

Calculation of benefit of replacing IE3 motor with IE3+ motor (15 kW, 1500 rpm) for Italy

1. Price of 1 kWh of active power in Italy in Euro: $Ca_{Italy} = 0.24$ Euro/kWh.

2. Power factor of the IE3+ motor: $\cos(\varphi) = 0.902$.

3. Price of 1 kVAh of reactive power in Italy in Euro for IE3+, for $\cos(\varphi) = 0.902$: $Cr3p_{Italy} = 0$ Euro/ kVAh.

if $\cos(\varphi) > 0.9$, then $Cr3p_{Italy} = 0$ Euro/kVAh,

if $0.8 \leq \cos(\varphi) \leq 0.9$, then $Cr3p_{Italy} = 0.032$ Euro/kVAh,

if $\cos(\varphi) < 0.8$, then $Cr3p_{Italy} = 0.042$ Euro/kVAh.

4. Duration of motor operation in hours per year (8 hours per day, 288 days per year): $t_{work} = 2304$ hours.

5. Motor efficiency of IE3+: $\eta_{ie3+} = 0.923$.

6. Standard motor efficiency of IE3: $\eta_{ie3} = 0.921$.

7. Active power consumption by IE3+ and IE3 motors:

$$Pa_{ie3+} = \frac{P_{2n}}{\eta_{ie3+}} t_{work} = \frac{15}{0.923} \cdot 2304 = 37457 \text{ kWh},$$

$$Pa_{ie3} = \frac{P_{2n}}{\eta_{ie3}} t_{work} = \frac{15}{0.921} \cdot 2304 = 37524 \text{ kWh}.$$

8. Payment for consumed active power by IE3+ and IE3 motors:

$$pay_{ie3+} = Pa_{ie3+} \cdot Ca_{Italy} = 8990 \text{ Euro},$$

$$pay_{ie3} = Pa_{ie3} \cdot Ca_{Italy} = 9006 \text{ Euro}.$$

9. Benefit per year due to increased efficiency:

$$E_{act} = pay_{ie3} - pay_{ie3+} = 16 \text{ Euro}.$$

10. Power factor of an average IE3 motor: $\cos(\varphi)_{ie3} = 0.83$.

11. Price of 1kVAh of reactive power in Italy in Euro for the IE3 motor ($\cos(\varphi)_{ie3} = 0.83$):

$$Cr3p_{Italy} = 0.032 \text{ Euro/ kVAh}.$$

12. Reactive power consumption by IE3+ and IE3 motors:

$$Q_{ie3+} = Pa_{ie3+} \cdot \frac{\sqrt{1-\cos^2(\varphi)}}{\cos(\varphi)} = 17925 \text{ kVAh},$$

$$Q_{ie3} = Pa_{ie3} \cdot \frac{\sqrt{1-\cos^2(\varphi)_{ie3}}}{\cos(\varphi)_{ie3}} = 25217 \text{ kVAh}.$$

13. Payment for consumed reactive power by IE3+ and IE3 motors:

$$payr_{ie3+} = Q_{ie3+} \cdot Cr3p_{Italy} = 0 \text{ Euro},$$

$$payr_{ie3} = Q_{ie3} \cdot Cr3p_{Italy} = 807 \text{ Euro}.$$

14. Benefit per year due to increased power factor:

$$E_{react} = payr_{ie3} - payr_{ie3+} = 807 \text{ Euro}.$$

15. Benefit per year due to increased efficiency and increased power factor:

$$E_{act} = 16 \text{ Euro}, \quad E_{react} = 807 \text{ Euro}.$$

16. Total benefit per year due to replacement of an average IE3 motor with an IE3+ motor:

$$E_{one_year} = E_{act} + E_{react} = 823 \text{ Euro}.$$