Given: $kJ := 1000J \quad MJ := 1000kJ \quad GJ := 1000MJ \quad USD := 1$

Consider a building whose annual air conditioning load is estimated to be 40,000 kWhr in an area where the unit cost of electricity is $0.10/kWhr. Two air conditioners are considered for the building. Air conditioner A has a seasonal average COP of 2.3 and costs $5,500 to install. Air conditioner B has a seasonal average COP of 3.6 and costs $7,000 to install.

Required:

In how many years, will the total cost to install and operate be equal between the two conditioners?

Solution:

The estimated air conditioning load per year is defined as

$$Q'_L := 40000\frac{kW\cdot hr}{yr} = 144\cdot\frac{GJ}{yr}$$

The unit cost of electricity is defined as

$$R_{elec} := 0.10\cdot\frac{USD}{kW\cdot hr}$$

The coefficient of performance of the two air conditioner units are defined as

$$COP_A := 2.3 \qquad COP_B := 3.6$$

The installation costs of the two air conditioner units are defined as

$$IC_A := 5500USD \qquad IC_B := 7000USD$$

The net work input of the two air conditioner units are found by

$$COP = \frac{Q'_L}{W'_{net,in}} \quad \text{or} \quad W'_{net,inA} := \frac{Q'_L}{COP_A} = 62.609\cdot\frac{GJ}{yr}$$

$$W'_{net,inB} := \frac{Q'_L}{COP_B} = 40\cdot\frac{GJ}{yr}$$

The operating cost per year of the two air conditioner units are found by

$$OC_A := R_{elec}\cdot W'_{net,inA} = 1739.13\cdot\frac{USD}{yr}$$

$$OC_B := R_{elec}\cdot W'_{net,inB} = 1111.11\cdot\frac{USD}{yr}$$

The cost savings per year of using air conditioner B instead of air conditioner A is given by

$$CS_{BA} := OC_A - OC_B = 628.02\cdot\frac{USD}{yr}$$

The pay back period is then found by

$$PBP := \frac{IC_B - IC_A}{CS_{BA}} = 2.39\cdot yr$$

So in $PBP = 2.388\,yr$ air conditioner B will pay for it self in comparison to air conditioner A.