Transformer All-Day (Energy) Efficiency

All-day (energy) efficiency of a transformer over a daily load cycle of up to four periods, from rating and losses, with the maximum-efficiency load.

Method: Chapman; Electric Machinery Fundamentals; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Rating	500.00	kVA
No-load (core) loss	1.0000	kW
Full-load copper loss	5.5000	kW
Load in period 1 (pu)	100.00	%
Duration of period 1	6.0000	h
Power factor 1	80.000	%
Load in period 2 (pu)	50.000	%
Duration of period 2	10.000	h
Power factor 2	85.000	%
Load in period 3 (pu)	10.000	%
Duration of period 3	8.0000	h
Power factor 3	90.000	%
Load in period 4 (pu)	0	%
Duration of period 4	0	h
Power factor 4	90.000	%

Calculated results

Parameter	Value	Unit
Energy delivered per day	4,885.0	kWh
Energy lost per day	71.190	kWh
All-day efficiency	98.564	%
Load fraction for maximum efficiency	42.640	%

Notes for this case

- Core loss runs all 24 hours whenever the transformer is energised (hours not entered count as no-load); copper loss follows load squared. Distribution transformers with long light-load hours benefit from low core loss.

Formula and method

$$\eta_{ad} = \frac{\sum x_i S \cos\phi_i t_i}{\sum x_i S \cos\phi_i t_i + P_0 t_{day} + \sum x_i^2 P_k t_i}, \quad x_{\eta,max} = \sqrt{\frac{P_0}{P_k}}$$

Variables

S	Rating	VA
P_0	No-load (core) loss	W
P_k	Full-load copper loss	W
x_1	Load in period 1 (pu)	-

t_1	Duration of period 1	s
$\cos\phi_1$	Power factor 1	-
x_2	Load in period 2 (pu)	-
t_2	Duration of period 2	s
$\cos\phi_2$	Power factor 2	-
x_3	Load in period 3 (pu)	-
t_3	Duration of period 3	s
$\cos\phi_3$	Power factor 3	-
x_4	Load in period 4 (pu)	-
t_4	Duration of period 4	s
$\cos\phi_4$	Power factor 4	-
E_{out}	Energy delivered per day	J
E_{loss}	Energy lost per day	J
η_{ad}	All-day efficiency	-
$x_{\eta,max}$	Load fraction for maximum efficiency	-
t_{day}	One day (24 h)	s

Method and standards

Energy balance.

Assumptions and limits

- The transformer is energised all day: hours not covered by the periods count as no-load, with core loss only. The periods must not add to more than 24 h.
- Constant load within each period.

References

- Chapman
- Electric Machinery Fundamentals
- 5th ed. (McGraw-Hill, 2012)
- ch. 2 (transformer efficiency; all-day efficiency)

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/electrical/transformers/transformer-all-day-efficiency

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.