IEA-EBC Annex 85

EBC

Energy in Buildings and Communities Programme

Feasibility Analysis of Indirect Evaporative Cooling

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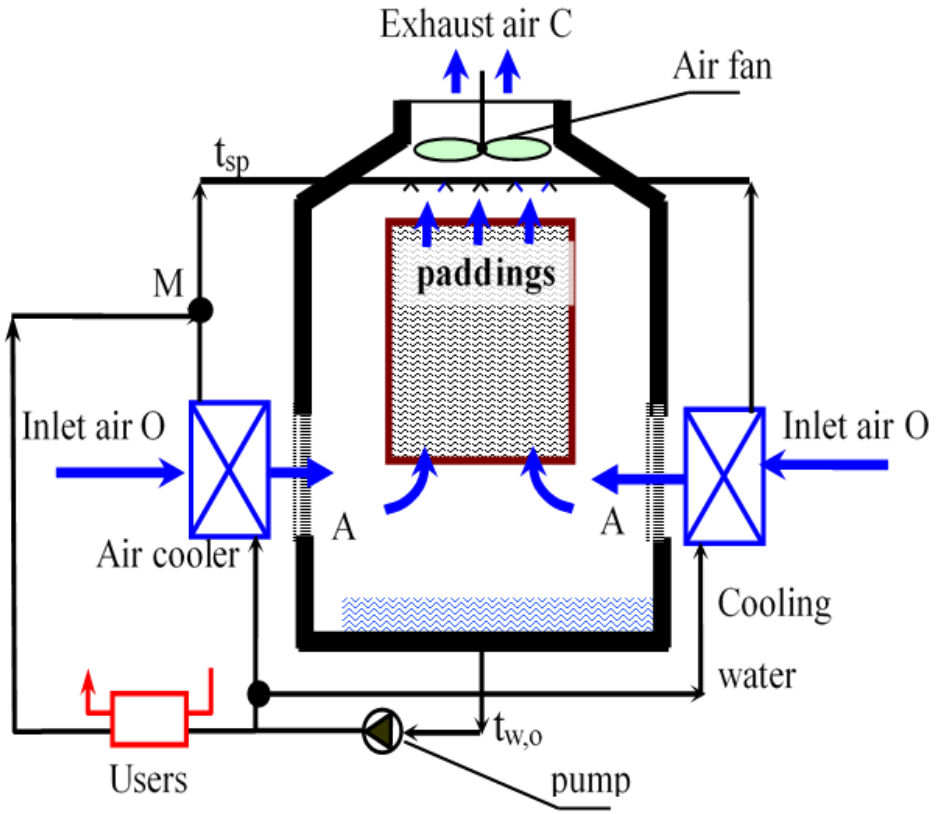
Outline

- IEC parameter optimization
- Difference of IEC and DEC
- Feasibility analysis
- Future research

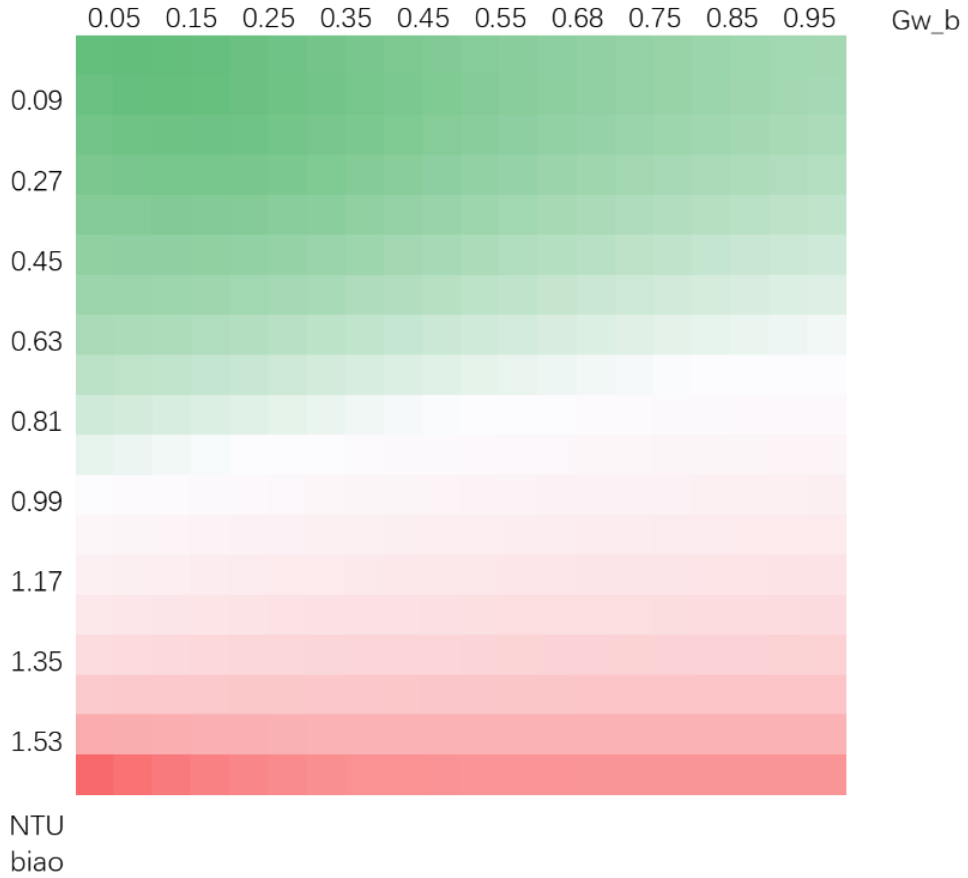
IEC parameter optimization

IEC parameter optimization

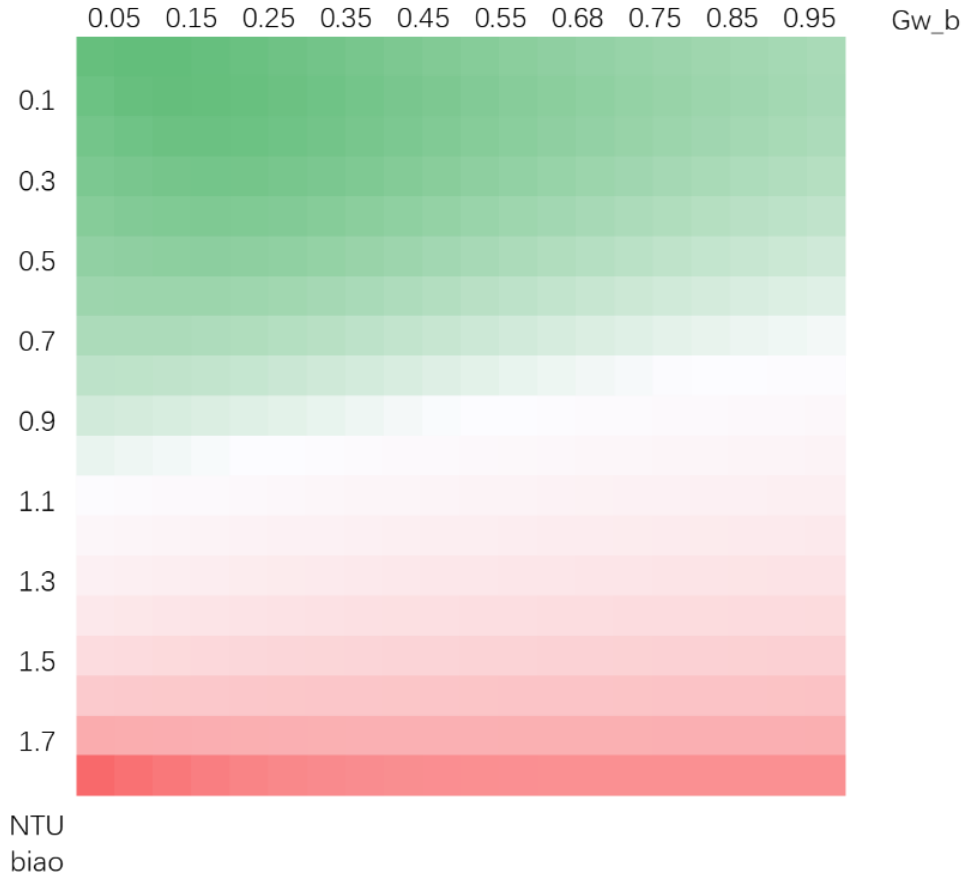
- Calculations are based on the IEC process shown on the right.
- **Assuming the temperature difference between supply and return water is 5 ℃**, EES simulation is used to calculate the effluent temperature.
- There are two important parameters that need to be determined: **the amount of water through the air cooler and its NTU**， in order to obtain the optimal working point of the system, we **consider the influence of both together**.
- It is assumed that the cost is fixed, that is, **the sum of air cooler NTU and paddings NTU is certain.**



IEC parameter optimization



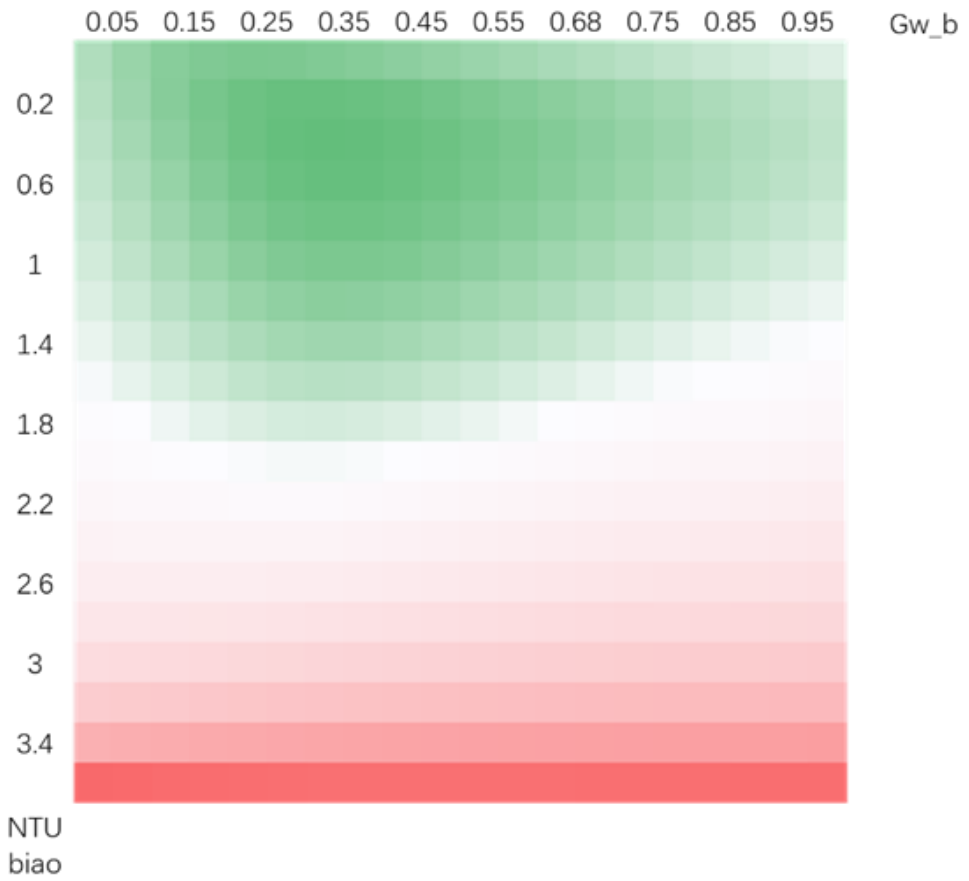
NTU=1.8 (DEC > IEC)



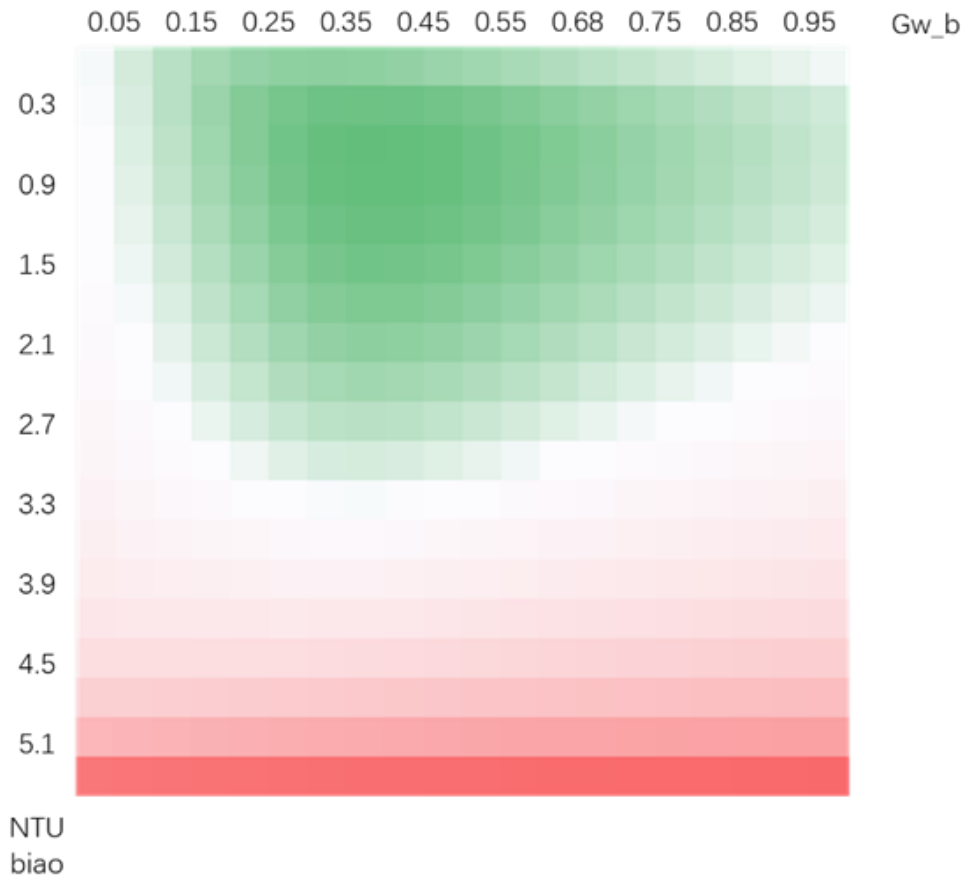
NTU=2 (0.1, 0.1)

- At 30℃ and 50% relative humidity, the relationship between water flow rate and outlet temperature of the chiller was simulated. The abscissa is the water quantity of the air cooler, and the ordinate is the NTU of the air cooler. The greener the color is, the lower the outlet water temperature is.

