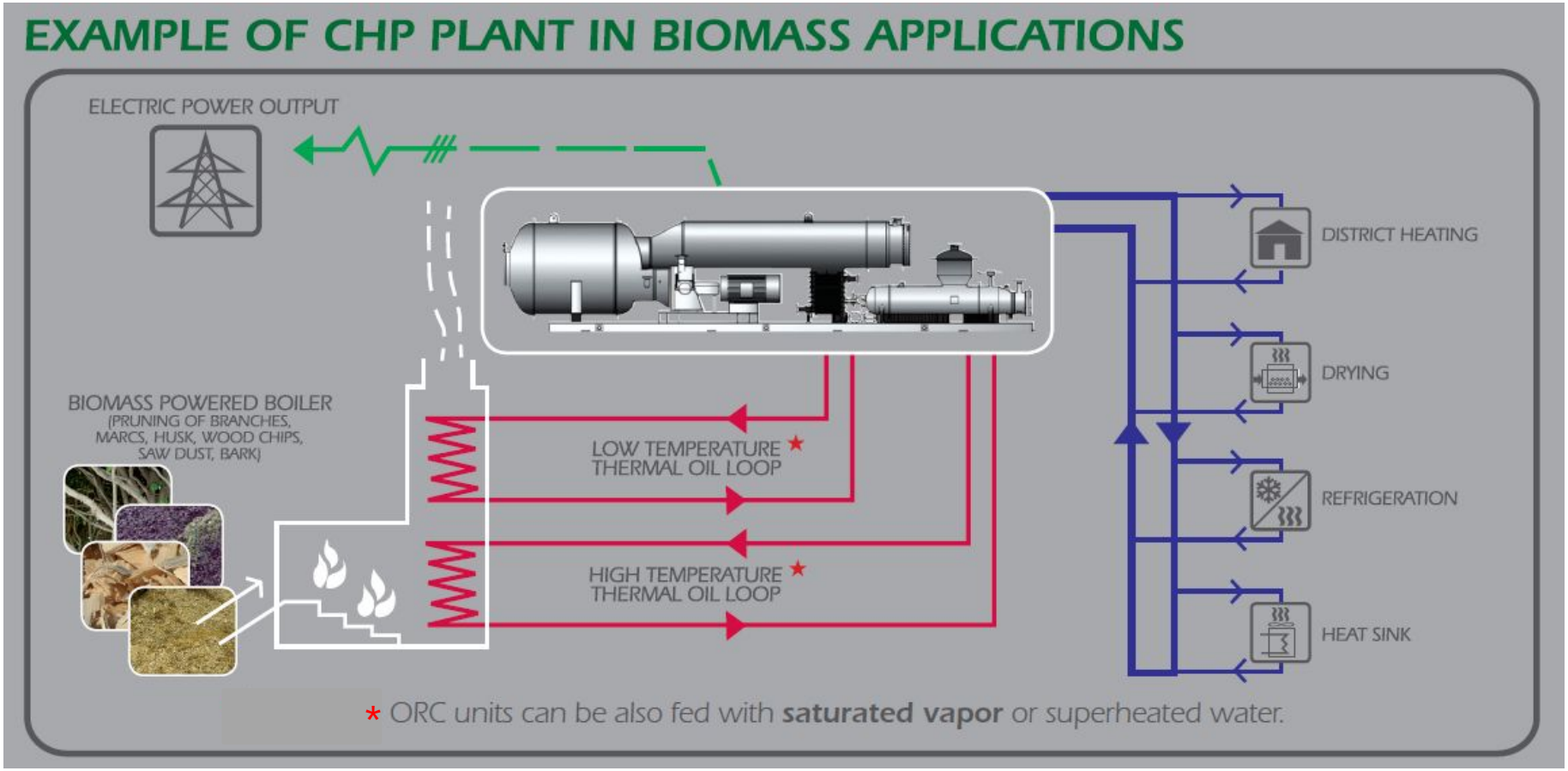
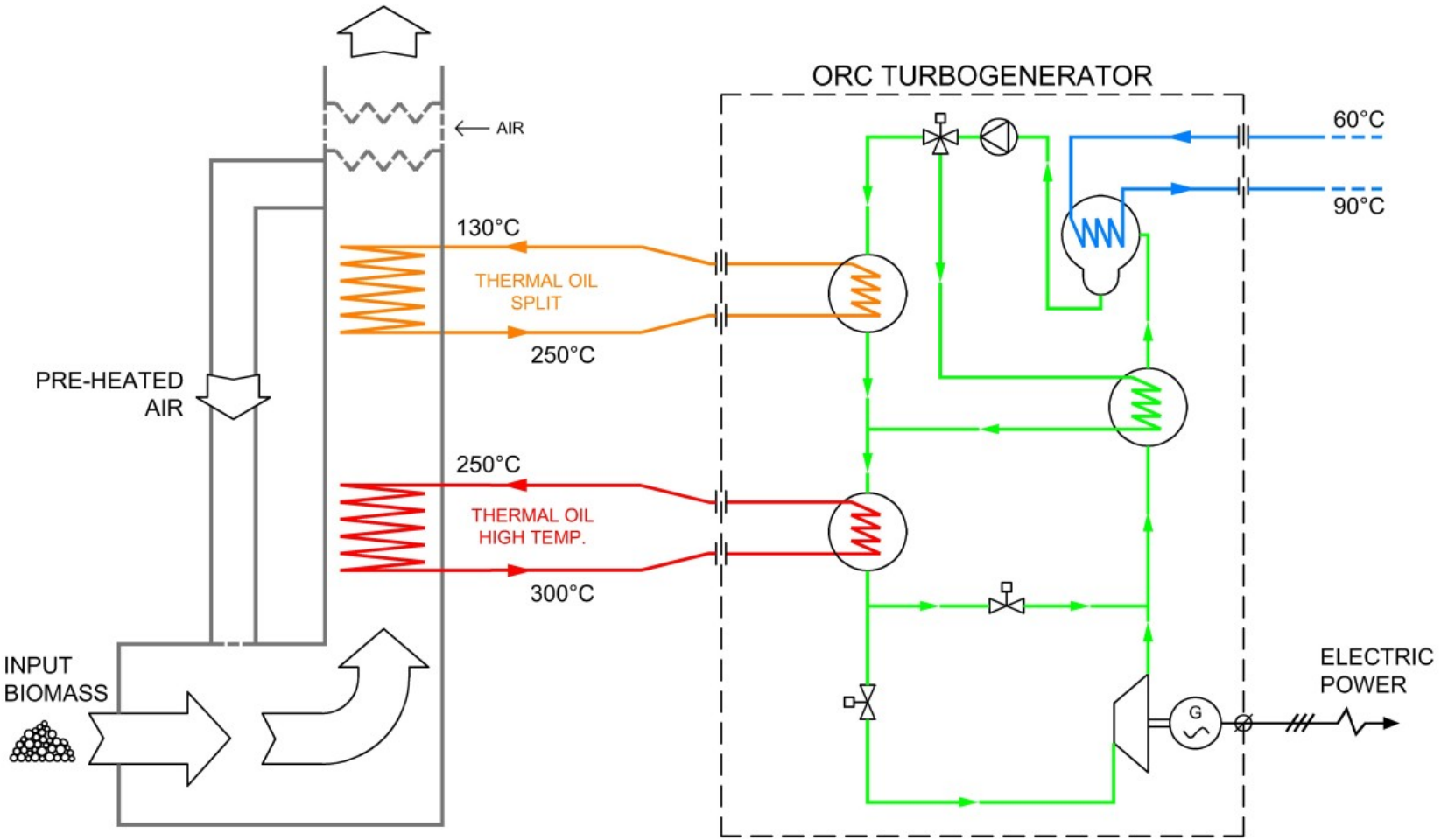
ORC Plant in a Process of Cogeneration from Biomass



