Calculation of benefit of replacing IE3 motor with conventional IE4 motor (75 kW, 30000 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 a conventional IE4 motor: $cos\ (\varphi) = 0.89$.

3. Price of 1 kVAh of reactive power in Italy in Euro for IE4, for $cos\ (\varphi) = 0.89$: $Cr4_{Italy} = 0.032$ 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: η_{ie4}= 0.959.

6. Standard motor efficiency of IE3: η_{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:

$$Q_{ie4} = Pa_{ie4} \cdot \frac{\sqrt{1 - Cos^2(\varphi)}}{Cos(\varphi)} = 92285 \text{ kVAh},$$

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

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

$$payr_{ie4} = Q_{ie4} \cdot Cr4_{Italy} = 2953 \text{ Euro},$$

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

14. Benefit per year due to increased power factor:

$$E_{react} = payr_{ie3} - payr_{ie4} = 199 \text{ Euro}.$$

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

$$E_{act} = 561 \text{ Euro}, \qquad E_{react} = 199 \text{ Euro}.$$

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

$$E_{one\_year} = E_{act} + E_{react} = 760 \text{ Euro}.$$