Effect of Fuel Moisture on Boiler Efficiency and Fuel Use

How a change in biomass or coal moisture changes the as-fired GCV, the fuel moisture loss (ASME PTC 4), boiler efficiency and the fuel needed for the same output.

Method: ASME PTC 4-2013 fuel moisture loss (water vapour at 1 psia); IAPWS-IF97

Input parameters

Unit system: SI

Parameter	Value	Unit
Gross calorific value on dry basis	18,500	kJ/kg
Fuel moisture now, as fired	45.000	%
Boiler efficiency now (on GCV)	70.000	%
Fuel moisture after the change	30.000	%
Flue gas temperature at the boiler exit	180.00	°C
Reference (air and fuel) temperature	30.000	°C
Fuel firing rate now	10.000	t/h

Calculated results

Parameter	Value	Unit
GCV as fired now	10,175	kJ/kg
GCV as fired after the change	12,950	kJ/kg
Fuel moisture loss now	12.008	%
Fuel moisture loss after the change	6.2901	%
Boiler efficiency after the change	75.718	%
Change in efficiency (points)	5.7183	%
Fuel rate for the same steam output	7.2638	t/h

Notes for this case

- The other losses are held at the same share of the fuel's heat; extra moisture also adds a little flue gas and fan power, not included.

Formula and method

$$GCV_{ar} = GCV_d(1 - M)$$

$$L_M = \frac{M\,[h_v(T_g, 1\ \text{psia}) - h_f(T_a)]}{GCV_{ar}}$$

$$\eta_2 = \eta_1 + L_{M1} - L_{M2}$$

$$\dot{m}_{f2} = \dot{m}_{f1}\frac{GCV_1\,\eta_1}{GCV_2\,\eta_2}$$

Variables

GCV_d	gross calorific value on dry basis	J/kg
GCV_1	GCV as fired now	J/kg
GCV_2	GCV as fired after the change	J/kg
GCV_{ar}	GCV as fired at moisture M	J/kg
M_1	fuel moisture now, as fired	-

M_2	fuel moisture after the change	-
M	fuel moisture, as fired	-
η_1	boiler efficiency now (GCV basis)	-
η_2	efficiency after the change	-
$\Delta\eta$	change in efficiency	-
T_g	flue gas temperature at the boiler exit	K
T_a	reference (air and fuel) temperature	K
L_{M1}	fuel moisture loss now	-
L_{M2}	fuel moisture loss after the change	-
L_M	fuel moisture loss	-
h_v	enthalpy of water vapour at T_g and 1 psia	J/kg
h_f	enthalpy of saturated liquid water at T_a	J/kg
$\dot{m}_{f1}$	fuel firing rate now	kg/s
$\dot{m}_{f2}$	fuel rate for the same steam output	kg/s

Method and standards

The fuel moisture loss follows ASME PTC 4: the water enters as liquid at the reference temperature and leaves as vapour at the flue gas temperature, with the vapour enthalpy taken at 1 psia from IAPWS-IF97. The other losses are a fixed amount per kg of dry fuel, so they keep the same share of the fuel's heat at any moisture; the efficiency therefore changes by exactly the change in the moisture loss.

Assumptions and limits

- Other losses are held at a fixed share of the fuel heat; the extra flue gas mass, any change in air demand and fan power from the added moisture are not included.
- The liquid reference is your reference temperature T_a, not PTC 4's fixed 25 °C; it is consistent with the efficiency entered only if that efficiency used the same reference.
- Flue gas temperature is taken as unchanged by the moisture change.
- Moisture is total moisture, as fired.

References

• ASME PTC 4-2013 fuel moisture loss (water vapour at 1 psia)
• IAPWS-IF97

Report details

Report reference	FCC-AM6Z-F90P (the same inputs always give the same reference)
Generated	17 November 2026, 19:49 UTC
Calculator	Effect of Fuel Moisture on Boiler Efficiency and Fuel Use
Method last reviewed	12 November 2026
Software release	FireCAD Calc, release of 17 November 2026
Release checks	3 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/boilers/biomass-moisture-effect

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.