The Split System

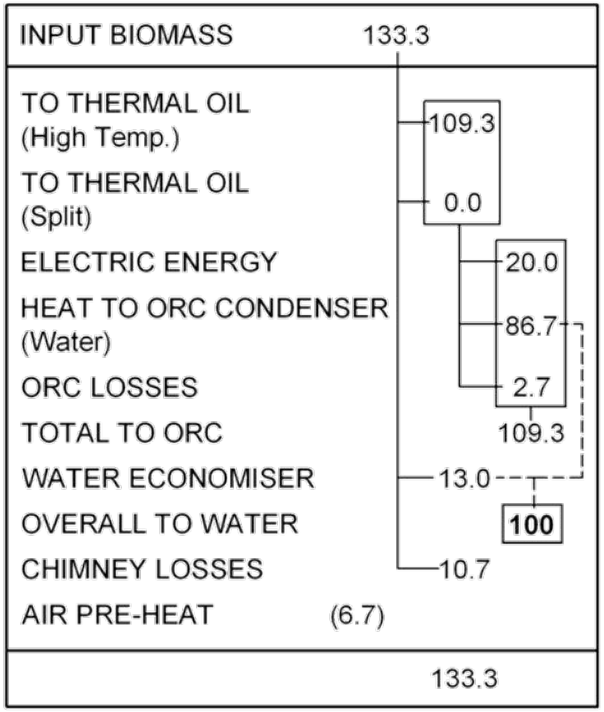


The Split System introduced in year 2000

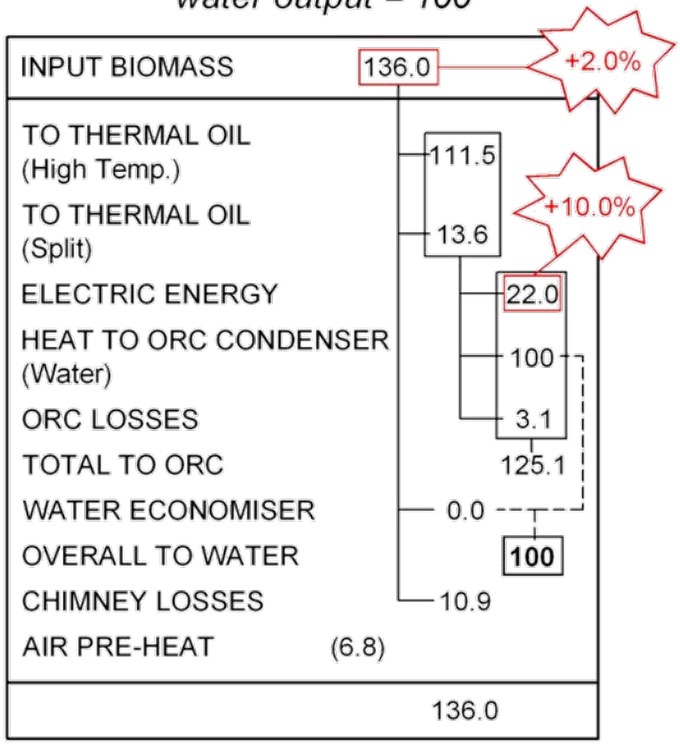
Energy balances referred to water output

(Values are depending from biomass quality and actual items design)

TRADITIONAL SYSTEM
Energy balance referred to
"water output = 100"



SPLIT SYSTEM
Energy balance referred to
"water output = 100"



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Biomass fuels & applications

