Calculation of benefit of replacing IE3 motor with IE5+ motor (55 kW, 18000 rpm) for USA

1. Price of 1 kWh of active power in USA in $: $Ca_{usa} = 0.15$ $/kWh.

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

3. Motor efficiency of IE5+: η_{ie5}= 0.964.

4. Standard motor efficiency of IE3: η_{ie3}= = 0.946.

5. Active power consumption by IE5+ and IE3 motors:

$$Pa_{ie5} = \frac{P_{2n}}{\eta_{ie5}} t_{work} = \frac{15}{0.964} \cdot 2304 = 131409 \text{ kWh},$$

$$Pa_{ie3} = \frac{P_{2n}}{\eta_{ie3}} t_{work} = \frac{15}{0.946} \cdot 2304 = 133953 \text{ kWh}.$$

6. Payment for consumed active power by IE5+ and IE3 motors:

$$pay_{ie5} = Pa_{ie5} \cdot Ca_{usa} = 19711 \text{ \$},$$

$$pay_{ie3} = Pa_{ie3} \cdot Ca_{usa} = 20093 \text{ \$}.$$

7. Benefit per year due to increased efficiency

$$E_{act} = pay_{ie3} - pay_{ie5} = 382 \text{ \$}.$$

8. Power factor of the motor IE5+: $cos\ (\varphi) = 0.908$.

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

10. Payment for consumed reactive power by IE5+ and IE3 motors:

$$payr_{ie5} = Ca_{usa} \left(\frac{0.9}{Cos\ (\varphi)} \cdot Pa_{ie5} - Pa_{ie5} \right) = 0 \text{ \$},$$

$$payr_{ie3} = Ca_{usa} \left(\frac{0.9}{Cos\ (\varphi)_{ie3}} \cdot Pa_{ie3} - Pa_{ie3} \right) = 1695 \text{ \$}.$$

11. Benefit per year due to increased power factor:

$$E_{react} = payr_{ie3} - payr_{ie5} = 1695 \text{ \$}.$$

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

$$E_{act} = 382 \text{ \$}, \qquad E_{react} = 1695 \text{ \$}.$$

13. Total benefit per year due to replacement of an average IE3 motor with an IE5+ motor:

$$E_{one\_year} = E_{act} + E_{react} = 2077 \text{ \$}.$$