Appendix. Method to measure the key devices in the air-conditioning system

Chiller

Fig. A1 is a sketch of a chiller with the measured parameters, including the temperature and flow rate of the chilled water ($T_{w,e\text{-}in}$, $T_{w,e\text{-}out}$, and $G_{w,e}$), the temperature and flow rate of the cooling water ($T_{w,c\text{-}in}$, $T_{w,c\text{-}out}$, and $G_{w,c}$), and the electric power of the chiller (P_{ch}).

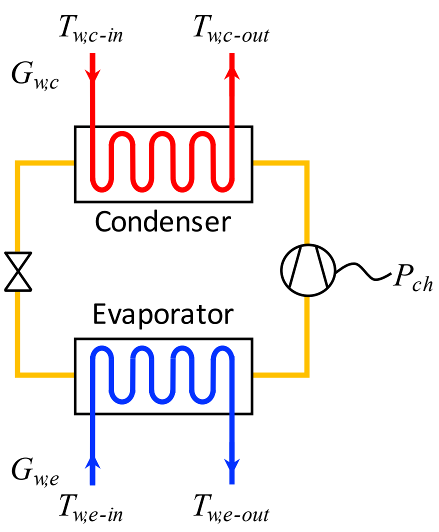

Fig. A1 Measured parameters of a chiller.

The cooling capacity of the evaporator (Q_e) is calculated by the temperature and flow rate of the chilled water, as shown in Eq. (A1).

$$Q_e = \rho_w G_{w,e} c_{p,w} \cdot \left(T_{w,e\text{-}in} - T_{w,e\text{-}out}\right) \tag{A1}$$

where $T_{w,e\text{-}in}$ and $T_{w,e\text{-}out}$ are the inlet and outlet temperature of the chilled water, respectively; $G_{w,e}$ is the volume flow rate of the chilled water.

The heating capacity of the condenser (Q_c) is calculated by the temperature and flow rate of the cooling water, as shown in Eq. (A2).

$$Q_c = \rho_w G_{w,c} c_{p,w} \cdot \left(T_{w,c\text{-}out} - T_{w,c\text{-}in}\right) \tag{A2}$$

where $T_{w,c\text{-}in}$ and $T_{w,c\text{-}out}$ are the inlet and outlet temperature of the cooling water, respectively; $G_{w,c}$ is the volume flow rate of the cooling water.

Air-conditioning water pumps

Air-conditioning water pumps (including chilled water pumps, cooling water pumps, and glycol pumps in an ice storage system) aim to transport cooling and heating capacities in air-conditioning systems. Thus, the cooling and heating capacities can be derived from the evaporators and condensers of chillers.

Cooling tower

Fig. A2 is a sketch of a cooling tower with the measured parameters, including the cooling water temperature ($T_{w,ct\text{-}in}$ and $T_{w,ct\text{-}out}$), the cooling water flow rate ($G_{w,ct}$), and the electric power of the cooling tower (P_{ct}).

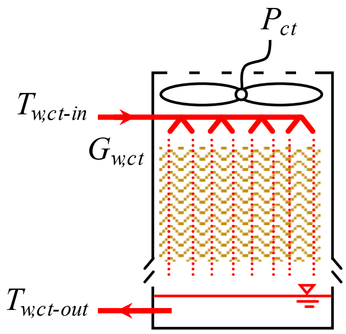

Fig. A2 Measured parameters of a cooling tower.

The cooling capacity of the cooling tower (Q_{ct}) is calculated by the temperature and flow rate of the cooling water, as shown in Eq. (A3).

$$Q_{ct} = \rho_w G_{w,ct} c_{p,w} \cdot \left(T_{w,ct\text{-}in} - T_{w,ct\text{-}out}\right) \tag{A3}$$

where $T_{w,ct\text{-}in}$ and $T_{w,ct\text{-}out}$ are the inlet and outlet temperature of the cooling water, respectively; $G_{w,ct}$ is the volume flow rate of the cooling water.

Air handling unit (AHU)

Fig. A3 is a sketch of an AHU with the measured parameters, including the chilled water temperature ($T_{w,AHU\text{-}in}$ and $T_{w,AHU\text{-}out}$), the chilled water flow rate ($G_{w,AHU}$), and the electric power of the AHU (P_{AHU}).

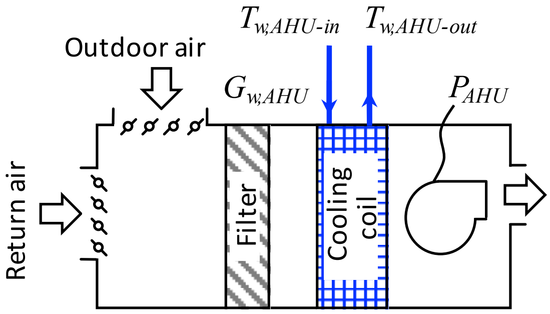

Fig. A3 Measured parameters of an AHU.

The cooling capacity of the AHU (Q_{AHU}) is calculated by the temperature and flow rate of the chilled water, as shown in Eq. (A4).

$$Q_{AHU} = \rho_w G_{w,AHU} c_{p,w} \cdot \left(T_{w,AHU\text{-}out} - T_{w,AHU\text{-}in}\right) \tag{A4}$$

where $T_{w,AHU\text{-}in}$ and $T_{w,AHU\text{-}out}$ are the inlet and outlet temperature of the chilled water, respectively; $G_{w,AHU}$ is the volume flow rate of the chilled water.