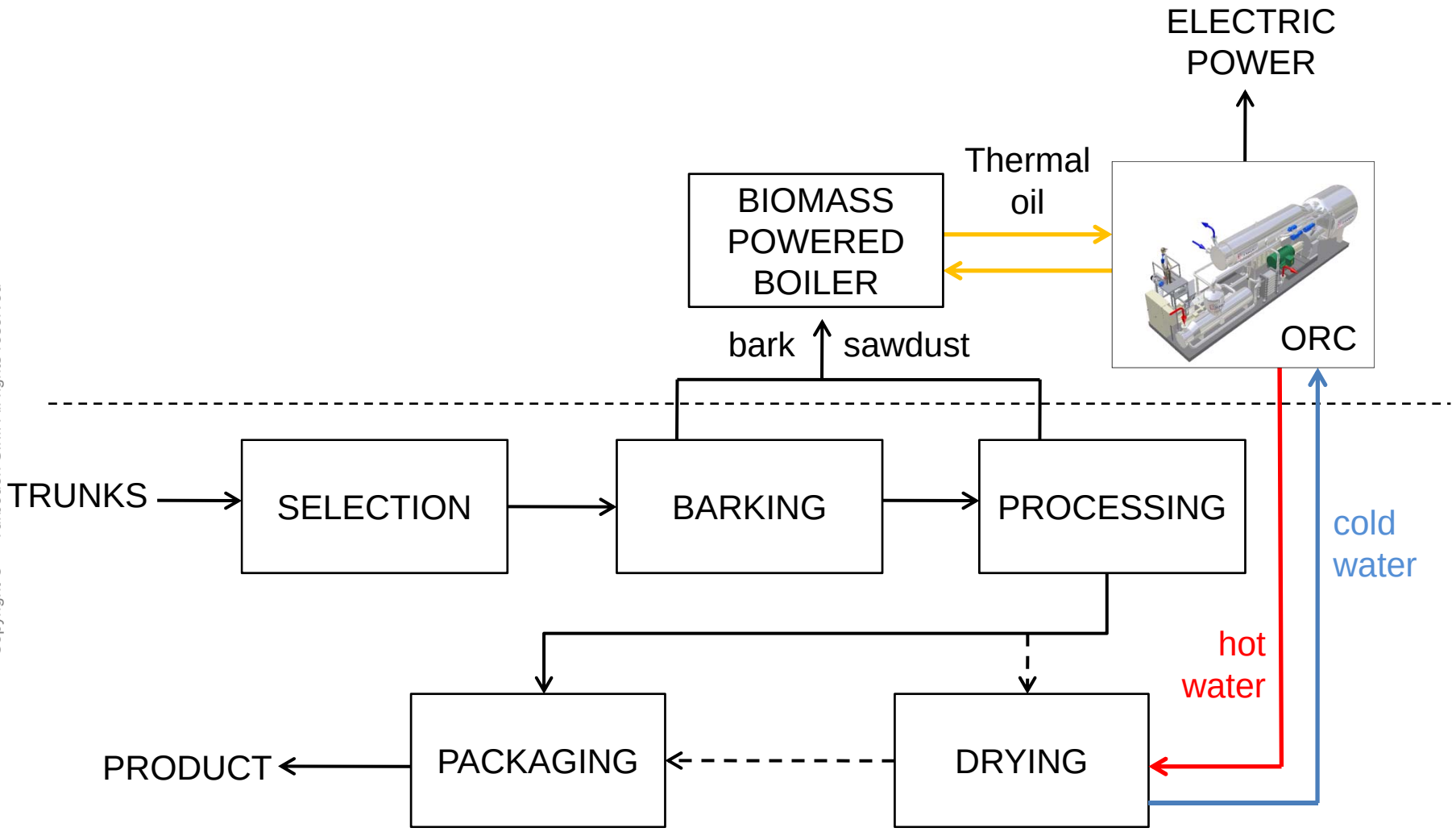
Fuels

- Wood biomass: sawdust, woodchips, bark, treated wood
- Other biomass: dried sewage sludge, straw, green cuttings, rice husk, etc.
- Waste material