IEC parameter optimization



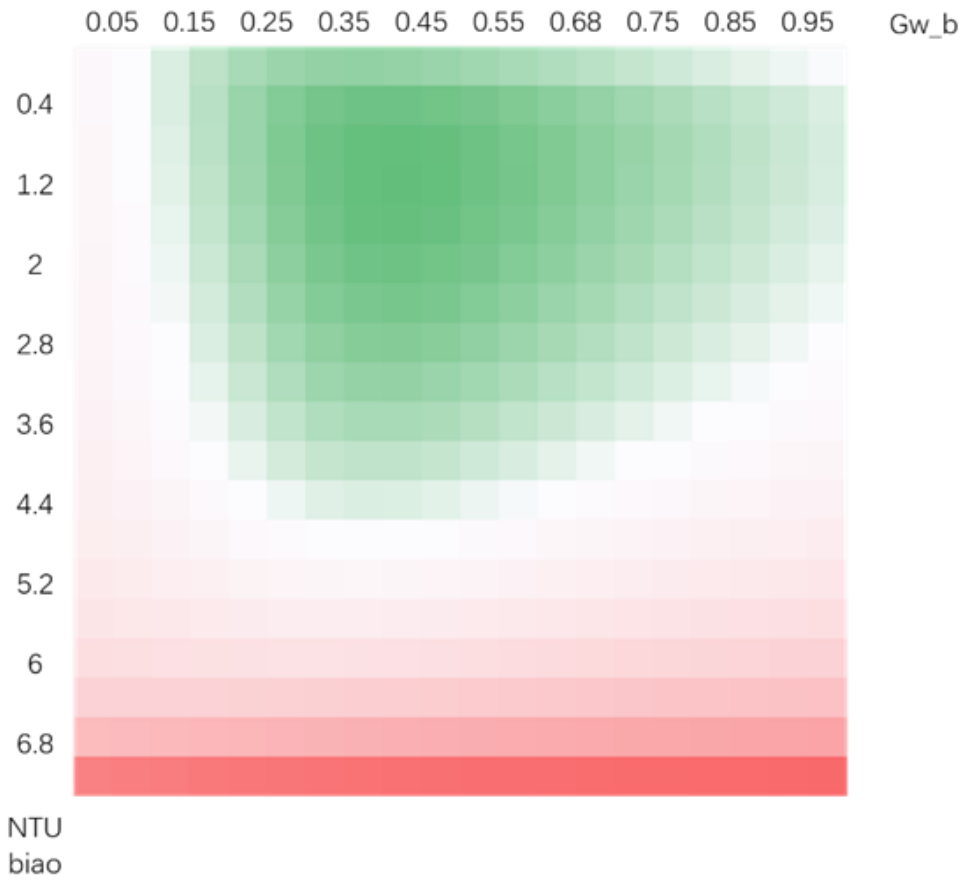
NTU=4 (0.35, 0.6)



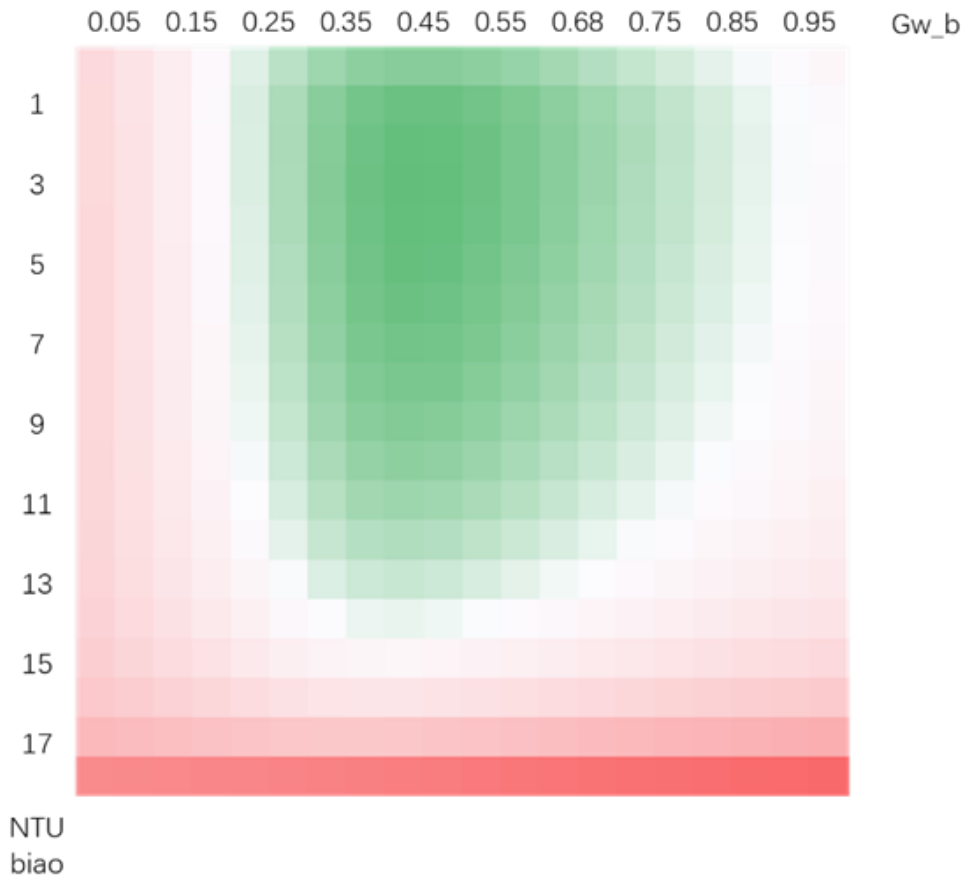
NTU=6 (0.4, 0.9)

- At 30℃ and 50% relative humidity, the relationship between water flow rate and outlet temperature of the chiller was simulated. The abscissa is the water quantity of the air cooler, and the ordinate is the NTU of the air cooler. The greener the color is, the lower the outlet water temperature is.

IEC parameter optimization



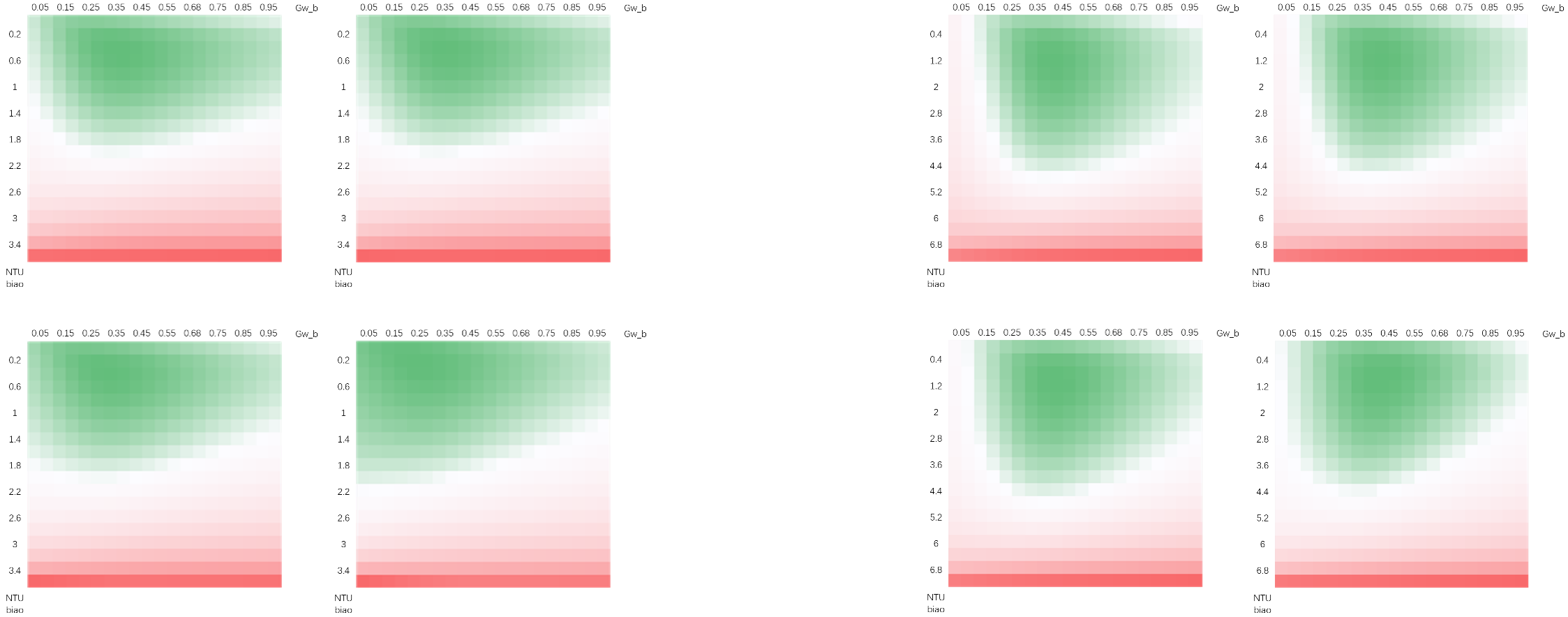
NTU=8 (0.45, 1.2)



NTU=20 (0.45, 3)

- At 30℃ and 50% relative humidity, the relationship between water flow rate and outlet temperature of the chiller was simulated. The abscissa is the water quantity of the air cooler, and the ordinate is the NTU of the air cooler. The greener the color is, the lower the outlet water temperature is.

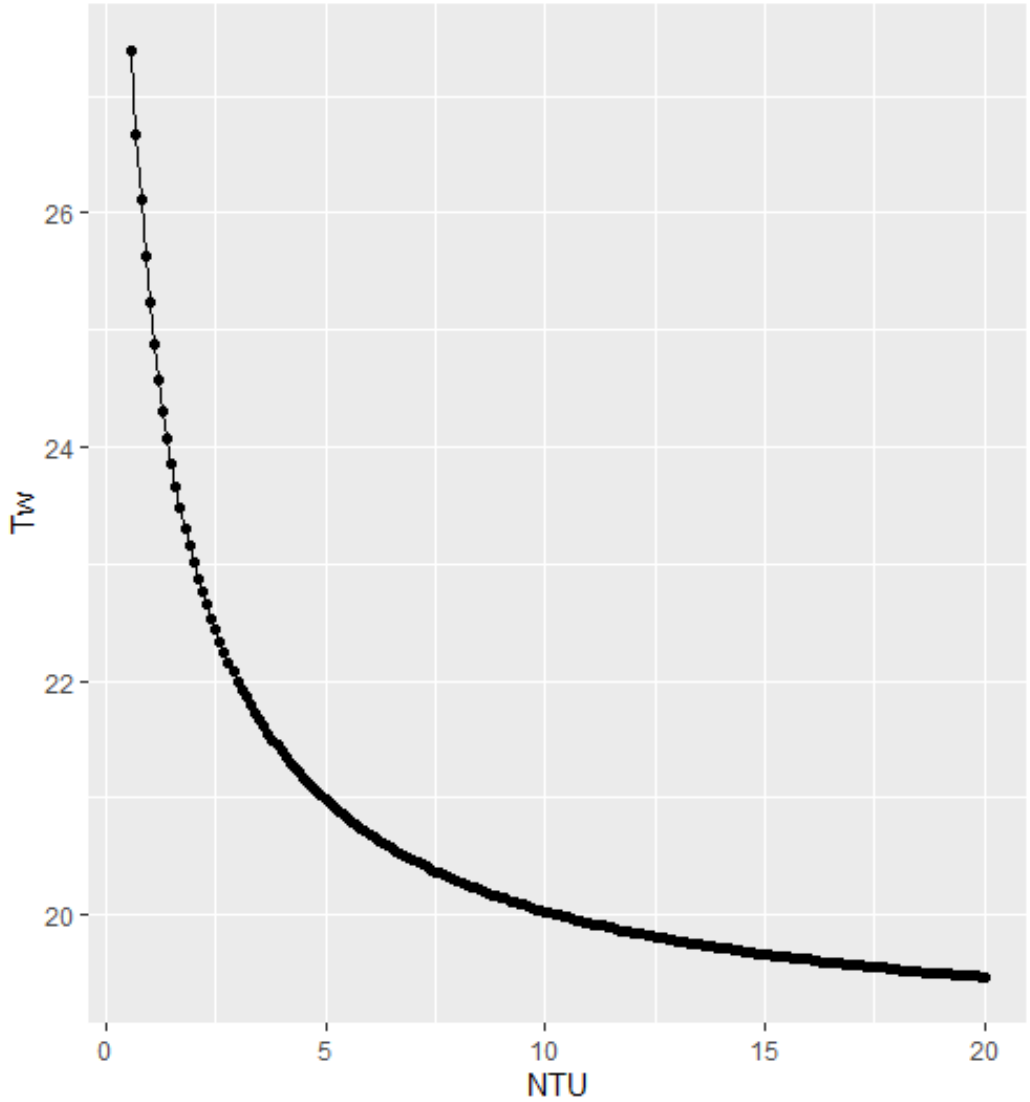
IEC parameter optimization



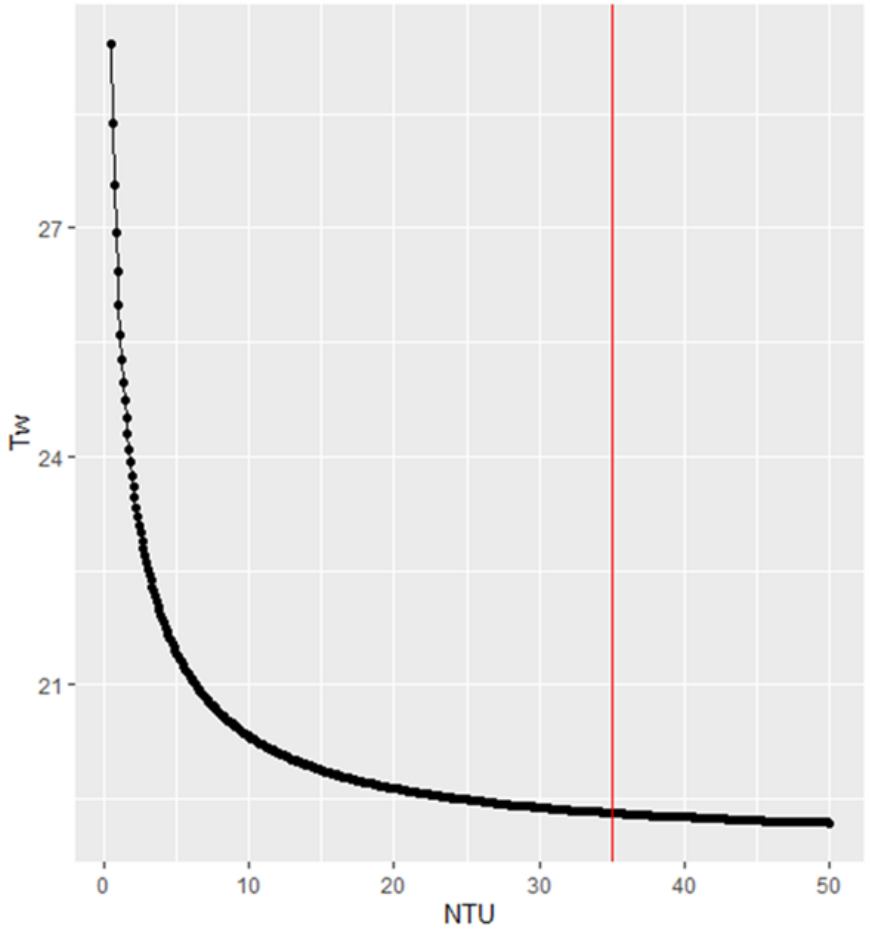
NTU=4 **NTU=8**

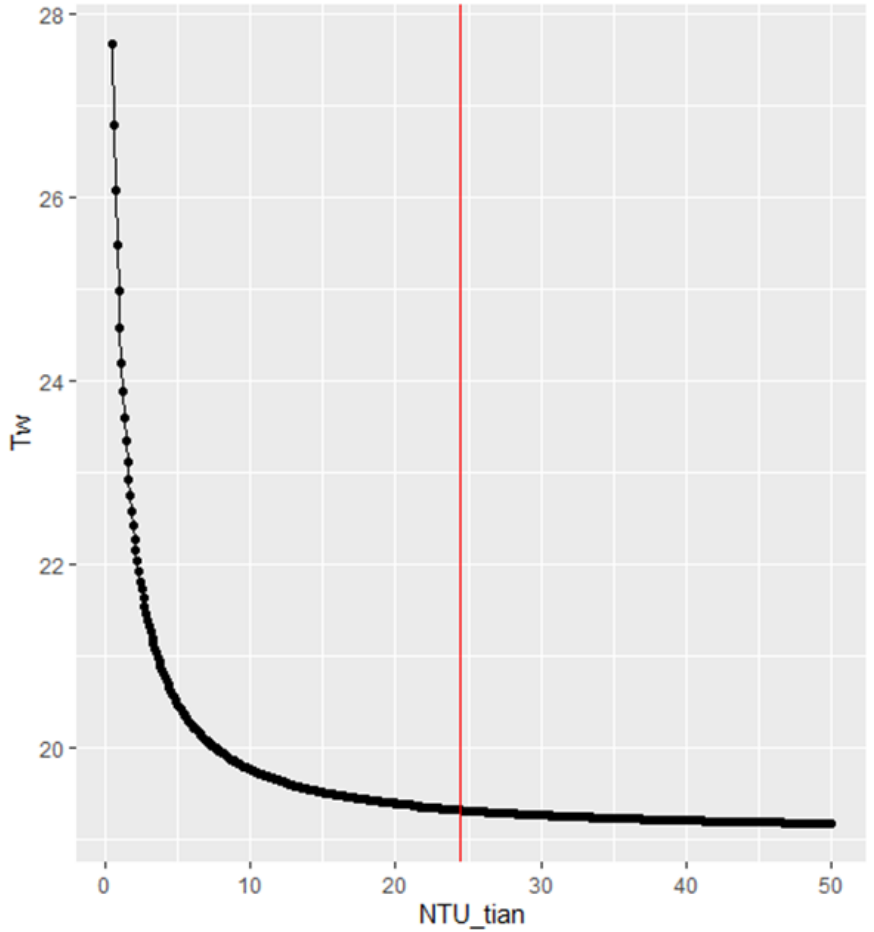
- At **30℃, 20%, 40%, 60%, 80% relative humidity** conditions, respectively, simulated calculation of the relationship between water temperature.

