Waste Heat Recovery Potential: Heat, Steam and Fuel Saved

Heat recoverable from a hot exhaust cooled to a stack limit, the saturated steam it can raise from feedwater (IF97), and the boiler fuel and cost it saves per year.

Method: Energy balances (definitions); Steam and water properties from IAPWS-IF97

Input parameters

Unit system: SI

Parameter	Value	Unit
Exhaust gas flow	30,000	kg/h
Gas specific heat	1.1000	kJ/(kg·K)
Exhaust temperature	450.00	°C
Lowest allowed exit temperature (dew point margin)	160.00	°C
Steam pressure (absolute)	11.000	bar
Feedwater temperature	105.00	°C
Efficiency of the boiler it displaces	85.000	%
Fuel cost per GJ (same calorific basis as the efficiency)	500.00	
Operating hours per year	8,000.0	h

Calculated results

Parameter	Value	Unit
Heat recoverable	2,658.3	kW
Steam raised (upper bound: pinch ignored)	4,090.2	kg/h
Fuel heat saved	3,127.5	kW
Annual fuel cost saved	4.5035e+07	

Notes for this case

- The steam estimate ignores the pinch: with saturated steam the gas cannot leave the evaporator below steam temperature plus the pinch. Use the HRSG calculator for the exact split.

Formula and method

$$Q = \dot{m}_g c_p (T_1 - T_2), \quad \dot{m}_s \le \frac{Q}{h_g - h_{fw}}, \quad \dot{Q}_f = \frac{Q}{\eta_b}$$

Variables

$\dot{m}_g$	Exhaust gas flow	kg/s
c_p	Gas specific heat	J/(kg·K)
T_1	Exhaust temperature	K
T_2	Lowest allowed exit temperature (dew point margin)	K
p_s	Steam pressure (absolute)	Pa
T_{fw}	Feedwater temperature	K
η_b	Efficiency of the boiler it displaces	-
c_f	Fuel cost per GJ	-
t	Operating hours per year	s
Q	Heat recoverable	W
$\dot{m}_s$	Steam raised (upper bound: pinch ignored)	kg/s

$\dot{Q}_f$	Fuel heat saved	W
C	Annual fuel cost saved	-

Method and standards

Energy balances: the heat given up by the gas between the two temperatures; the steam it could raise from compressed feedwater at the steam pressure to dry saturated steam (IAPWS-IF97); and the fuel heat a boiler of the given efficiency would burn for the same heat, costed per GJ.

Assumptions and limits

- Constant gas specific heat.
- The steam figure uses all the heat down to the exit limit, even below the saturation temperature plus pinch, so it is an upper bound; the HRSG calculator gives the real split.
- The fuel cost per GJ and the boiler efficiency must be on the same calorific basis (both gross or both net).

References

- Energy balances (definitions)
- Steam and water properties from IAPWS-IF97

Report details

Report reference	FCC-HWCR-Y5MH (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/hrsg-waste-heat/waste-heat-recovery-potential

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.