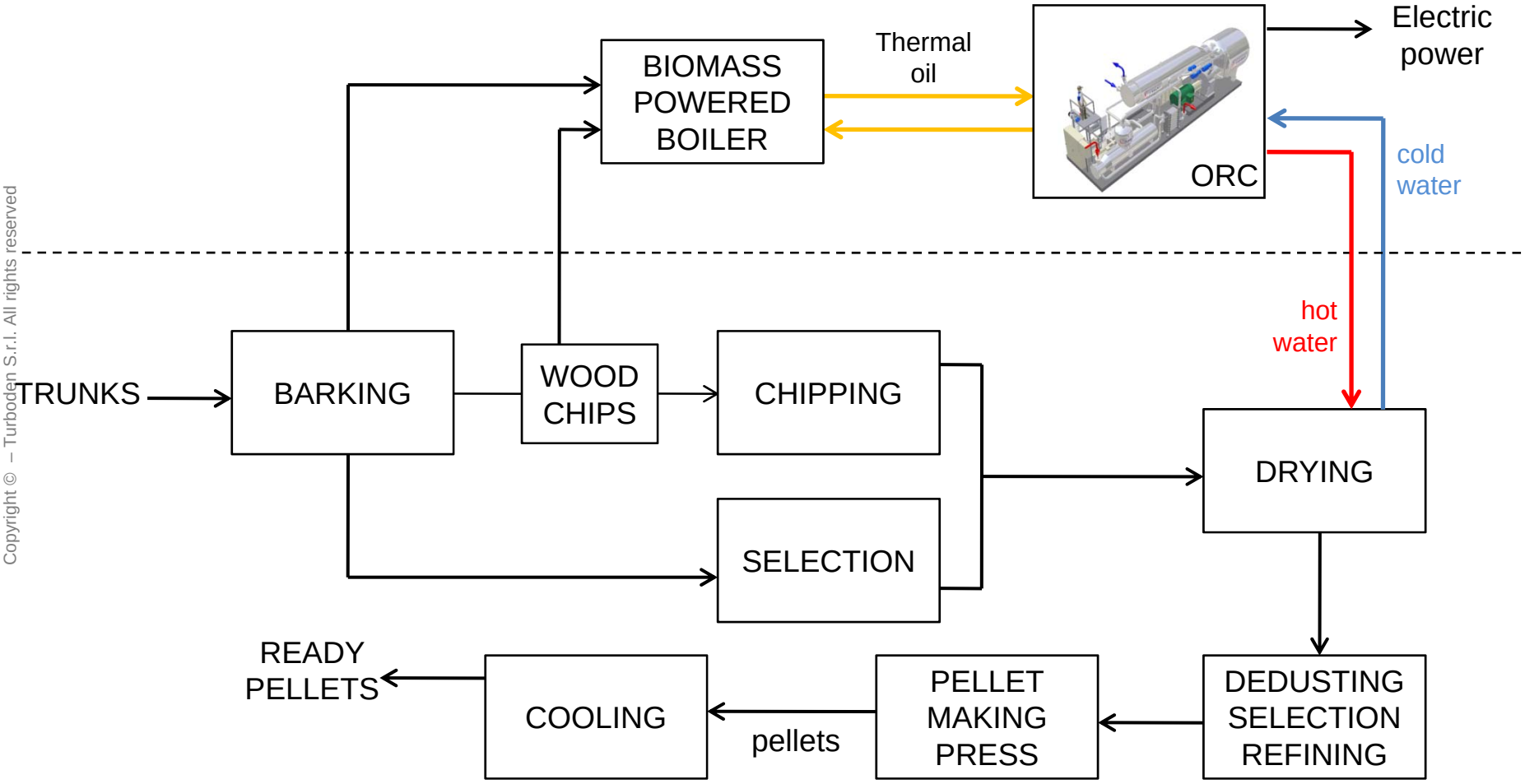
Heat Consumers

- Timber drying in sawmills
- Saw dust drying in wood pellet factories
- Air pre-heating in MDF industry
- District Heating networks
- Refrigeration
- Greenhouses

