

Calculation of benefit of replacing IE3 motor with IE4+ motor (75 kW, 3000 rpm) for Italy, for full load

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

2. Power factor of the motor IE4+: $\cos(\varphi) = 0.935$.

3. Price of 1 kVAh of reactive power in Italy in Euro for IE4+, for $\cos(\varphi) = 0.935$: $Cr4_{Italy} = 0$ Euro/ kVAh.

if $\cos(\varphi) > 0.9$, then $Cr4_{Italy} = 0$ Euro/kVAh,

if $0.8 \leq \cos(\varphi) \leq 0.9$, then $Cr4_{Italy} = 0.032$ Euro/kVAh,

if $\cos(\varphi) < 0.8$, then $Cr4_{Italy} = 0.042$ 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 IE4+: $\eta_{ie4+} = 0.959$.

6. Standard motor efficiency of IE3: $\eta_{ie3} = 0.947$.

7. Active power consumption by IE4+ and IE3 motors:

$$Pa_{ie4+} = \frac{P_{2n}}{\eta_{ie4+}} t_{work} = \frac{75}{0.959} \cdot 2304 = 180133 \text{ kWh},$$

$$Pa_{ie3} = \frac{P_{2n}}{\eta_{ie3}} t_{work} = \frac{75}{0.947} \cdot 2304 = 182471 \text{ kWh}.$$

8. Payment for consumed active power by IE4+ and IE3 motors:

$$pay_{ie4+} = Pa_{ie4+} \cdot Ca_{Italy} = 43232 \text{ Euro},$$

$$pay_{ie3} = Pa_{ie3} \cdot Ca_{Italy} = 43793 \text{ Euro}.$$

9. Benefit per year due to increased efficiency

$$E_{act} = pay_{ie3} - pay_{ie4+} = 561 \text{ Euro}.$$

10. Power factor of an average IE3 motor: $\cos(\varphi)_{ie3} = 0.88$.

11. Price of 1kVAh of reactive power in Italy in Euro for the IE3 motor ($\cos(\varphi)_{ie3} = 0.88$):

$$Cr3_{Italy} = 0.032 \text{ Euro/ kVAh}.$$

12. Reactive power consumption by IE4+ and IE3 motors:

$$Q_{ie4+} = Pa_{ie4+} \cdot \frac{\sqrt{1-\cos^2(\varphi)}}{\cos(\varphi)} = 68375 \text{ kVAh},$$

$$Q_{ie3} = Pa_{ie3} \cdot \frac{\sqrt{1-\cos^2(\varphi)_{ie3}}}{\cos(\varphi)_{ie3}} = 98487 \text{ kVAh}.$$

13. Payment for consumed reactive power by IE4+ and IE3 motors:

$$payr_{ie4+} = Q_{ie4+} \cdot Cr4_{Italy} = 0 \text{ Euro},$$

$$payr_{ie3} = Q_{ie3} \cdot Cr3_{Italy} = 3152 \text{ Euro}.$$

14. Benefit per year due to increased power factor:

$$E_{react} = payr_{ie3} - payr_{ie4+} = 3152 \text{ Euro}.$$

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

$$E_{act} = 561 \text{ Euro}, \quad E_{react} = 3152 \text{ Euro}.$$

16. Total benefit per year due to replacement of an average IE3 motor with an IE4+ motor:

$$E_{one_year} = E_{act} + E_{react} = 3713 \text{ Euro}.$$