IEC parameter optimization



IEC parameter optimization

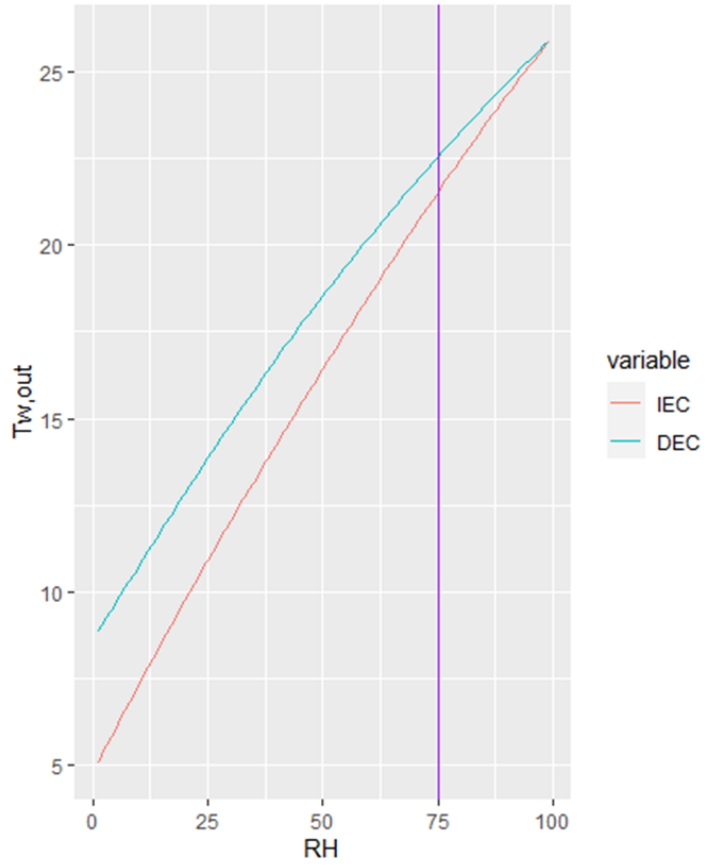




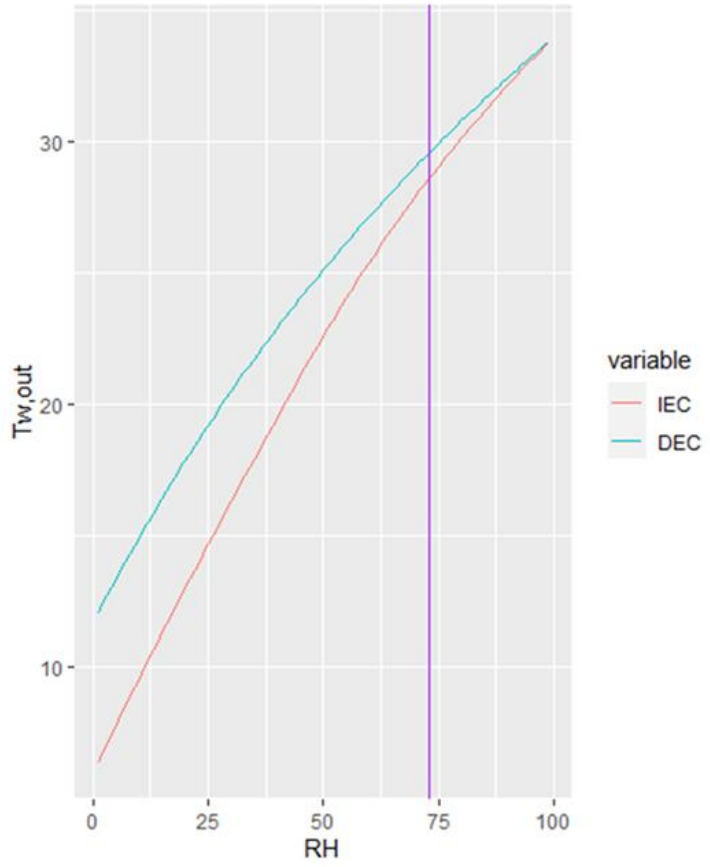
- In fact, NTU of the surface cooler costs more than the packed NTU, and it is assumed that the price of NTU of the surface cooler is 3 times that of the packed NTU. $\mathbf{NTU_{biao} \times 3 + NTU_{tian} = NTU}$
- An **eight-row air cooler** has an NTU of about **3.5**.

Difference of IEC and DEC

IEC parameter optimization



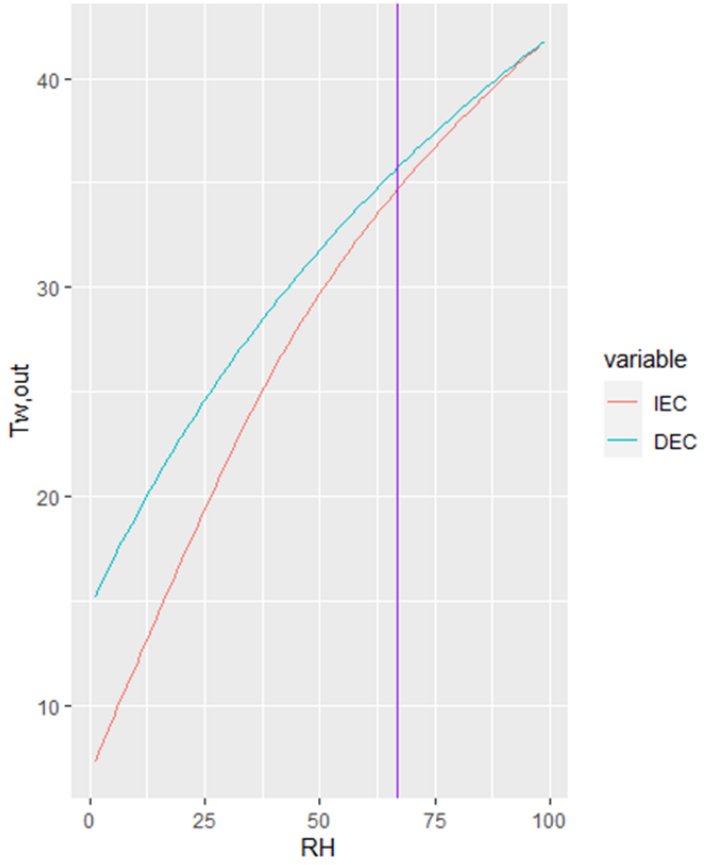
26℃



34℃

- IEC temperature corresponding to the purple line is **1℃** lower than DEC

IEC parameter optimization



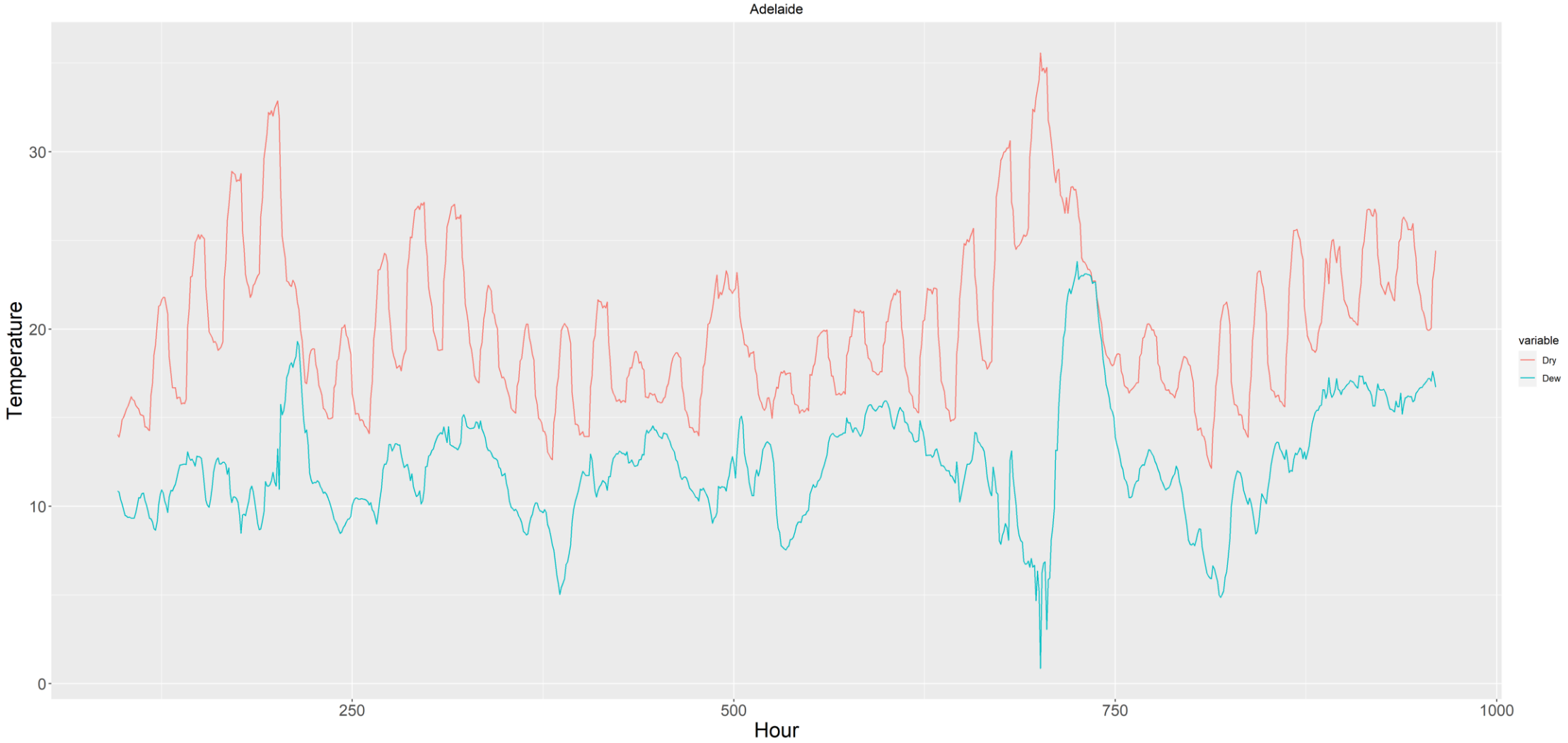
42℃

Drybulb (℃)	Wetbulb (℃)	RH(%)
26	22.6	75
28	24.5	75
30	26.3	75
32	27.9	73
34	29.6	73
36	31.2	71
38	32.8	70
40	34.4	69
42	35.9	67

Feasibility analysis

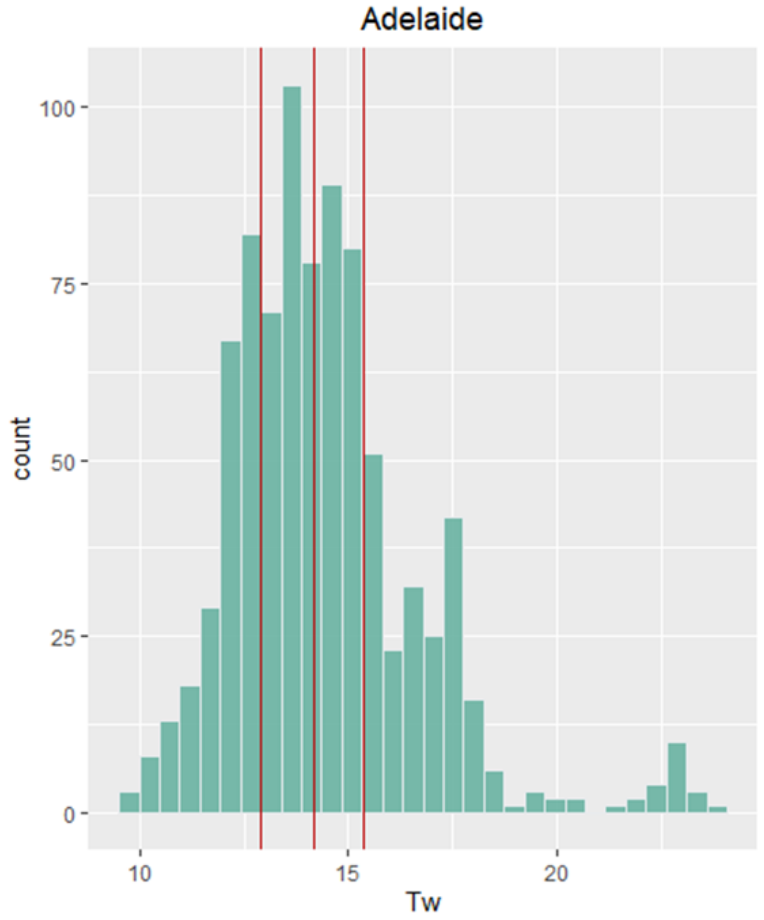
IEC parameter optimization

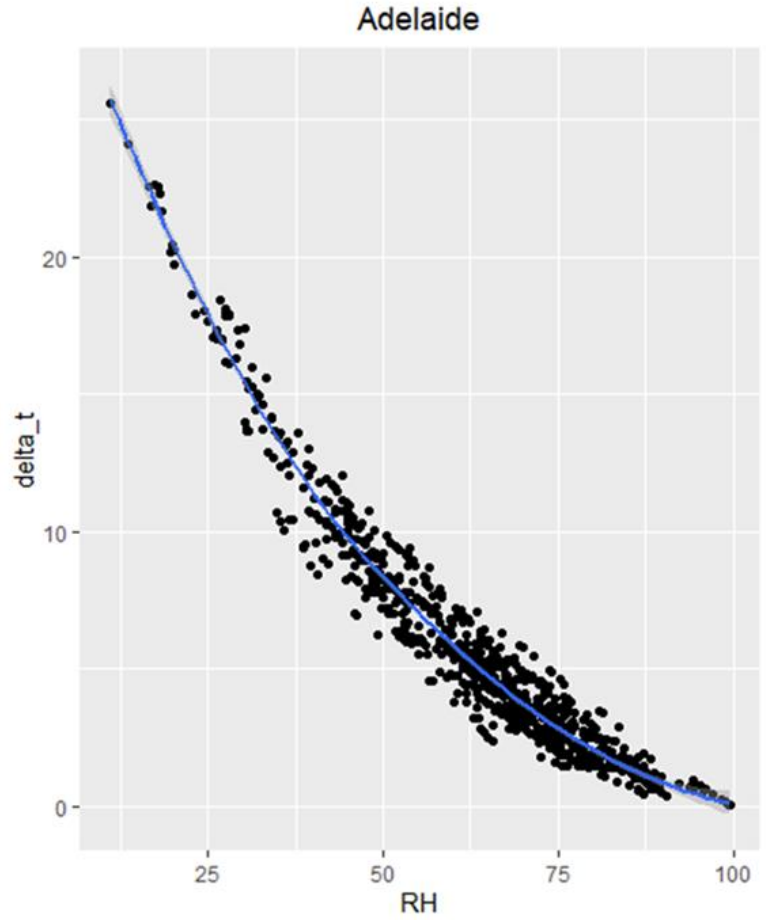
- Adelaide, Australia, outdoor air conditions in 2020 summer



IEC parameter optimization

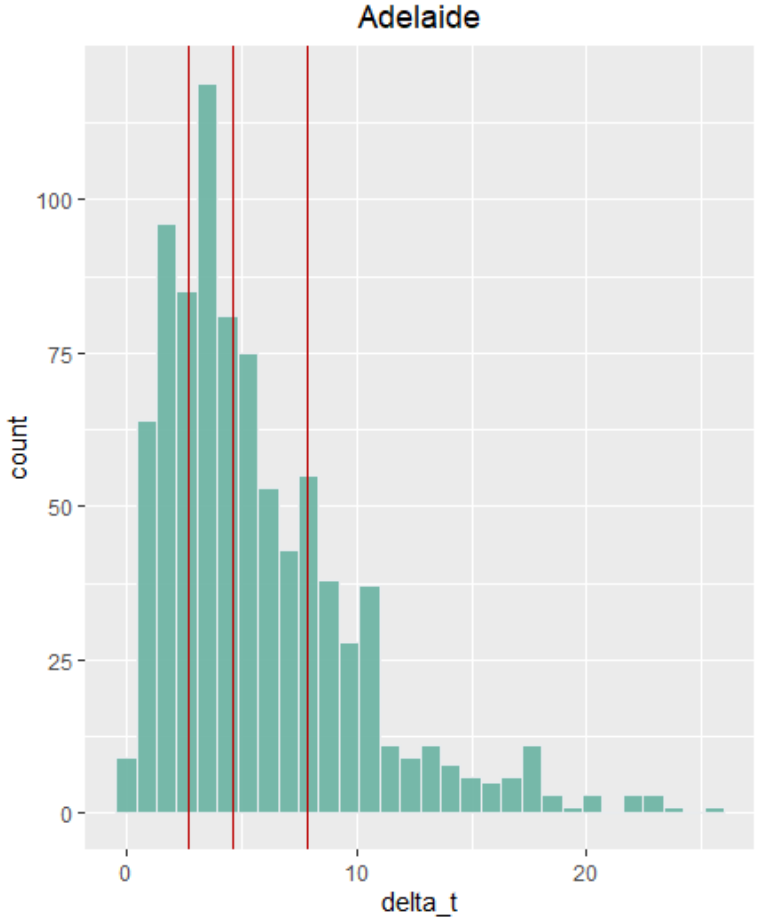
- Adelaide, Australia, outlet water temperature in 2020 summer
- The outlet cold water temperature is lower than 15℃ for about 75% hours
- Adelaide is suitable to use IEC water chillers as the cooling source