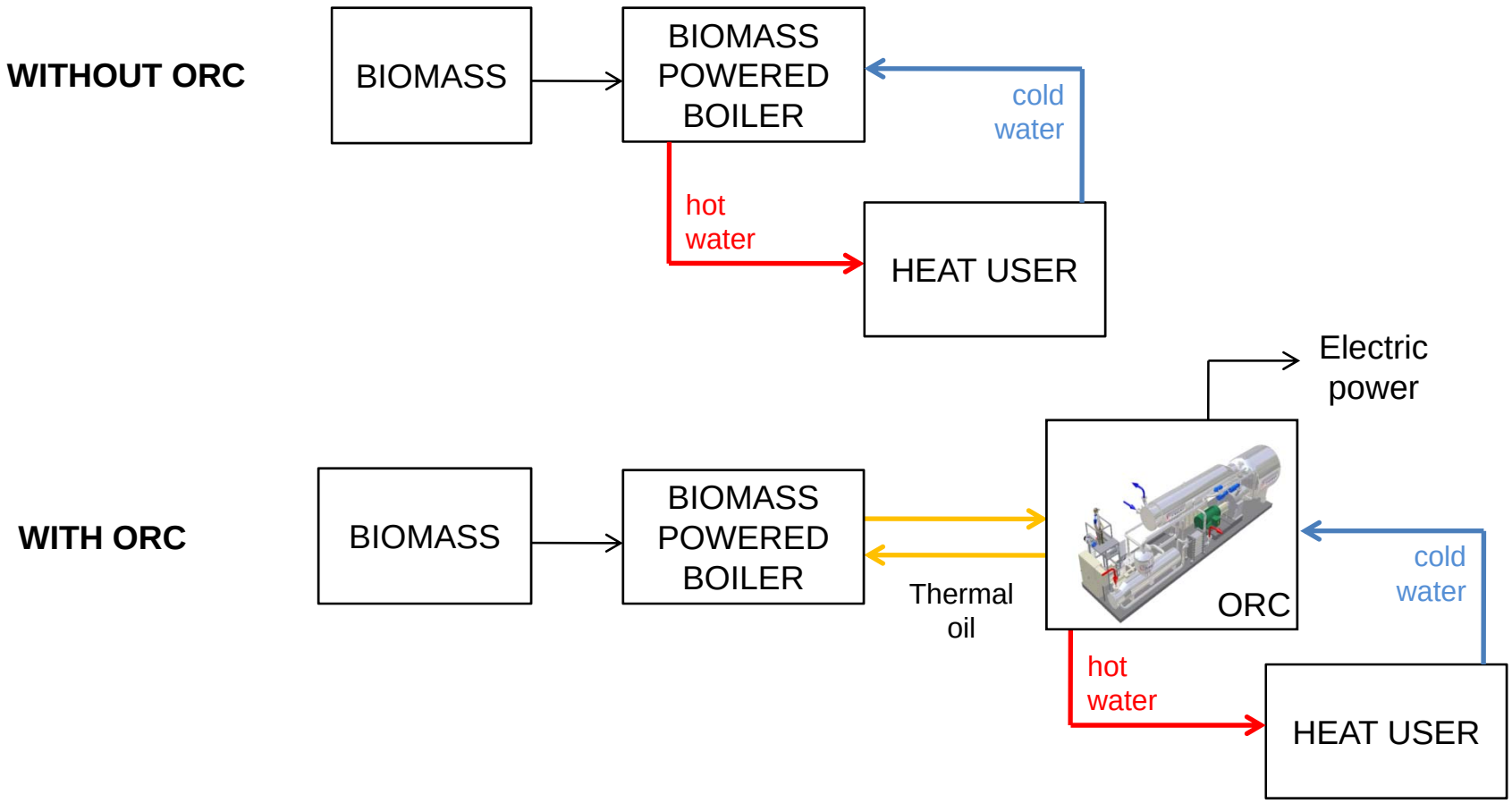
ORC Application in Sawmills



CHP Applications: Wood Pellet Production with ORC



CHP – District Heating Networks



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