Cogeneration vs Power Only: Energy Utilisation

Power and process heat from steam expanded to a back pressure, against power from expansion to a condenser, with IF97 expansions (Ganapathy Q5.02b).

Method: Ganapathy; Steam Plant Calculations Manual; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Steam flow	22.680	t/h
Throttle pressure (absolute)	68.948	bar
Throttle temperature	482.22	°C
Process (back) pressure (absolute)	13.790	bar
Condenser pressure (absolute)	6.8948	kPa
Back-pressure expansion efficiency	70.000	%
Condensing expansion efficiency	75.000	%
Return condensate enthalpy 0 counts all of the exhaust enthalpy as useful, as Ganapathy does.	0	kJ/kg

Calculated results

Parameter	Value	Unit
Power, back-pressure scheme	1,955.7	kW
Process heat, back-pressure scheme	19,270	kW
Energy output, back-pressure (power + heat)	21,226	kW
Power, condensing scheme	6,022.9	kW
Energy output ratio	3.5242	

Notes for this case

• With condensate enthalpy 0 the process heat counts all the exhaust enthalpy above the IF97 zero (Ganapathy's convention), including heat the condensate takes back; enter the return enthalpy for a realistic figure.

Formula and method

$$P_b = \dot{m}\eta_b(h_1 - h_{2s,b}), \quad Q_p = \dot{m}(h_2 - h_r), \quad P_c = \dot{m}\eta_c(h_1 - h_{2s,c})$$

Variables

$\dot{m}$	Steam flow	kg/s
p_1	Throttle pressure (absolute)	Pa
T_1	Throttle temperature	K
p_b	Process (back) pressure (absolute)	Pa
p_c	Condenser pressure (absolute)	Pa
η_b	Back-pressure expansion efficiency	-
η_c	Condensing expansion efficiency	-
h_r	Return condensate enthalpy	J/kg
P_b	Power, back-pressure scheme	W
Q_p	Process heat, back-pressure scheme	W
E_b	Energy output, back-pressure (power + heat)	W
P_c	Power, condensing scheme	W

E_b/P_c	Energy output ratio	-

Method and standards

Isentropic expansions with IF97 and expansion efficiencies.

Assumptions and limits

- No extraction; generator losses not deducted.
- With $h_r = 0$ (the default, Ganapathy's convention) the process heat includes the condensate's sensible heat, which inflates E_b and the ratio; enter the return condensate enthalpy for a realistic comparison.
- A warning appears when the condensing exhaust is wetter than about 0.88 dryness.
- The throttle must be superheated (or supercritical) steam; a throttle state below saturation is rejected.

References

- Ganapathy
- Steam Plant Calculations Manual
- 2nd ed. (Marcel Dekker, 1993)
- Q5.02b (comparison of energy utilisation)
- Steam and water properties from IAPWS-IF97

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/boilers-power-plant/hrsg-waste-heat/cogeneration-energy-utilisation

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Reopens the calculator with the inputs of this report.