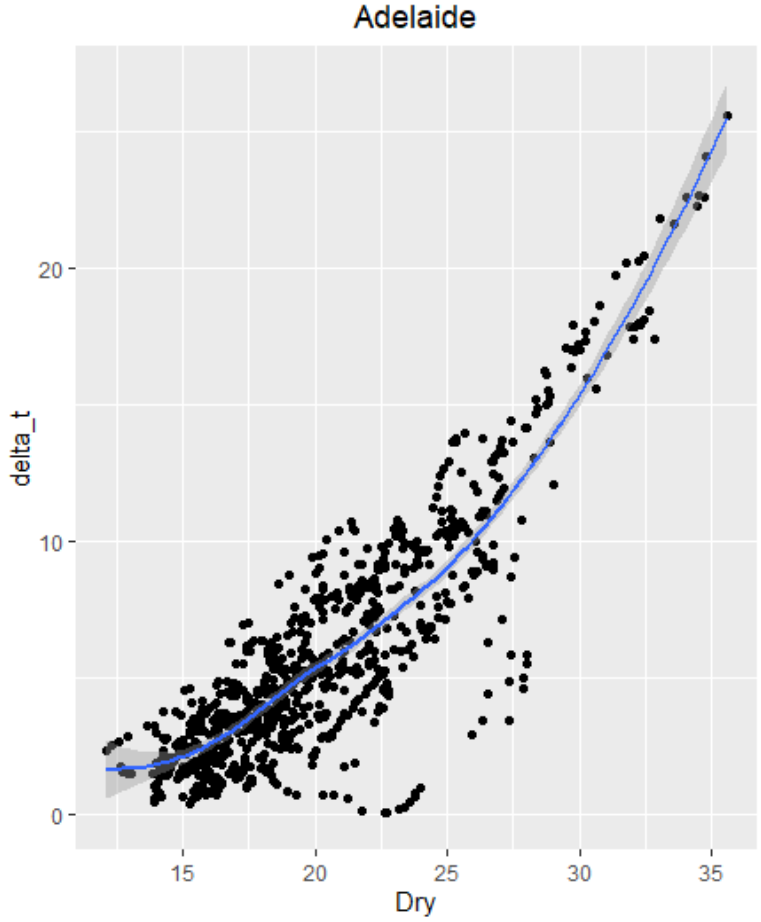




IEC parameter optimization

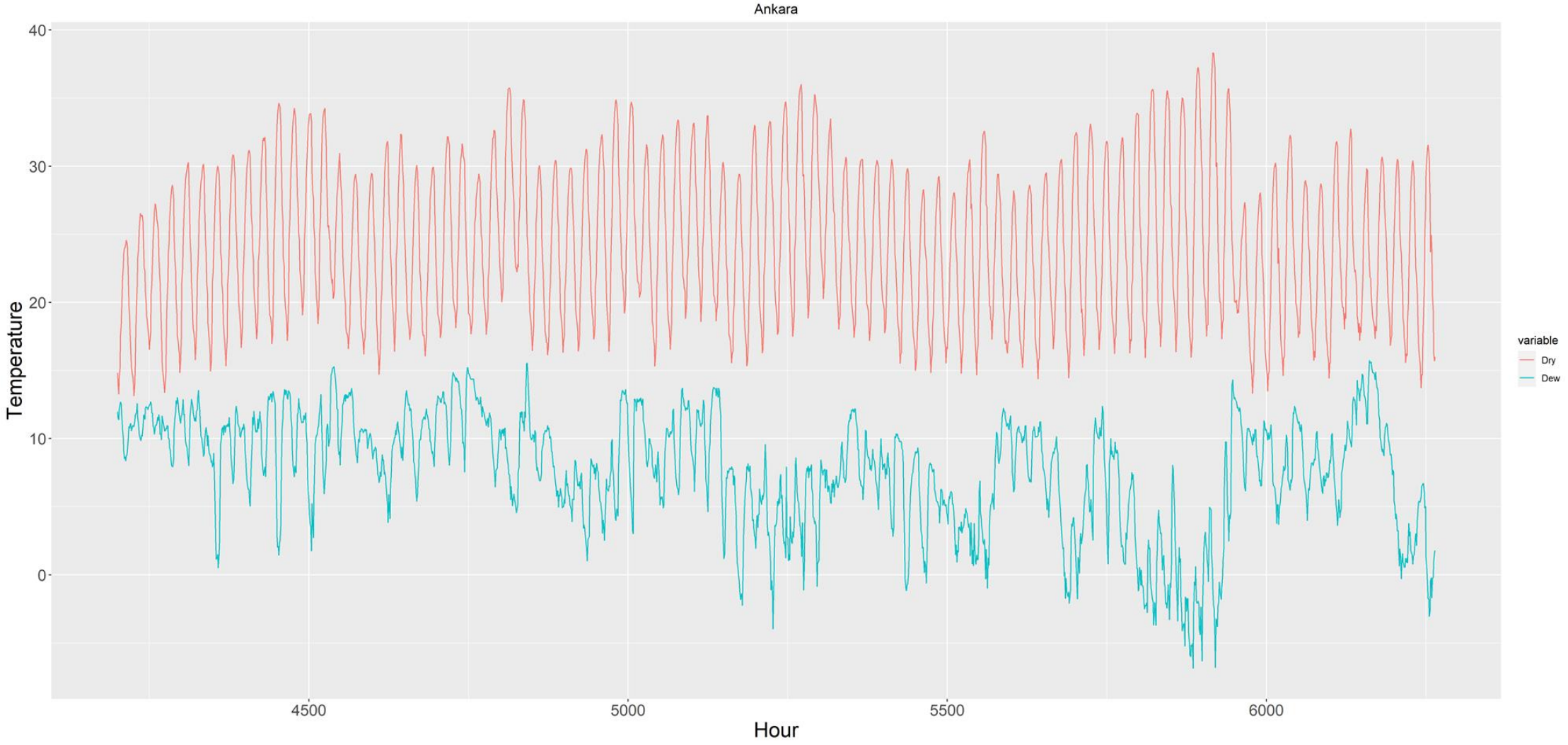
- Adelaide, Australia, 2020 summer
- The higher the outdoor dry bulb temperature , the higher the temperature difference between outdoor dry bulb temperature and output cold water temperature.
- IEC processes could be used for well for Adelaide climate, and the cooling capacity could fit with heat loads.





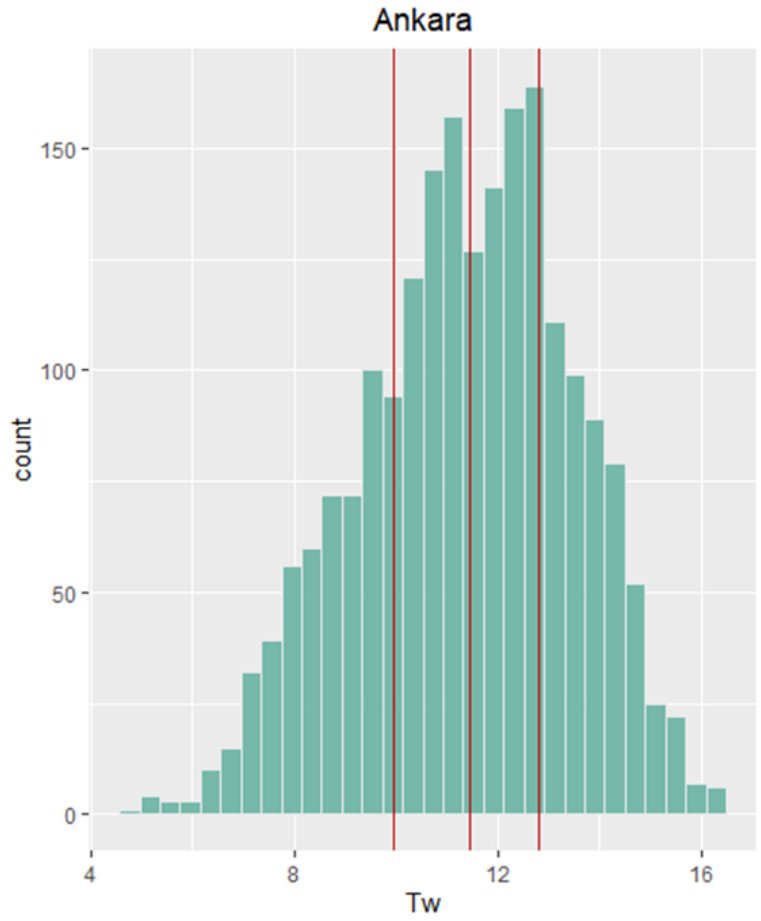
IEC parameter optimization

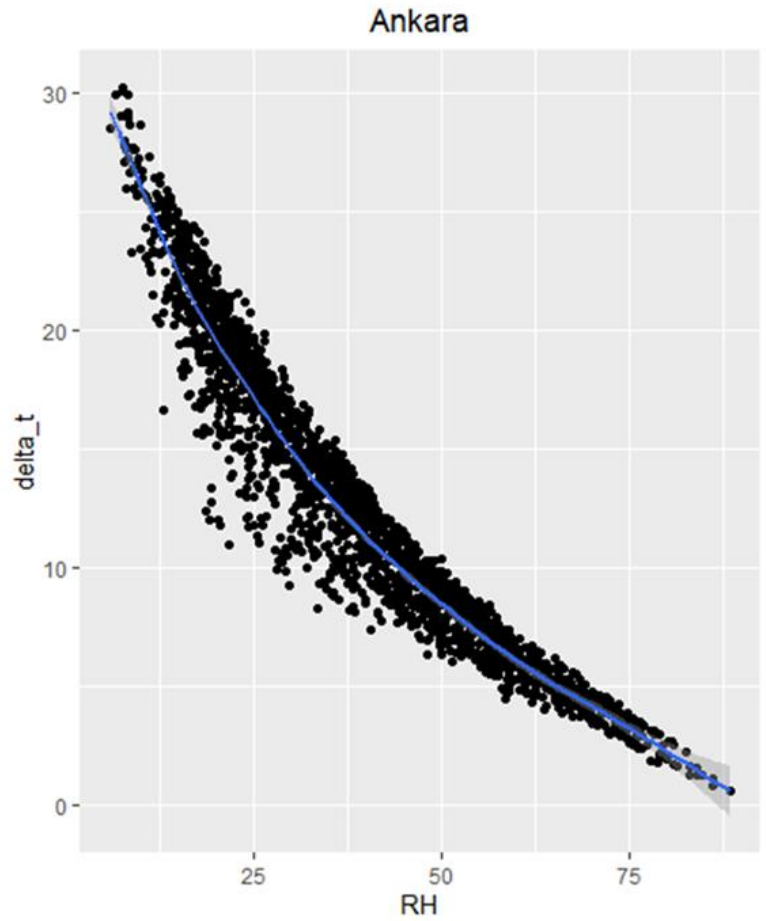
- Ankara, Turkey, outdoor air conditions in 2020 summer



IEC parameter optimization

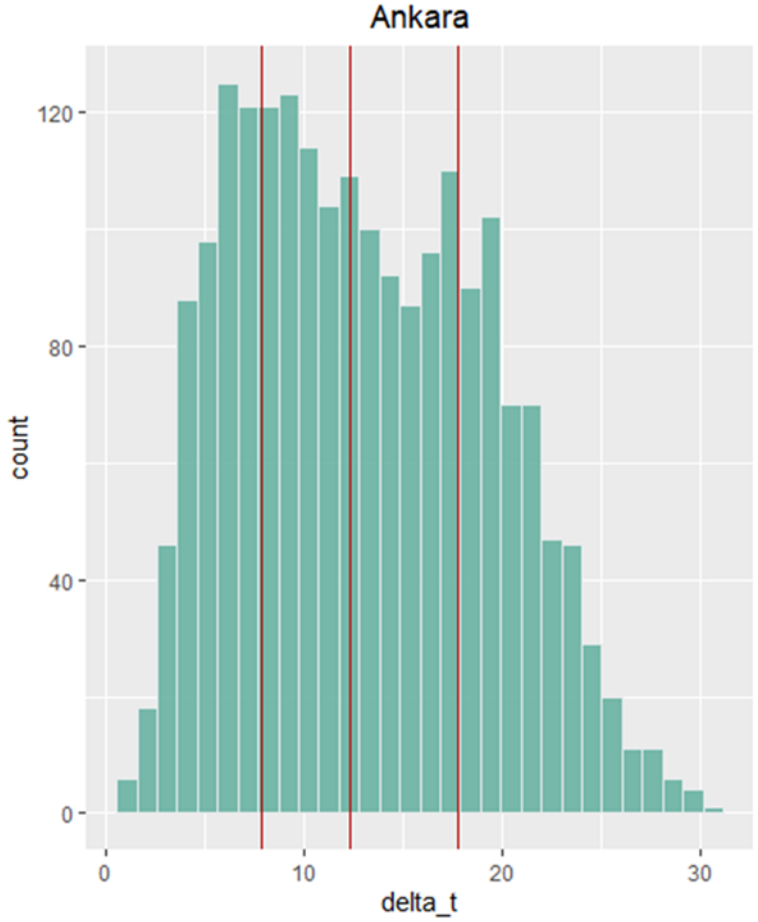
- Ankara, Turkey, outlet water temperature in 2020 summer
- The outlet cold water temperature is lower than 18℃ for all the summer
- Ankara is suitable to use IEC water chillers as the cooling source

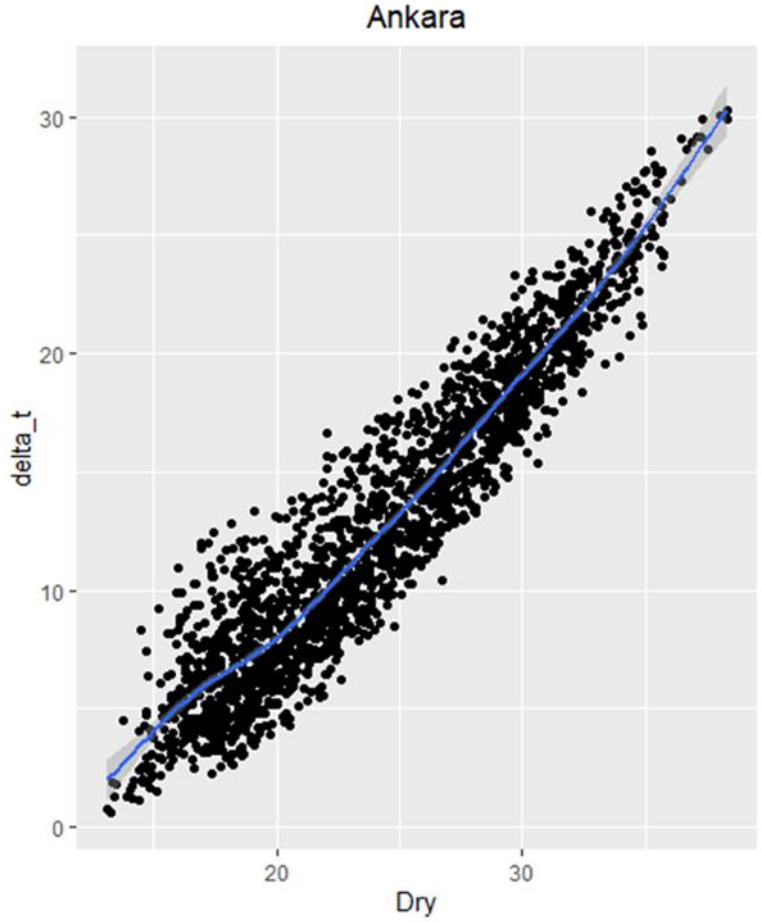




IEC parameter optimization

- Ankara, Turkey, 2020 summer
- The higher the outdoor dry bulb temperature , the higher the temperature difference between outdoor dry bulb temperature and output cold water temperature.
- IEC processes could be used for well for Ankara climate, and the cooling capacity could fit with heat loads.