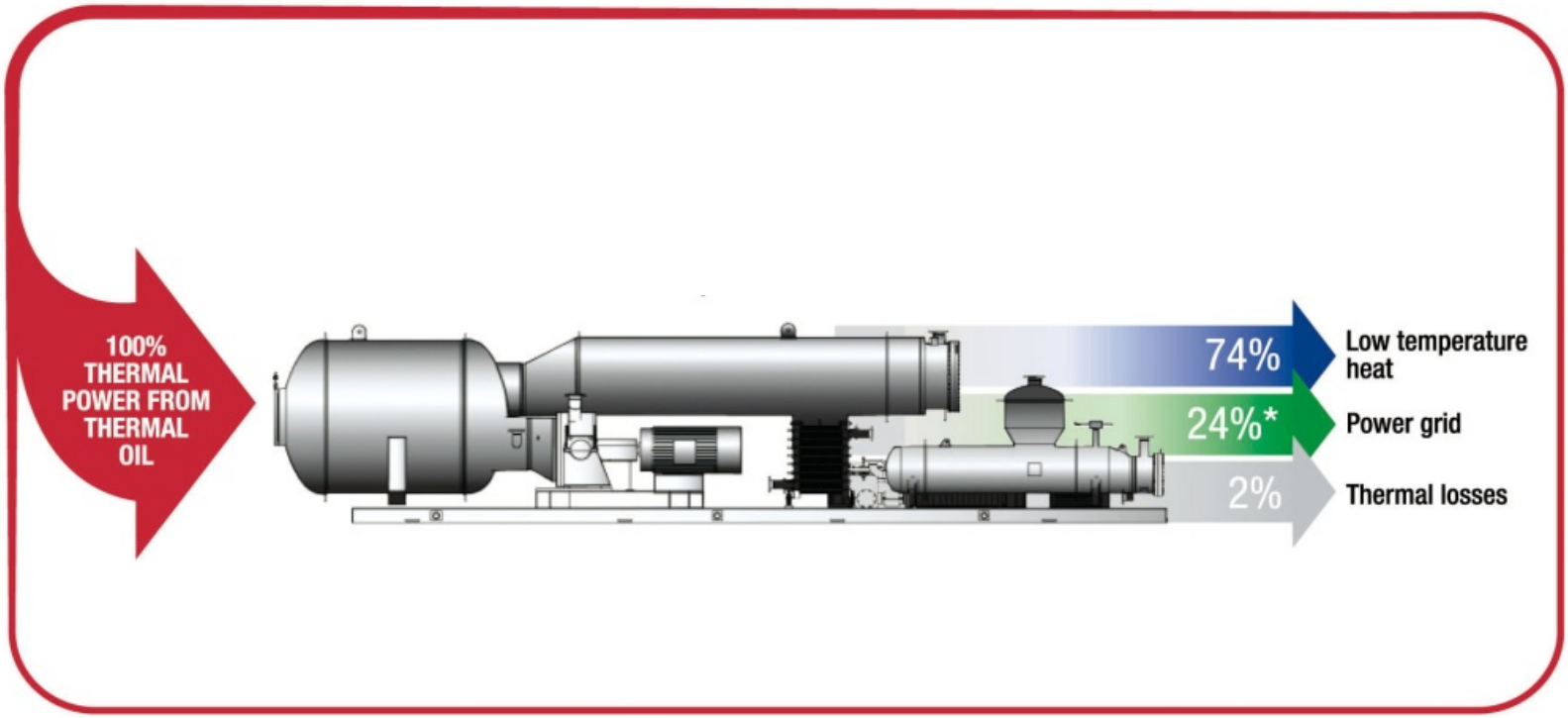
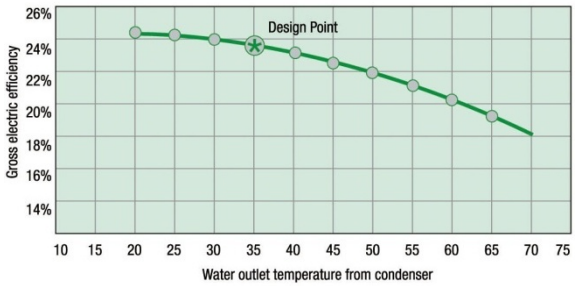
3. Biomass fuels & applications
4. **High electrical efficiency units and new developments**

