Motor Efficiency Calculations

Technical Reference Manual - IEC 60034-30-1 Standards

Document: MEC-TR-2025-001 | **Version:** 3.2 | **Date:** November 2025 | **Authority:** International Electrotechnical Commission

1. Basic Motor Efficiency Calculation

Motor Efficiency (η) = (P_out / P_in) × 100%

Where:
- P_out = Mechanical Output Power (kW)
- P_in = Electrical Input Power (kW)
- η = Efficiency (%)

Example Calculation - 75kW IE4 Motor:

Given Data:
- Motor Rating: 75 kW
- Measured Input Power: 79.2 kW
- Shaft Output Power: 74.6 kW
- Load Factor: 100%

Calculation:
η = (74.6 / 79.2) × 100%
η = 0.942 × 100%
η = 94.2%

IE4 Requirement for 75kW, 4-pole: ≥94.1%
Result: PASS (94.2% > 94.1%)

Note: Measurements must be taken at rated voltage, frequency, and temperature conditions as specified in IEC 60034-2-1.

2. Load Factor Correction

Actual Load Factor = (P_measured / P_rated) × 100%

Efficiency at Partial Load:

$\eta_{partial} = \eta_{rated} \times K_{load}$

Where K_{load} varies by motor type and load percentage

Load Factor (%)	IE2 Correction	IE3 Correction	IE4 Correction
25%	0.85	0.87	0.89
50%	0.92	0.94	0.95
75%	0.97	0.98	0.99
100%	1.00	1.00	1.00

Example - Partial Load Efficiency:

- Motor: 30kW IE3, rated efficiency 92.8%
- Operating at 75% load
- Correction factor: 0.98
- Actual efficiency = 92.8% × 0.98 = 90.9%

3. Annual Energy Consumption

Annual Energy = P_rated × LF × OH × (1/η) × CF

Where:
- P_rated = Rated Power (kW)
- LF = Load Factor (decimal)
- OH = Operating Hours per year
- η = Motor Efficiency (decimal)
- CF = Capacity Factor (typically 0.85-0.95)

Detailed Annual Energy Calculation:

Motor Specifications:
- Rated Power: 75 kW
- Load Factor: 85% (0.85)
- Operating Hours: 6,500 hours/year
- Efficiency: 94.2% (0.942)
- Capacity Factor: 0.90

Step-by-step Calculation:
1. Effective Power = 75 × 0.85 = 63.75 kW
2. Power Input = 63.75 ÷ 0.942 = 67.67 kW
3. Adjusted Power = 67.67 × 0.90 = 60.90 kW
4. Annual Energy = 60.90 × 6,500 = 395,850 kWh/year

Total Annual Energy Consumption: 395,850 kWh/year

4. Power Factor Calculations

Power Factor (PF) = P / (√3 × V × I)

Reactive Power (Q) = P × tan(arccos(PF))

Apparent Power (S) = P / PF

Power Factor Analysis:

- Active Power (P): 67.67 kW
- Voltage (V): 400V (line-to-line)
- Current (I): 98.5 A
- Power Factor = 67,670 ÷ (√3 × 400 × 98.5)
- Power Factor = 67,670 ÷ 68,285 = 0.991
- Reactive Power = 67.67 × tan(arccos(0.991)) = 9.12 kVAR

5. IE Classification Standards

Motor Power (kW)	Minimum Efficiency Requirements (%)			
	IE1	IE2	IE3	IE4
0.75	75.2	79.6	82.5	85.7
1.1	78.1	81.4	84.1	87.2
1.5	79.8	82.8	85.3	88.1
2.2	81.5	84.3	86.7	89.2
3.0	82.7	85.2	87.7	90.1
4.0	83.7	86.0	88.4	90.8
5.5	84.7	87.0	89.2	91.6
7.5	85.6	87.8	90.0	92.3
11.0	86.8	89.0	91.0	93.0
15.0	87.7	89.8	91.8	93.6
18.5	88.2	90.3	92.3	94.0
22.0	88.7	90.7	92.7	94.3
30.0	89.4	91.4	93.3	94.8
37.0	89.9	91.9	93.7	95.2
45.0	90.3	92.3	94.1	95.5
55.0	90.7	92.7	94.4	95.8
75.0	91.3	93.3	94.8	96.2
90.0	91.6	93.6	95.1	96.4
110.0	92.0	94.0	95.4	96.7
132.0	92.3	94.3	95.7	96.9
160.0	92.6	94.6	96.0	97.1
200.0	92.9	94.9	96.2	97.4

Important: Values shown are for 4-pole, 50Hz motors at rated conditions. Different pole configurations and frequencies have different requirements as per IEC 60034-30-1.

6. Temperature Correction Factors

$$\eta_{corrected} = \eta_{measured} \times K_{temp}$$

$$K_{temp} = 1 + \alpha \times (T_{ref} - T_{measured})$$

Where:

- α = Temperature coefficient (typically 0.005/°C)
- T_{ref} = Reference temperature (25°C)
- $T_{measured}$ = Actual measurement temperature

Temperature Correction Example:

- Measured efficiency: 93.8% at 35°C
- Reference temperature: 25°C
- Temperature coefficient: 0.005/°C
- $K_{temp} = 1 + 0.005 \times (25 - 35) = 1 - 0.05 = 0.95$
- Corrected efficiency = 93.8% × 0.95 = 89.1%