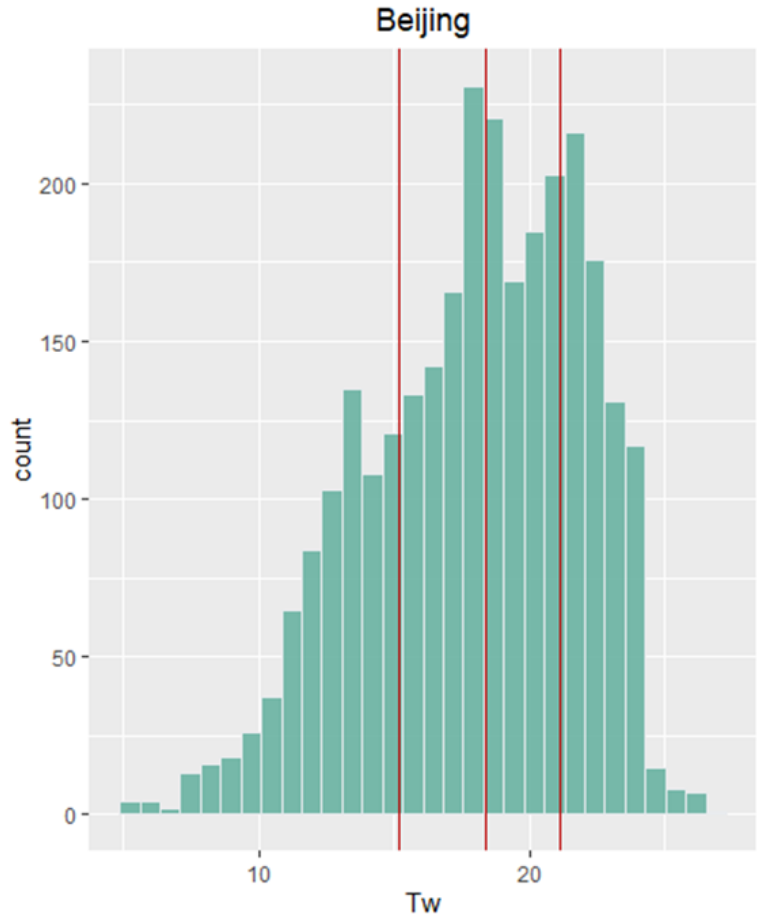


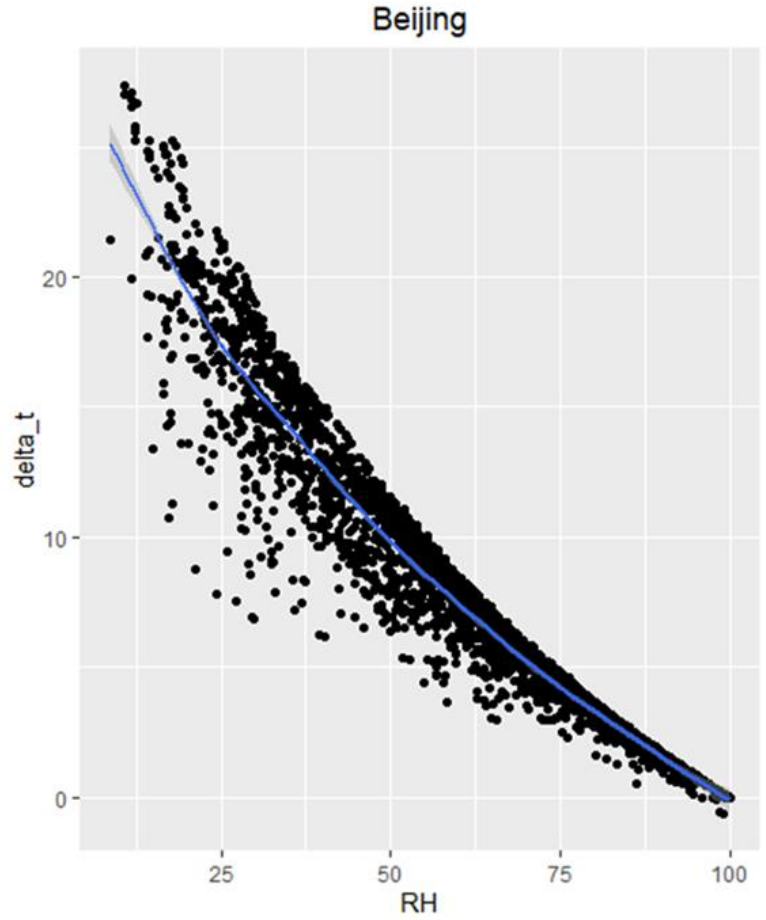
IEC parameter optimization

- Beijing, China, outdoor air conditions in 2020 summer

IEC parameter optimization

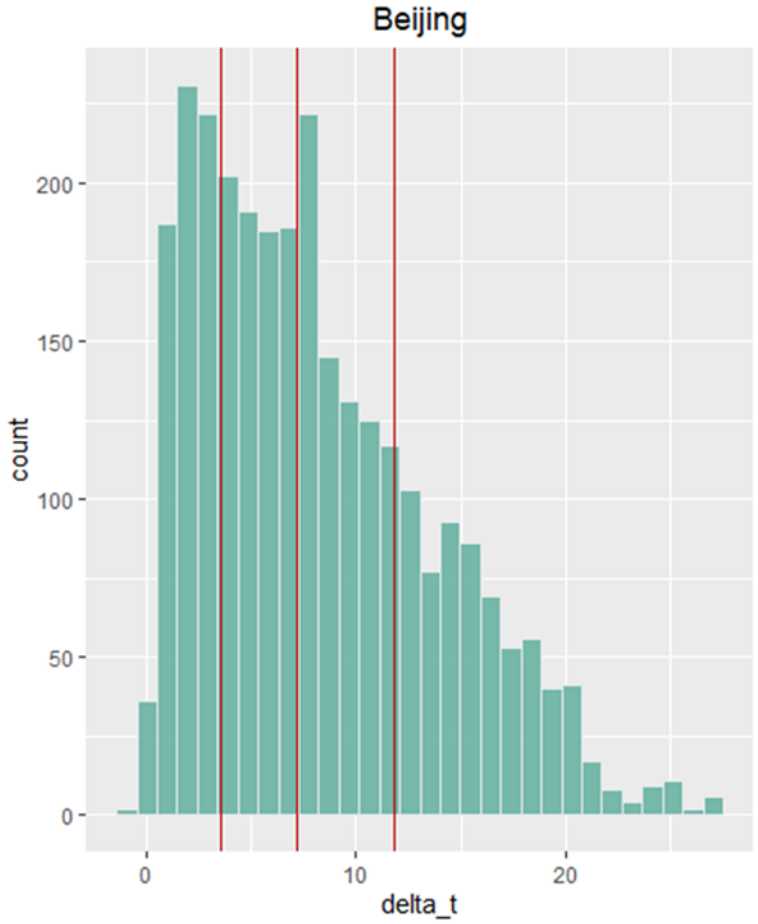
- Beijing, China, outlet water temperature in 2020 summer
- The outlet cold water temperature is higher than 20℃ for about 50% hours
- Beijing is not suitable to use IEC water chillers as the cooling source

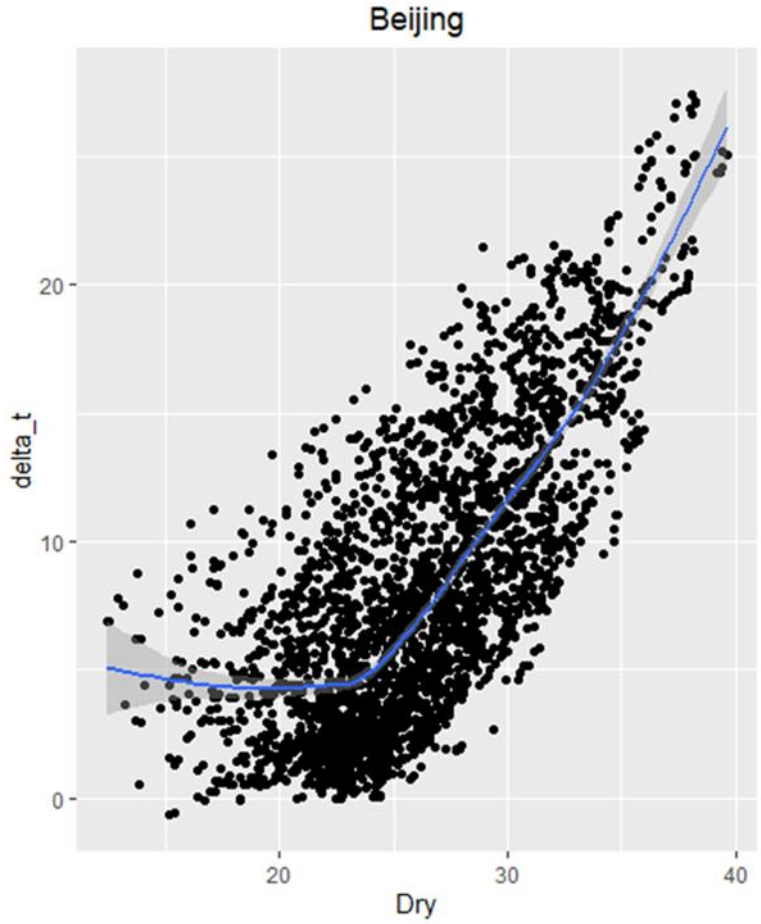




IEC parameter optimization

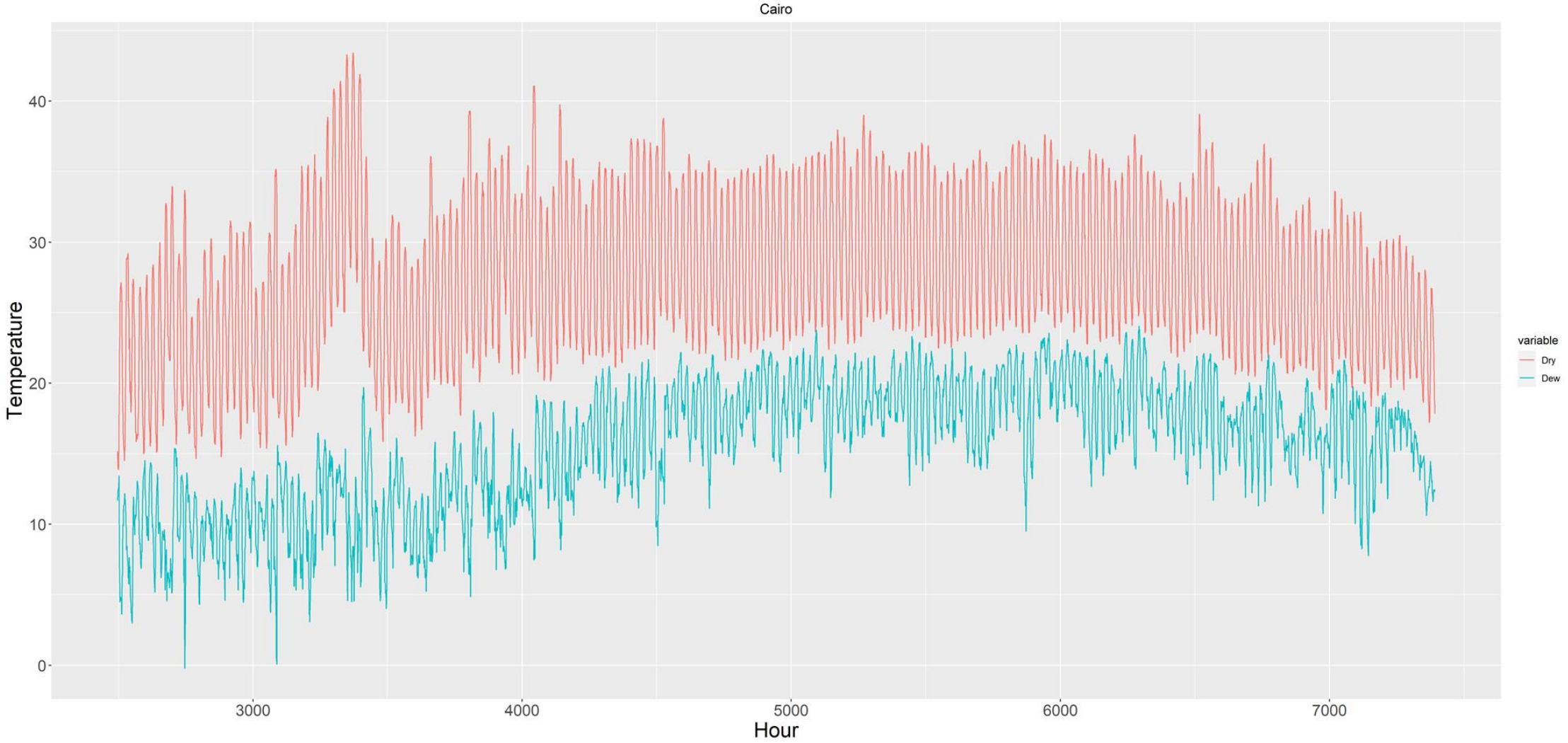
- Beijing, China, 2020 summer
- The higher the outdoor dry bulb temperature , the higher the temperature difference between outdoor dry bulb temperature and output cold water temperature.
- IEC processes could be used for pre-cooling for Beijing climate.





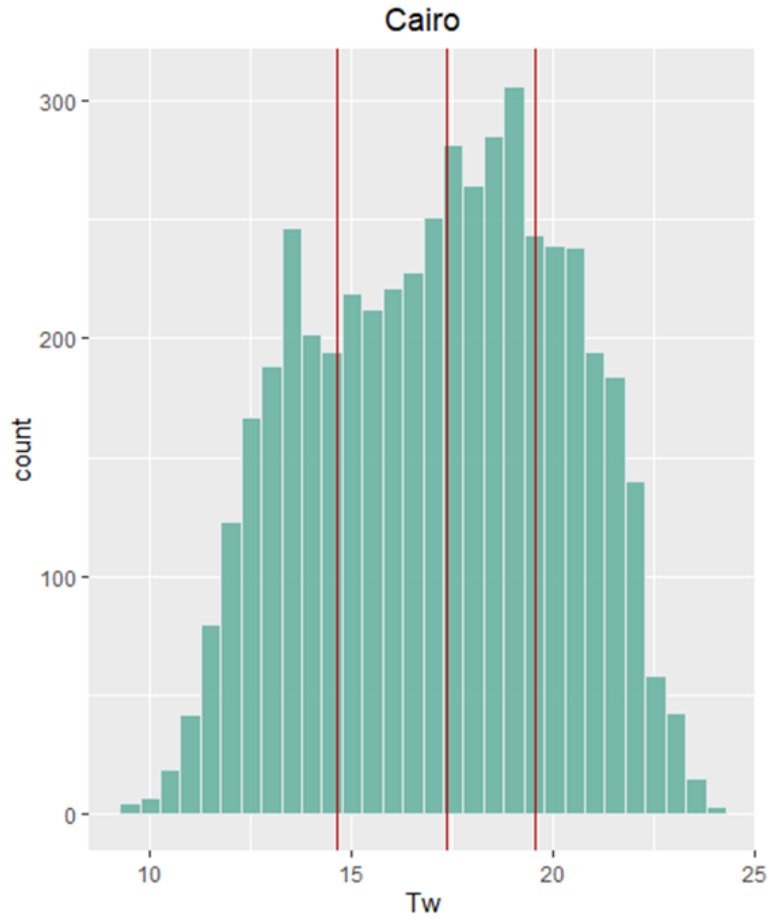
IEC parameter optimization

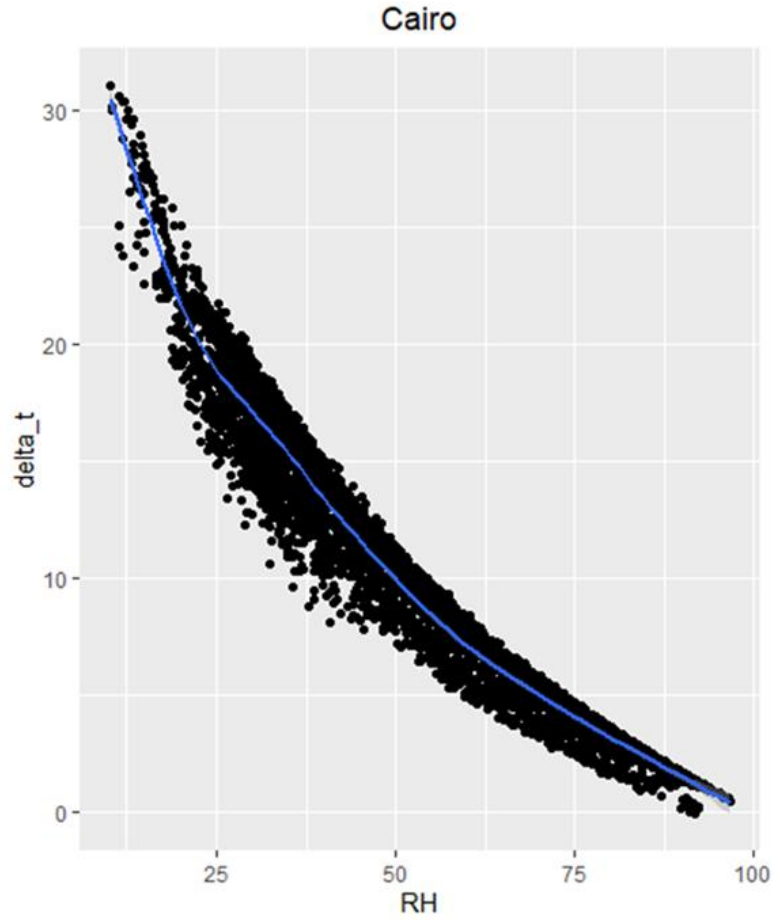
- Cairo, Egypt, outdoor air conditions in 2020 summer