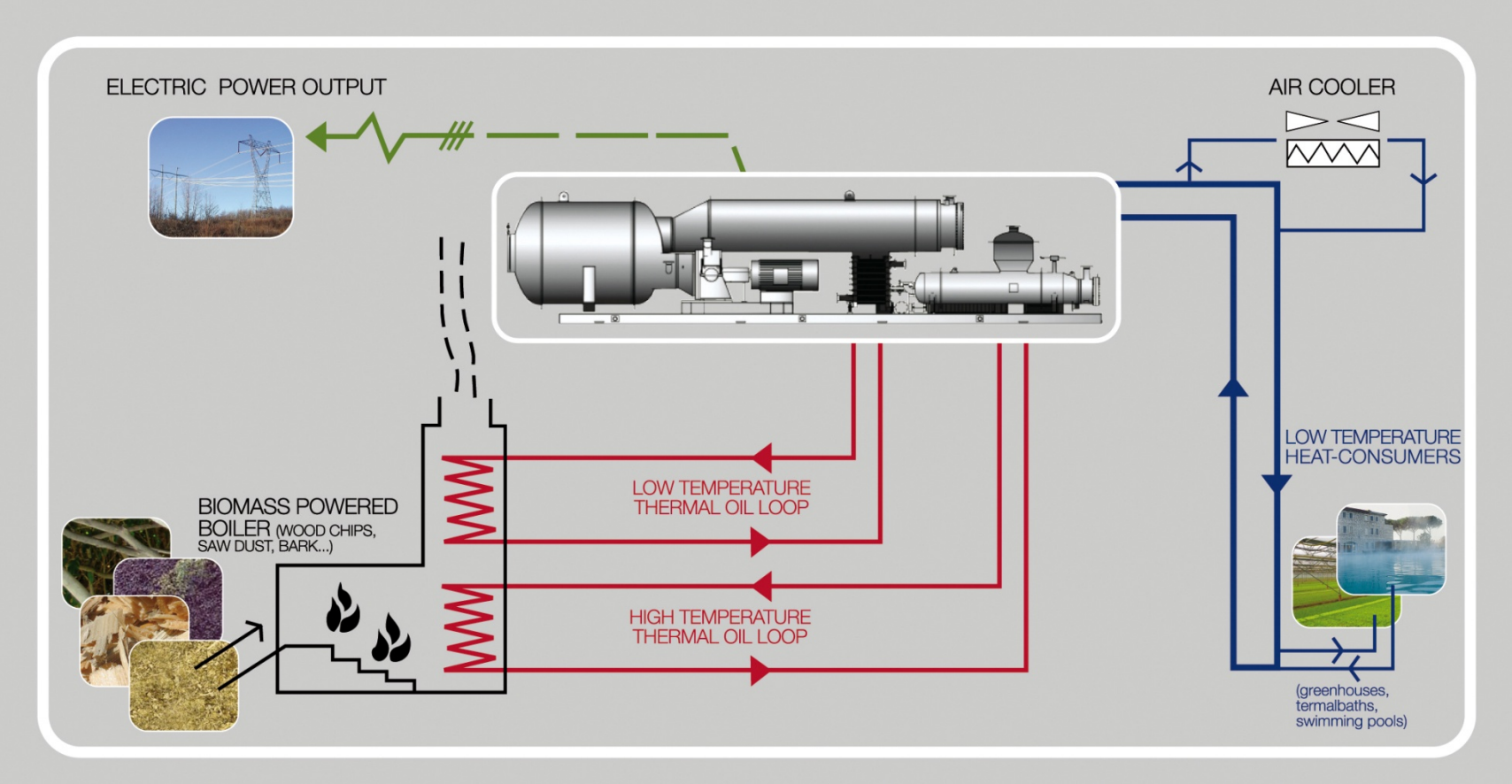
High electrical efficiency ORC units





Gross performance of the Turboden HRS modules at various condensation water temperatures

