Back-Pressure vs Extraction-Condensing Turbine Power

Power of a back-pressure turbine on process steam only against an extraction-condensing turbine on more steam, with condenser heat and extra steam rate (IF97).

Method: Expansion with isentropic efficiency per section; IAPWS-IF97 enthalpies and entropies

Input parameters

Unit system: SI

Parameter	Value	Unit
Turbine inlet pressure (absolute)	87.000	bar
Turbine inlet temperature	515.00	°C
Process (exhaust or extraction) pressure (absolute)	2.5000	bar
Condenser pressure (absolute)	10.000	kPa
Process steam demand	100.00	t/h
Steam to the extraction-condensing turbine	130.00	t/h
Isentropic efficiency (each section)	80.000	%
Gearbox and generator efficiency	96.000	%

Calculated results

Parameter	Value	Unit
Power, back-pressure turbine	17.966	MW
Power, extraction-condensing turbine	26.497	MW
Extra power	8.5308	MW
Condenser heat rejected	18.086	MW
Extra steam per extra kWh	3.5167	kg/kWh

Notes for this case

- Same isentropic efficiency is applied to each section; real machines differ by section and load.

Formula and method

$$P_{BP} = \dot{m}_p (h_1 - h_e)\eta_g, \quad P_{EC} = [\dot{m}_t (h_1 - h_e) + (\dot{m}_t - \dot{m}_p)(h_e - h_c)]\eta_g$$

Variables

p_1	Turbine inlet pressure (absolute)	Pa
T_1	Turbine inlet temperature	K
p_e	Process (exhaust or extraction) pressure (absolute)	Pa
p_c	Condenser pressure (absolute)	Pa
$\dot{m}_p$	Process steam demand	kg/s
$\dot{m}_t$	Steam to the extraction-condensing turbine	kg/s
η_s	Isentropic efficiency (each section)	-
η_g	Gearbox and generator efficiency	-
P_{BP}	Power, back-pressure turbine	W
P_{EC}	Power, extraction-condensing turbine	W
ΔP	Extra power	W
$\dot{Q}_c$	Condenser heat rejected	W
SR	Extra steam per extra kWh	kg/J

Method and standards

IF97 expansion.

Assumptions and limits

- Same efficiency for both sections; a note warns when the condenser exhaust is wetter than about 88 %.
- The extra steam (ṁ_t − ṁ_p) needs extra boiler fuel, which this comparison does not count: weigh the extra power against that fuel.
- With no condensing flow the extra steam rate is not shown.
- The inlet must be superheated (or supercritical) steam; a liquid inlet state is rejected.

References

Expansion with isentropic efficiency per section; IAPWS-IF97 enthalpies and entropies

Report details

Report reference	FCC-DB42-CRTA (the same inputs always give the same reference)
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Release checks	2 reference cases of this calculator, computed independently, are checked on every release

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/steam-turbines/bp-vs-extraction-condensing

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.