Fuel Cell Polarisation Curve: Cell Voltage, Power and Efficiency

Cell voltage at a current density from the activation, ohmic and mass-transport losses, with power density, stack voltage, current, power and efficiency.

Method: Empirical polarisation equation V = E_oc − ir − A ln i − m exp(ni)

Input parameters

Unit system: SI

Parameter	Value	Unit
Current density	600.00	mA/cm²
Practical open-circuit constant	1.0200	V
Area-specific resistance	0.20000	Ω·cm²
Tafel slope constant	0.035000	V
Mass-transport constant	3.0000e-05	V
Mass-transport exponent (cm² per mA)	0.007500	
Cells in the stack	100.00	
Active area per cell	200.00	cm²
Fuel utilisation	95.000	%

Calculated results

Parameter	Value	Unit
Cell voltage	0.67341	V
Power density	404.04	mW/cm²
Ohmic loss	120.00	mV
Activation loss A ln i	223.89	mV
Mass-transport loss	2.7005	mV
Stack voltage	67.341	V
Stack current	120.00	A
Stack power	8.0809	kW
Efficiency on the higher heating value	43.195	%
Efficiency on the lower heating value	51.052	%

Notes for this case

• V = E_oc − ir − A ln i − m e^(ni) with i in mA/cm² inside the logarithm and exponential; E_oc includes the exchange-current term. Efficiency η = μ_f V/1.481 V (HHV) or V/1.253 V (LHV).

Formula and method

$$V = E_{oc} - ir - A\ln i - me^{ni}, \quad \eta_{HHV} = \mu_f \frac{V}{1.481}$$

Variables

i	Current density	A/m²
E_{oc}	Practical open-circuit constant	V
r	Area-specific resistance	Ω·m²

A	Tafel slope constant	V
m	Mass-transport constant	V
n	Mass-transport exponent (cm² per mA)	-
N	Cells in the stack	-
A_c	Active area per cell	m²
μ_f	Fuel utilisation	-
V_c	Cell voltage	V
P/A	Power density	W/m²
ΔV_{ohm}	Ohmic loss	V
ΔV_{act}	Activation loss A ln i	V
ΔV_{trans}	Mass-transport loss	V
V_{stack}	Stack voltage	V
I	Stack current	A
P	Stack power	W
η_{HHV}	Efficiency on the higher heating value	-
η_{LHV}	Efficiency on the lower heating value	-

Method and standards

Empirical polarisation model.

Assumptions and limits

- Steady state; constants from a fit to the cell in question.

References

Empirical polarisation equation V = E_oc − ir − A ln i − m exp(ni)

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/environmental/hydrogen-fuel-cells/fuel-cell-polarisation-curve

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.