High electrical efficiency ORC units



AVAILABLE SIZES: 1.2, 2.4 MWel

High electrical efficiency ORC units

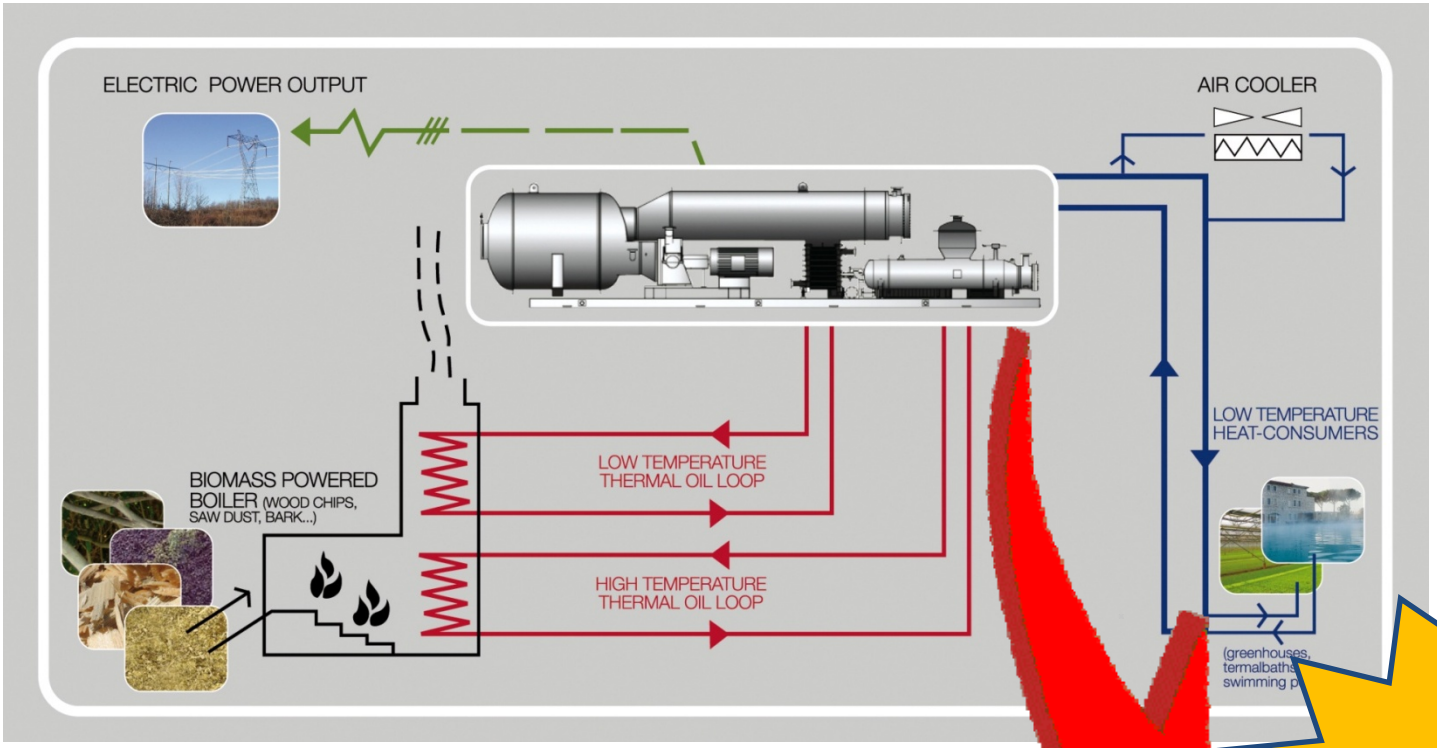
HRS for biomass application - Standard Sizes and typical performances

		TURBODEN 12 HRS		TURBODEN 24 HRS	
		Pel=1156 kW with Split* standard conditions	Pel=1188 kW without Split standard conditions	Pel=2269 kW with Split* standard conditions	Pel=2342 kW without Split standard conditions
INPUT - Thermal oil					
Nominal temperature "HT" loop (in/out)	°C	305/210	305/206	300/214	300/211
Thermal power input "HT" loop	kW	4425	4817	8850	9634
Nominal temperature "LT" loop (in/out)	°C	210/130	-	214/130	-
Thermal power input "LT" loop	kW	392	-	784	-
Overall thermal power input	kW	4817	4817	9634	9634
OUTPUT - Cooling water					
Cooling water temperature (in/out)	°C	25/35	25/35	24/37	24/37
Thermal power to the cooling water	kW	3586	3556	7212	7143
PERFORMANCES					
Gross electric power	kW	1156	1188	2269	2342
Gross electric efficiency		24,0%	24,7%	23,6%	24,3%
Captive power consumption	kW	46	49	89	94
Net active electric power output	kW	1110	1139	2180	2248
Net electric efficiency		23,0%	23,6%	22,6%	23,3%
Electrical generator		asynchronous triphase, L.V.	asynchronous triphase, L.V.	asynchronous triphase, M.V.	asynchronous triphase, M.V.
Plant size		multiple skid	multiple skid	multiple skid	multiple skid
Biomass consumption**	kg/h	2105	2316	4211	4632

(*) The Turboden split system allows maximizing power production for a given biomass consumption.

(**) Assuming a low heat 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.

New developments of high efficiency ORC units



Plus possibility of 60 - 80°C water cogeneration fraction!

New developments of high efficiency ORC units

With new ORC units today it is possible to produce:

1000 kWel

Electricity Net efficiency	plus	Cogenerative fraction water (60-80°C)	plus	Waste heat (or low temp. utilization) water (25-35°C)	Operation	
16.5%		70%		/	Fully cogenerative	CHP unit
20.4%		0%		66%	Power only	HRS unit operated at different conditions
19%		9%		58.5%	Partially cogenerative	
16.2%		20%		50.3%	Partially cogenerative	

Efficiencies are referred to biomass input = 100% with a boiler efficiency of 88% (with split system) and include air coolers consumption (water pumps and fans) if present

Thank you for your attention!

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