IEC parameter optimization

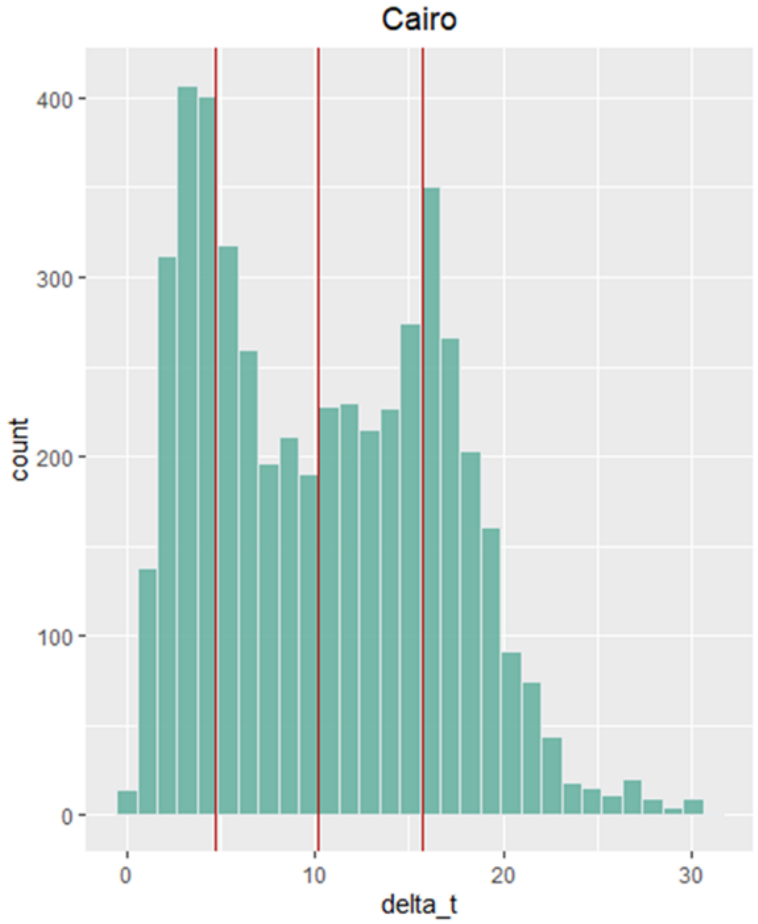
- Cairo, Egypt, outlet water temperature in 2020 summer
- The outlet cold water temperature is higher than 18℃ for about 50% hours
- Cairo is not suitable to use IEC water chillers as the cooling source

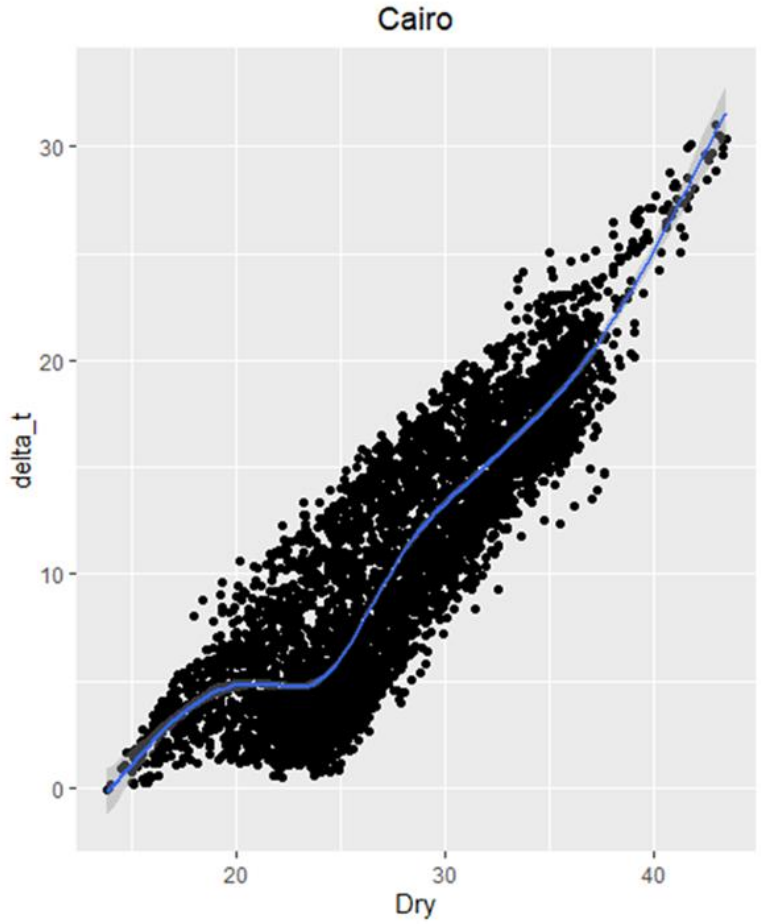




IEC parameter optimization

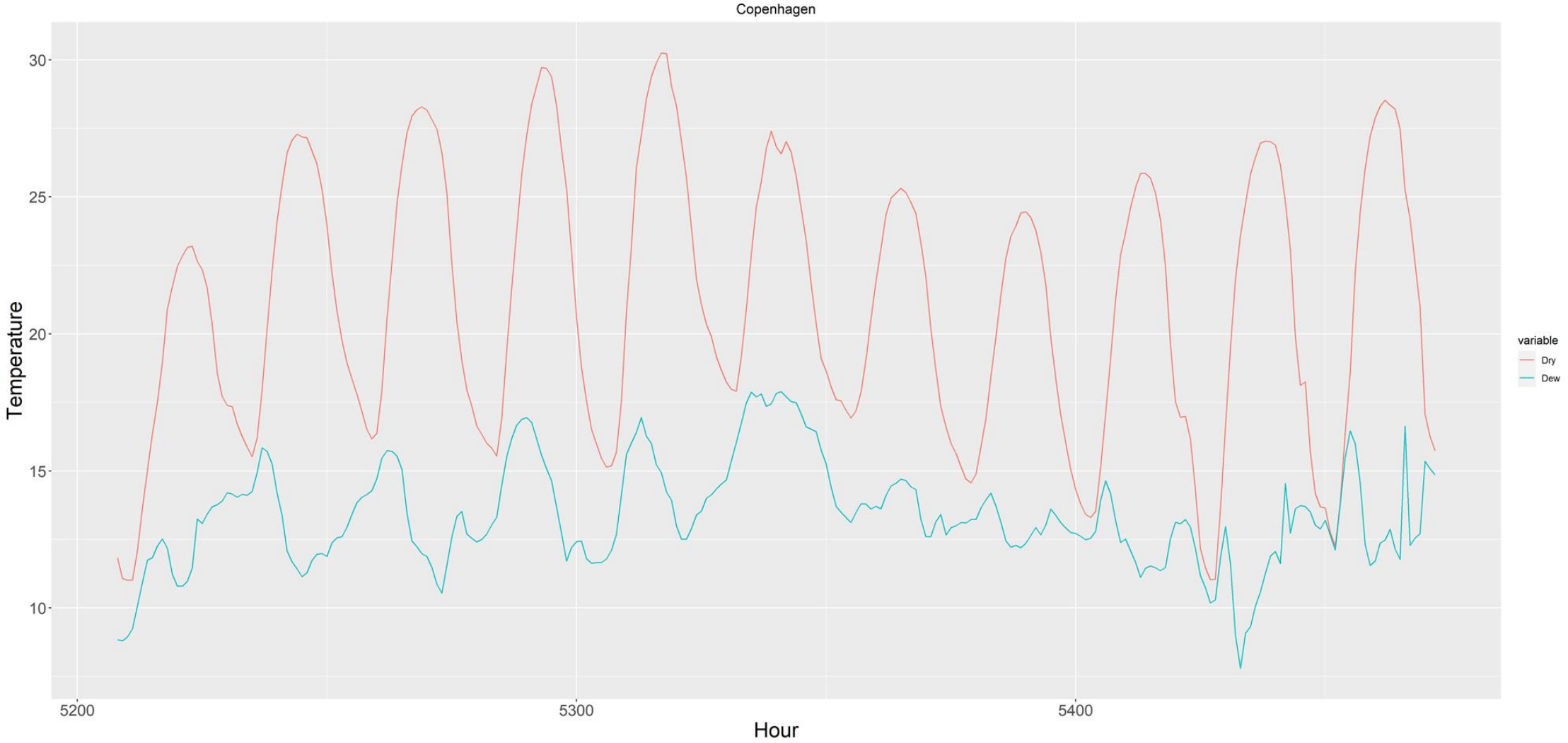
- Cairo, Egypt, 2020 summer
- The higher the outdoor dry bulb temperature , the higher the temperature difference between outdoor dry bulb temperature and output cold water temperature.
- IEC processes could be used for pre-cooling for Cairo climate.





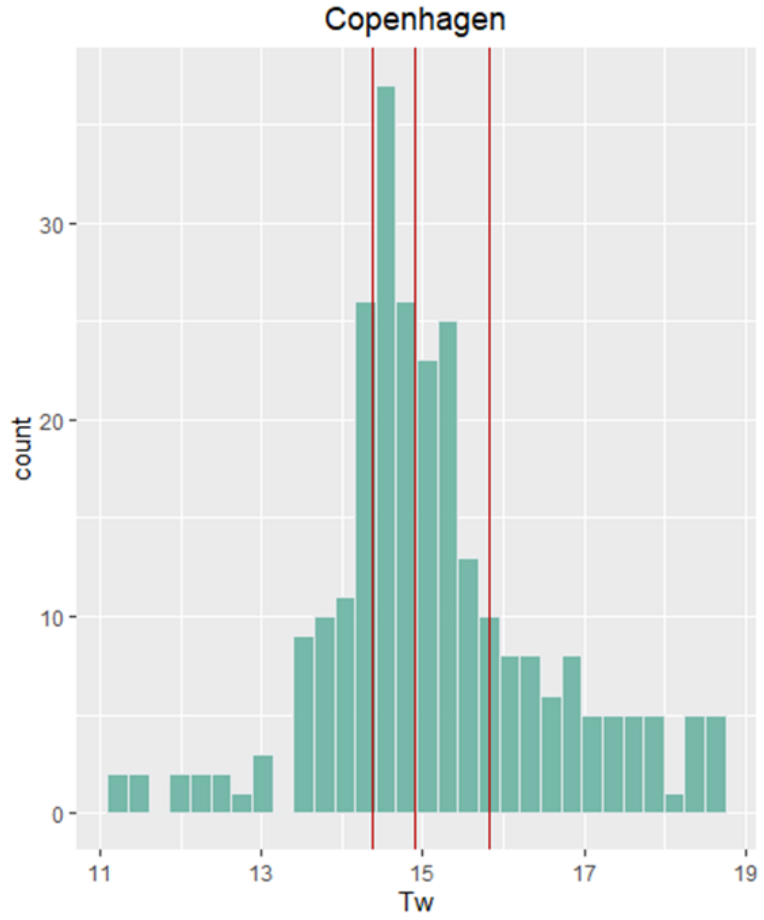
IEC parameter optimization

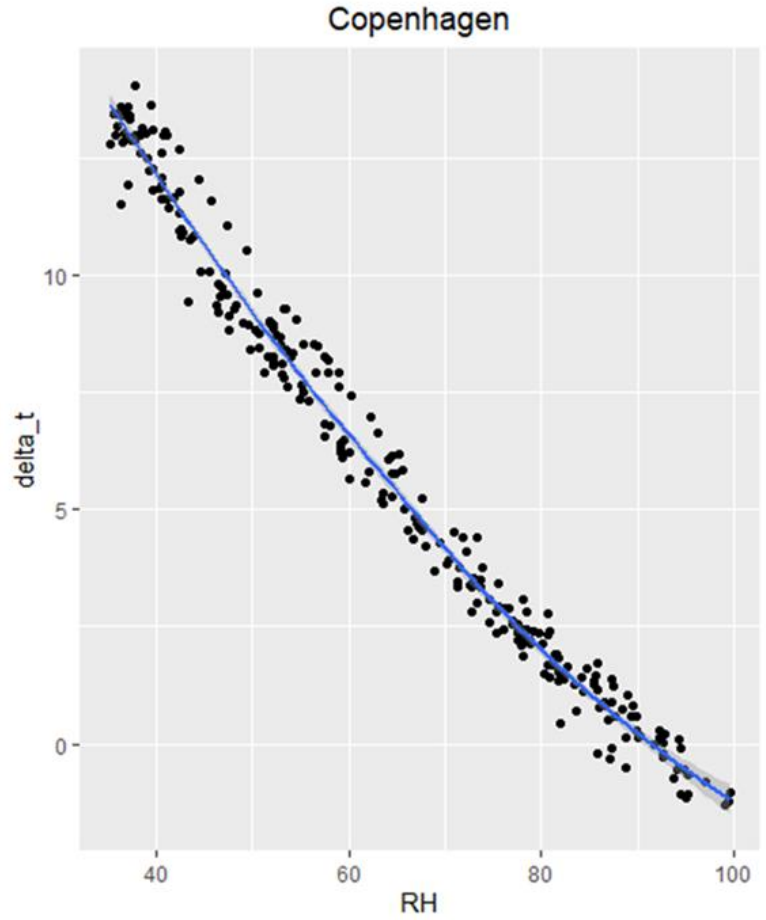
- Copenhagen, Denmark, outdoor air conditions in 2020 summer



IEC parameter optimization

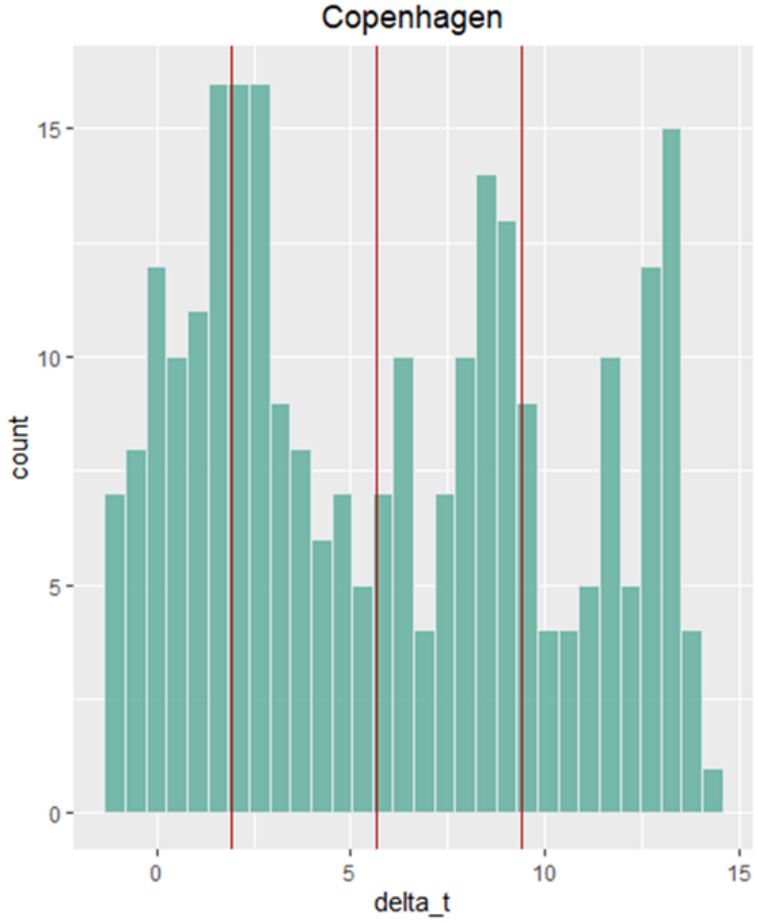
- Copenhagen, Denmark, outlet water temperature in 2020 summer
- The outlet cold water temperature is lower than 16℃ for about 75% hours
- Copenhagen is suitable to use IEC water chillers as the cooling source

