Turboden standard units

ORC UNIT		TD 3 CHP	TD 7 CHP	TD 8 HRS	TD 10 CHP (h)	TD 12 HRS (h)	TD 14 CHP	TD 22 CHP
Operation mode		CHP	CHP	POWER ONLY	CHP	POWER ONLY	CHP	CHP
Gross power output (a)	MW	0.35	0.70	0.80	1.10	1.20	1.35	2.20
Auxiliary power consumption (b)	MW	0.02	0.04	0.03	0.05	0.05	0.05	0.10
Net power output (c)	MW	0.33	0.66	0.77	1.05	1.16	1.30	2.10
Gross efficiency	%	16.5%	20%	24%	21%	25%	21%	19.5%
Net efficiency	%	15.3%	19%	23%	20.1%	24%	20.1%	18.6
Thermal oil inlet / outlet temperature (d)	°C	310 / 250	310 / 250	310 / 205	313 / 253	305 / 206	310 / 250	310 / 245
Thermal power input	MW	2.15	3.50	3.33	5.25	4.82	6.45	11.30
Cooling water inlet / outlet temperature (e)	°C	60 / 80	60 / 80	25 / 35	60 / 80	25 / 35	60 / 80	60 / 90
Thermal power to cooling water	MW	1.75	2.78	2.53	4.13	3.61	5.05	9.02
Ambient air temperature (f)	°C	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Estimated yearly biomass consumption (g)	ton/year	8,094	13,176	12,549	19,765	18,146	24,282	45,541

ORC UNIT		TD 24 HRS	TD 35 HR	TD 50 CHP	TD 50 HRS	TD 100 CHP	TD 100 HRS	TD 180 HRS
Operation mode		POWER ONLY	POWER ONLY	CHP	POWER ONLY	CHP	POWER ONLY	POWER ONLY
Gross power output (a)	MW	2.41	3.50	5.00	5.00	10.00	10.00	18.00
Auxiliary power consumption (b)	MW	0.09	0.30	0.33	0.38	0.67	0.73	1.30
Net power output (c)	MW	2.36	3.20	4.67	4.62	9.33	9.27	16.70
Gross efficiency	%	25%	24.5%	21.3%	27.7%	21.4%	28%	28%
Net efficiency	%	24.4%	22.5%	20%	25.6%	20.1%	26%	26%
Thermal oil inlet / outlet temperature (d)	°C	310 / 212	310 / 115	315 / 230	315 / 180	315 / 230	315 / 180	315 / 180
Thermal power input	MW	9.64	14.30	23.47	18.05	46.73	35.71	64.29
Cooling water inlet / outlet temperature (e)	°C	25 / 35	N/A	60 / 80	N/A	60 / 80	N/A	N/A
Thermal power to cooling water	MW	7.23	N/A	18.23	N/A	36.26	N/A	N/A
Ambient air temperature (f)	°C	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Estimated yearly biomass consumption (g)	ton/year	36,277	N/A	88,358	67,955	175,925	134,454	242,017

Notes and assumptions:

1. The data provided shall be used as indicative guidelines to get ORC efficiencies and power generated in the conditions reported. Turboden will customize the design of the units to meet specific customer requests in terms of power output, efficiency, thermal media temperature and type feeding the ORC unit (thermal oil indicated as standard version but as alternative pressurized water, steam, hot gas, molten salts can be used), cooling system type (water cooled or air cooled systems), space available, electric grid frequency (50 or 60 Hz), voltage (from 400 V up to 15 kV) and operation (grid mode or island mode), type of installation (indoor or outdoor), design standards (EN, ASME, API, company standards, etc.).
2. The units described can be employed for various Turboden applications like Biomass, Waste To Energy, Waste Heat Recovery from industrial processes , and Combined Heat & Power (CHP).

(a) At ORC generator terminals.
(b) ORC auxiliaries, mainly feed pump. Cooling system accounted for ACC units only. No thermal oil pump consumption considered.
(c) Defined as gross power minus auxiliary consumption.
(d) Values considering "non-split" configuration. The units can be configured with "split systems" to improve the overall boiler + ORC efficiency. In case of split configuration, about 10% of the thermal input enters the ORC unit with thermal oil at inlet/outlet temperatures of 250 / 130 °C. Gross and net efficiencies of ORC modules with split configuration decrease by about 0.2 - 0.4%.
(e) For Water Cooled Condensers - WCC. Cooling water temperatures in CHP systems can be modified to meet specific requirements, e.g. from 40 up to 120 °C.
(f) For Air Cooled Condensers - ACC.
(g) Assumed biomass LHV 2.5 kWh/kg corresponding to about 40% R.U.; assumed thermal oil boiler efficiency 85%; assumed yearly operational hours 8,000 h/y.
(h) These units can be produced with 1 MW output limit (generator nameplate) to meet specific legislation requirements.

clean energy ahead TURBODEN

Turboden S.p.A.
Via Cernaia, 10
25124 Brescia, Italy
www.turboden.com