Heat Rate Deviation from Controllable Losses and Its Cost

Heat rate deviation and annual fuel cost from main steam, reheat, condenser pressure, exit gas and excess O_2 deviations, with user sensitivity factors.

Method: Linear superposition of heat rate correction factors (performance monitoring practice; Babcock & Wilcox, Steam: Its Generation and Use, 41st ed. (2005), ch. 1)

Input parameters

Unit system: SI

Parameter	Value	Unit
Design heat rate	8,640.0	kJ/kWh
Average generation	100.00	MW
Hours per year	7,500.0	h
Fuel cost (currency per GJ)	300.00	
Main steam temperature below design	10.000	K
Heat rate change per K of main steam (%/K)	0.030000	
Reheat temperature below design	8.0000	K
Heat rate change per K of reheat (%/K)	0.025000	
Condenser pressure above design (kPa)	1.5000	
Heat rate change per kPa of back pressure (%/kPa)	0.90000	
Exit gas temperature above design	12.000	K
Heat rate change per K of exit gas (%/K)	0.050000	
Excess O_2 above design (percentage points)	1.0000	
Heat rate change per % O_2 (%)	0.30000	

Calculated results

Parameter	Value	Unit
Total heat rate deviation	2.7500	%
Actual heat rate	8,877.6	kJ/kWh
Extra fuel heat per year (GJ)	178,200	
Annual cost of the deviation	5.3460e+07	

Notes for this case

- Sensitivity factors are unit-specific: take them from the turbine and boiler makers' correction curves. Default factors are typical orders of magnitude for a 100–500 MW reheat unit, not design data. Effects are added linearly.

Formula and method

$$\frac{\Delta HR}{HR} = \sum_i k_i \Delta x_i, \quad \Delta E = \frac{\Delta HR}{HR}\, HR\, Pt_a, \quad C = \Delta E\, c_f$$

Variables

HR	Design heat rate	J/J
P	Average generation	W
t_a	Hours per year	s
c_f	Fuel cost (currency per GJ)	-
ΔT_{ms}	Main steam temperature below design	K

k_1	Heat rate change per K of main steam (%/K)	-
ΔT_{rh}	Reheat temperature below design	K
k_2	Heat rate change per K of reheat (%/K)	-
Δp_c	Condenser pressure above design (kPa)	-
k_3	Heat rate change per kPa of back pressure (%/kPa)	-
ΔT_{eg}	Exit gas temperature above design	K
k_4	Heat rate change per K of exit gas (%/K)	-
ΔO_2	Excess O_2 above design (percentage points)	-
k_5	Heat rate change per % O_2 (%)	-
ΔHR	Total heat rate deviation	-
HR_a	Actual heat rate	J/J
ΔE	Extra fuel heat per year (GJ)	-
C	Annual cost of the deviation	-

Method and standards

Linear correction factors: each deviation times its sensitivity factor, added. The default factors are typical orders of magnitude for a 100–500 MW reheat unit, not design data; use the makers' correction curves. The heat rate and fuel cost must share a basis (gross or net).

Assumptions and limits

- Small deviations; additive effects. Exit gas temperature and excess O_2 are coupled (more air raises the exit gas temperature), so adding both can double-count; take their factors from one consistent boiler calculation.
- The condenser pressure deviation is entered in kPa in every unit system.

References

• Linear superposition of heat rate correction factors (performance monitoring practice; Babcock & Wilcox, Steam: Its Generation and Use, 41st ed. (2005), ch. 1)

Report details

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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/plant-performance/heat-rate-deviation-cost

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Reopens the calculator with the inputs of this report.