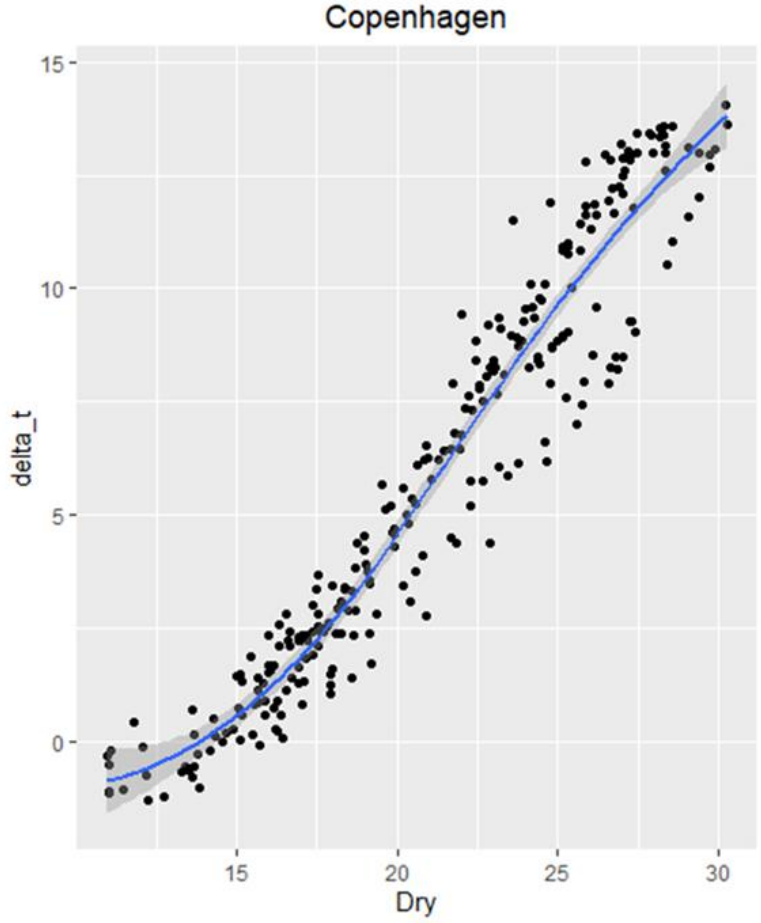




IEC parameter optimization

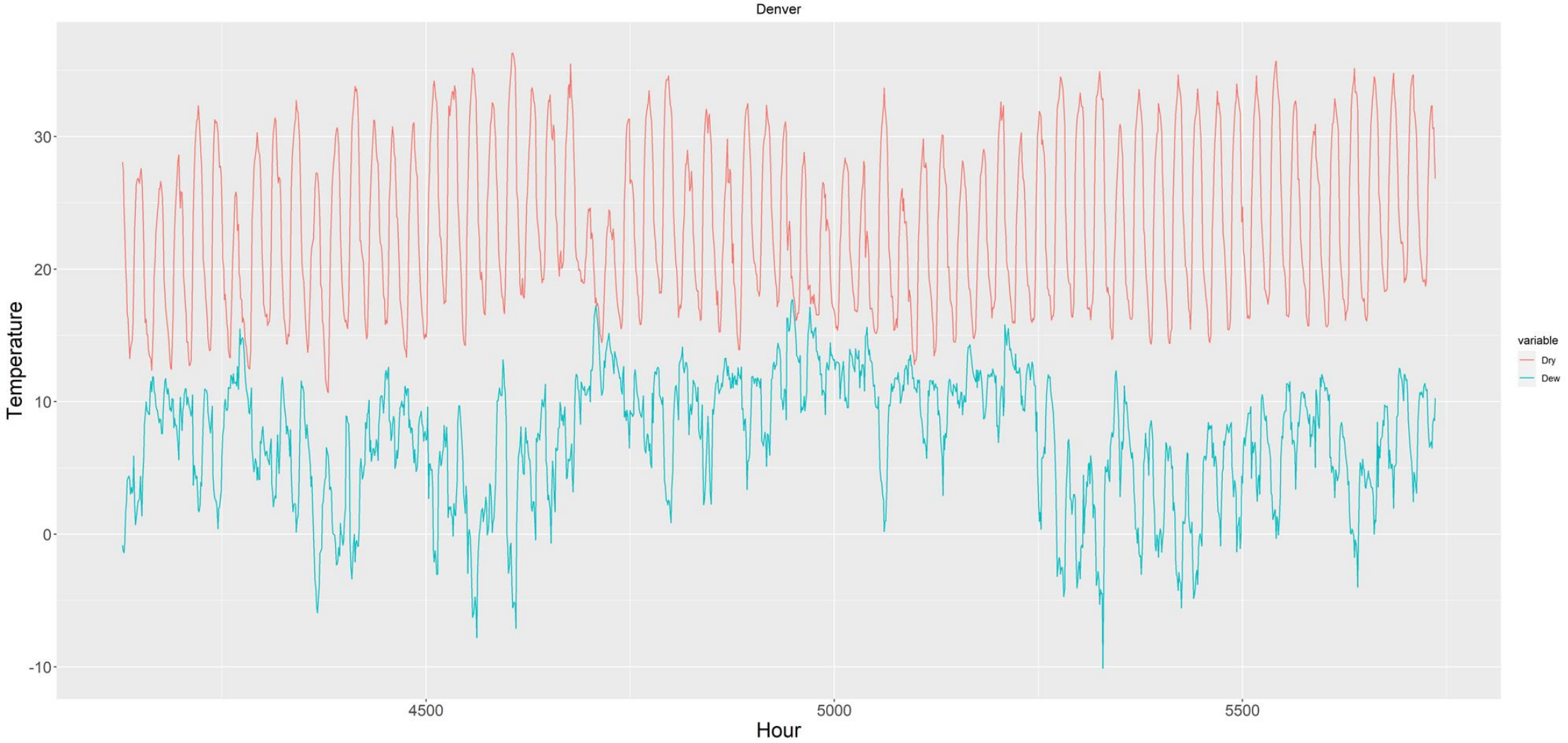
- Copenhagen, Denmark, 2020 summer
- The higher the outdoor dry bulb temperature , the higher the temperature difference between outdoor dry bulb temperature and output cold water temperature.
- IEC processes could be used for well for Copenhagen climate, and the cooling capacity could fit with heat loads.





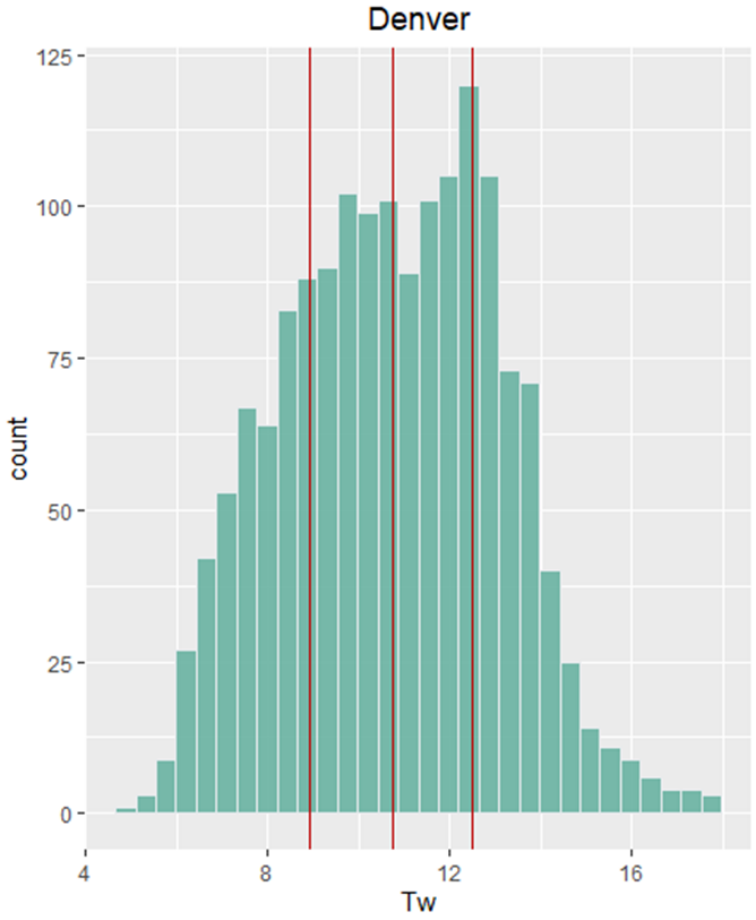
IEC parameter optimization

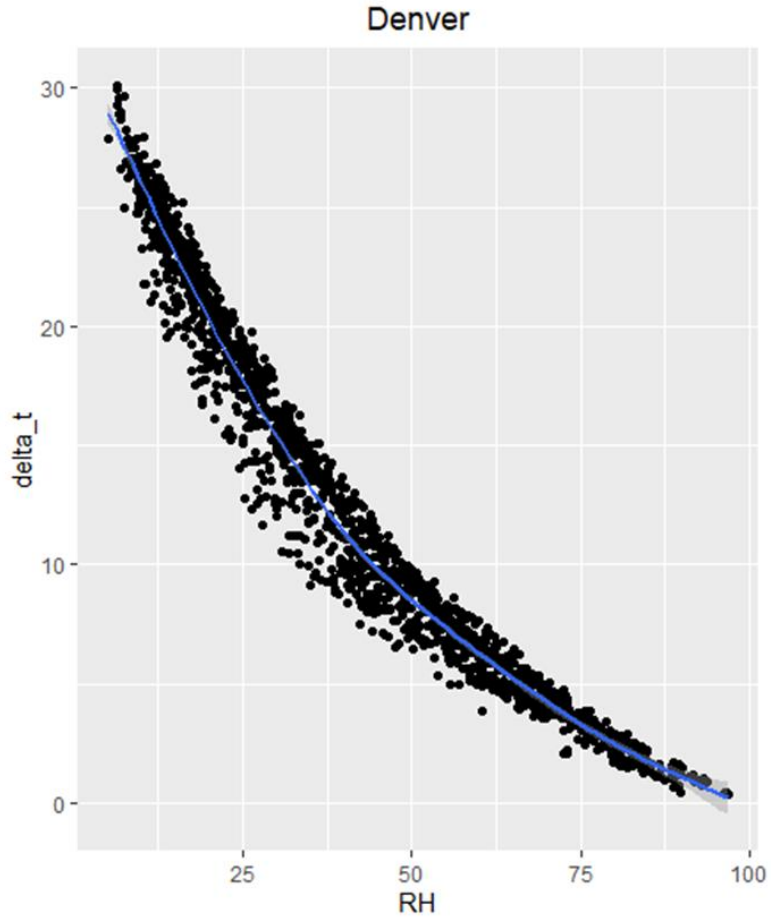
- Denver, America, outdoor air conditions in 2020 summer



IEC parameter optimization

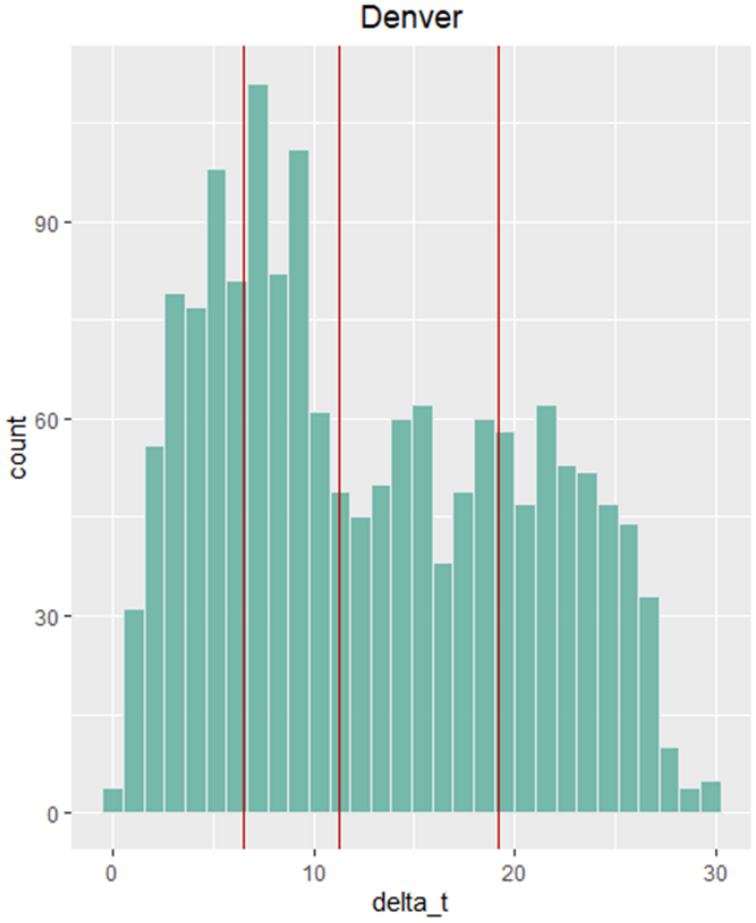
- Denver, America, outlet water temperature in 2020 summer
- The outlet cold water temperature is lower than 20℃ for all the summer
- Denver is suitable to use IEC water chillers as the cooling source

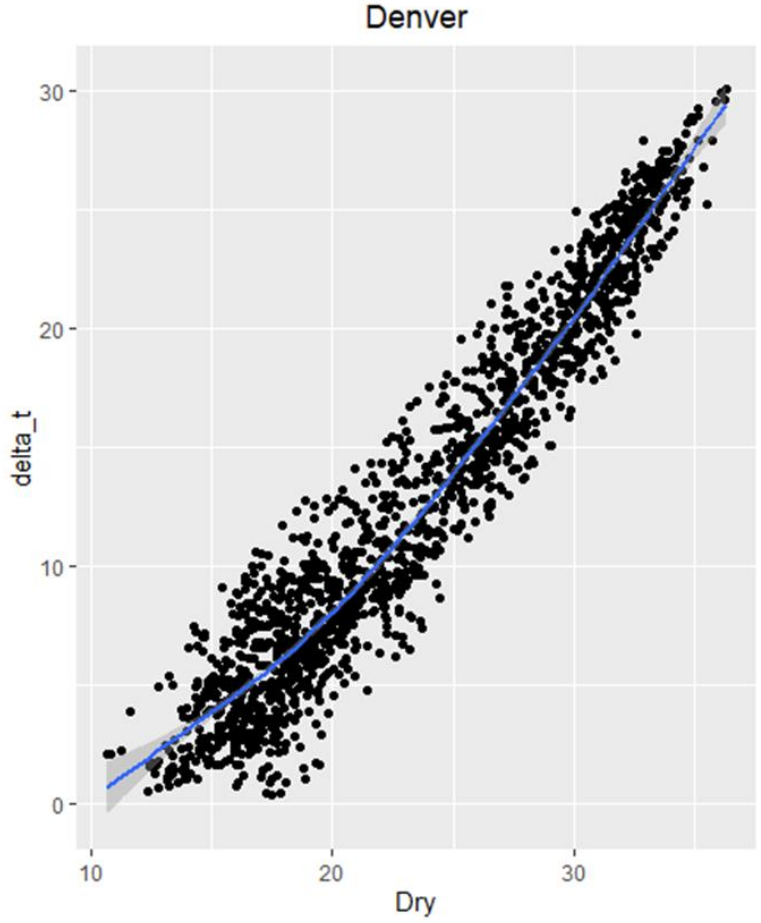




IEC parameter optimization

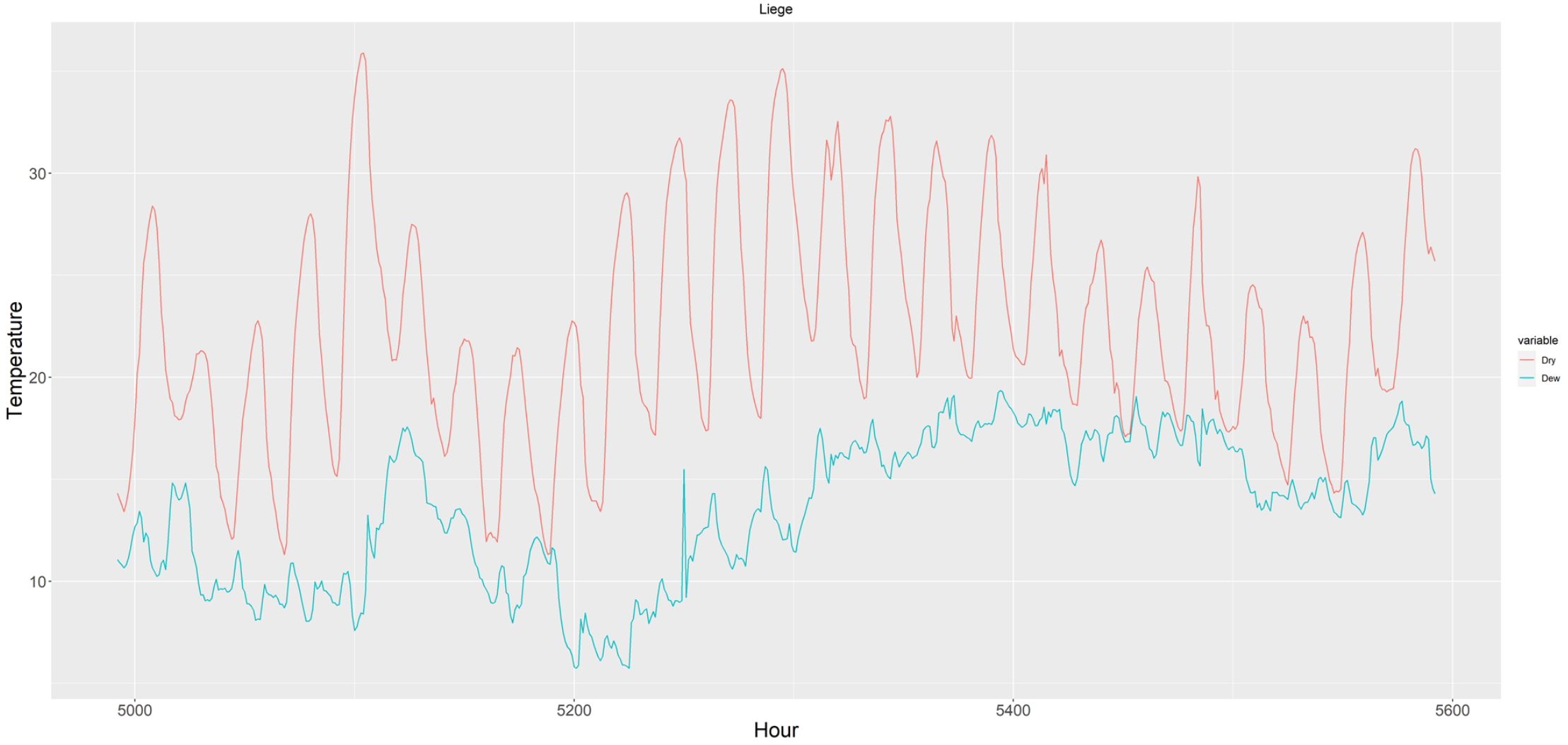
- Denver, America, 2020 summer
- The higher the outdoor dry bulb temperature , the higher the temperature difference between outdoor dry bulb temperature and output cold water temperature.
- IEC processes could be used for well for Denver climate, and the cooling capacity could fit with heat loads.





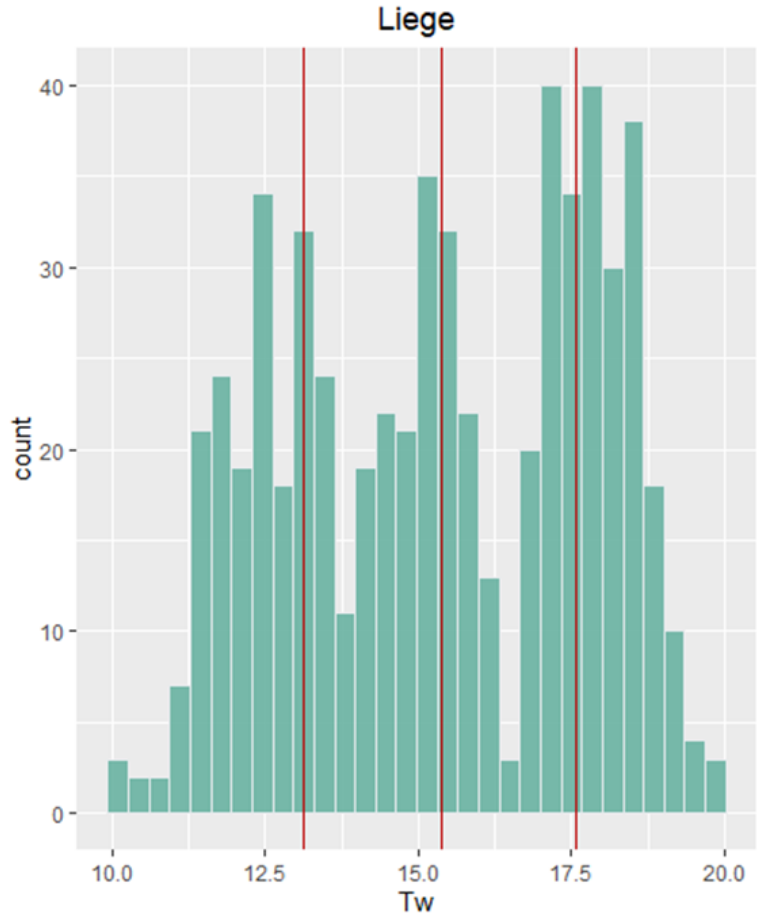
IEC parameter optimization

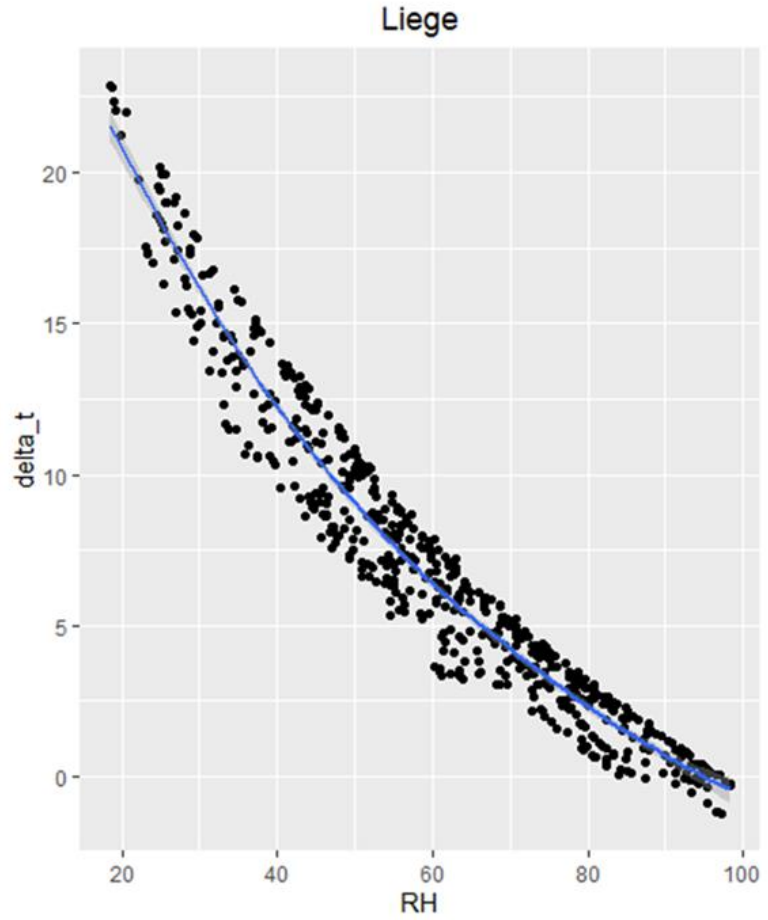
- Liege, Belgium, outdoor air conditions in 2020 summer



IEC parameter optimization

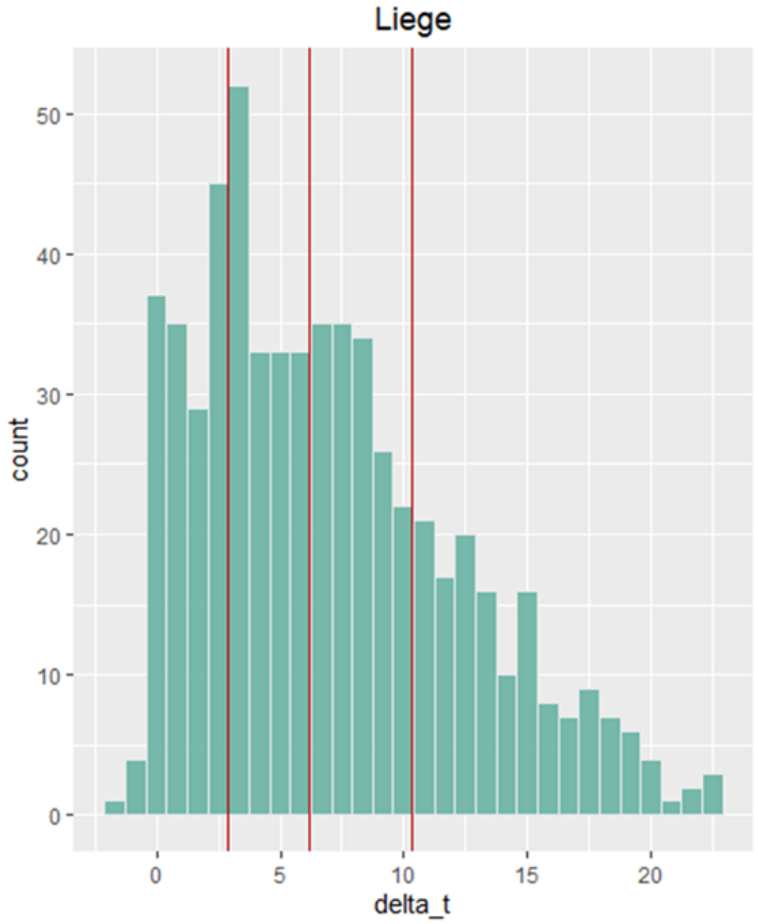
- Liege, Belgium, outlet water temperature in 2020 summer
- The outlet cold water temperature is lower than 17.5℃ for about 75% hours
- Liege is suitable to use IEC water chillers as the cooling source

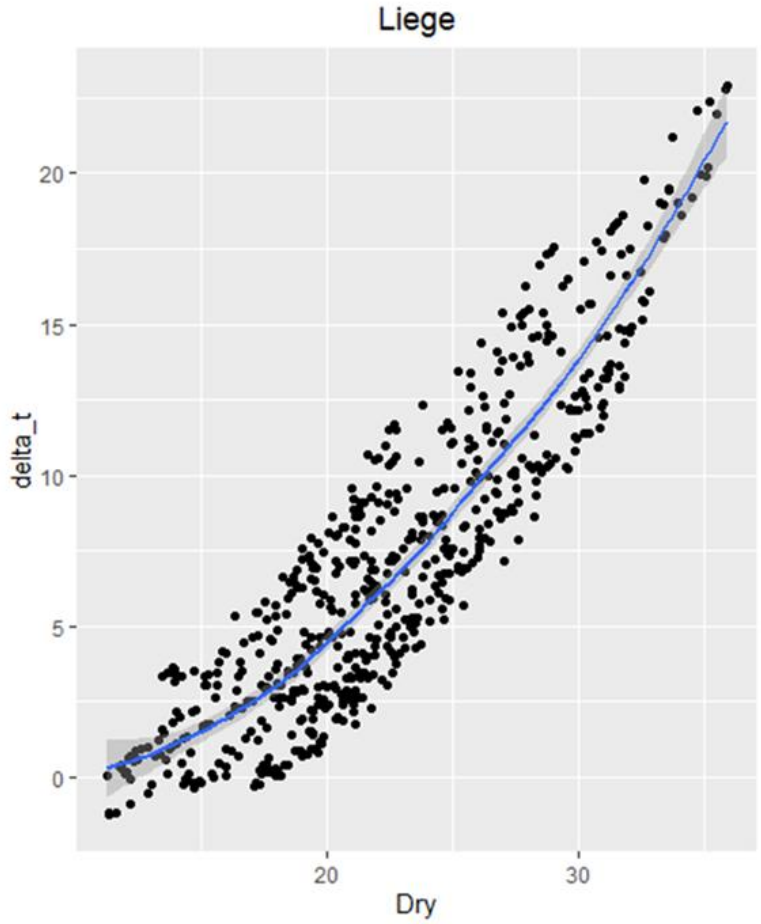




IEC parameter optimization

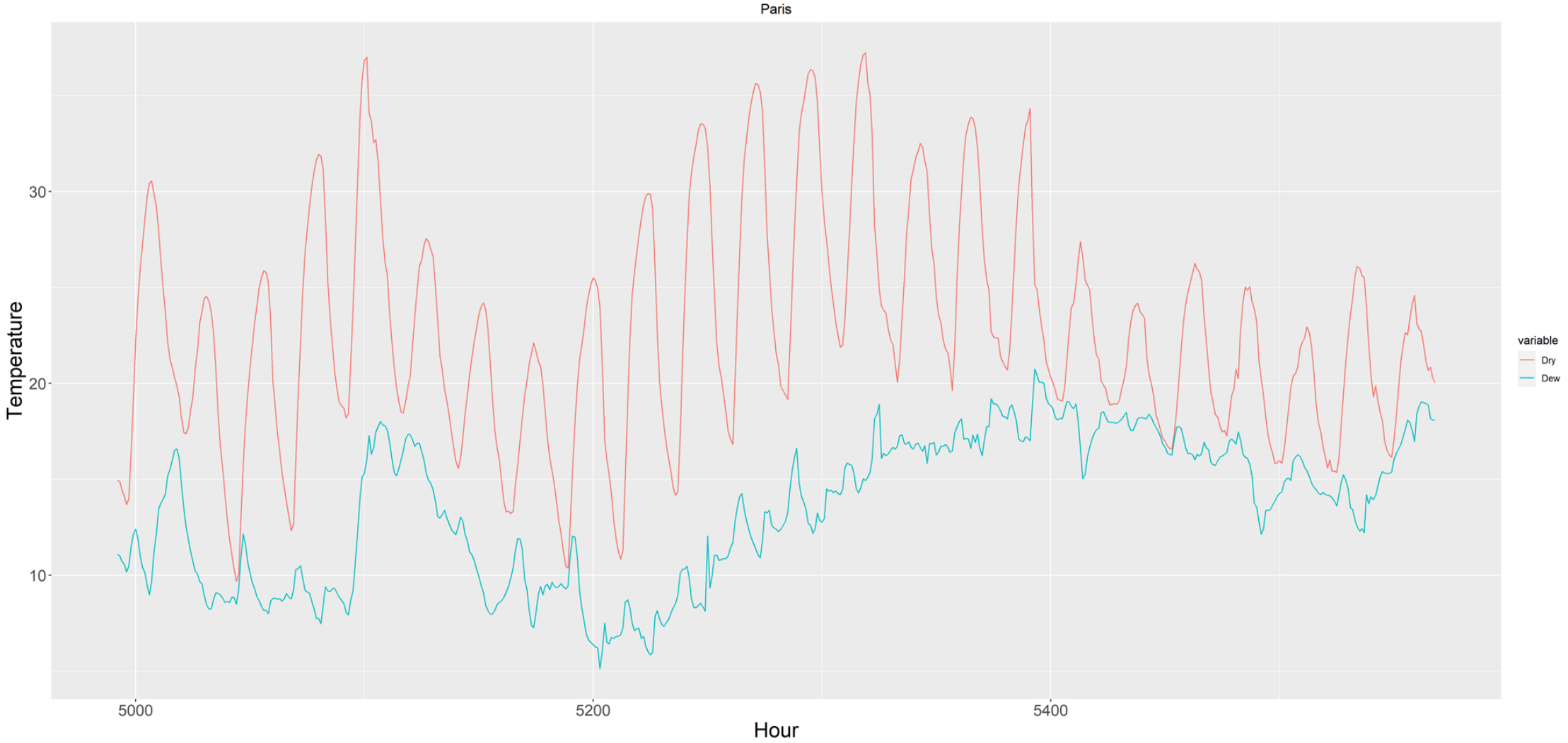
- Liege, Belgium, 2020 summer
- The higher the outdoor dry bulb temperature , the higher the temperature difference between outdoor dry bulb temperature and output cold water temperature.
- IEC processes could be used for well for Liege climate, and the cooling capacity could fit with heat loads.





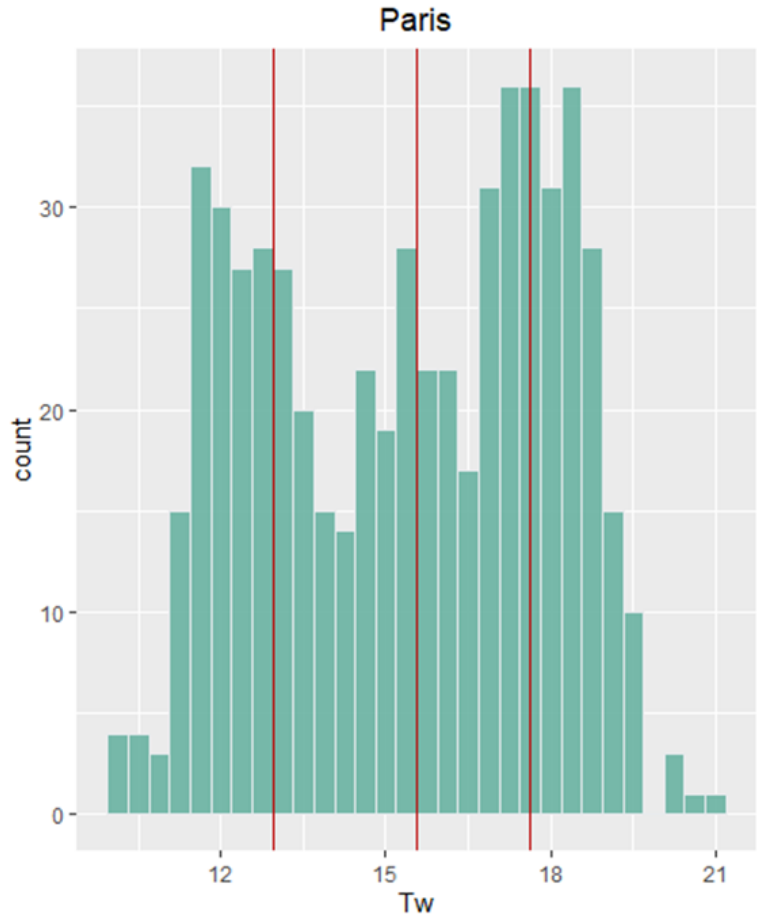
IEC parameter optimization

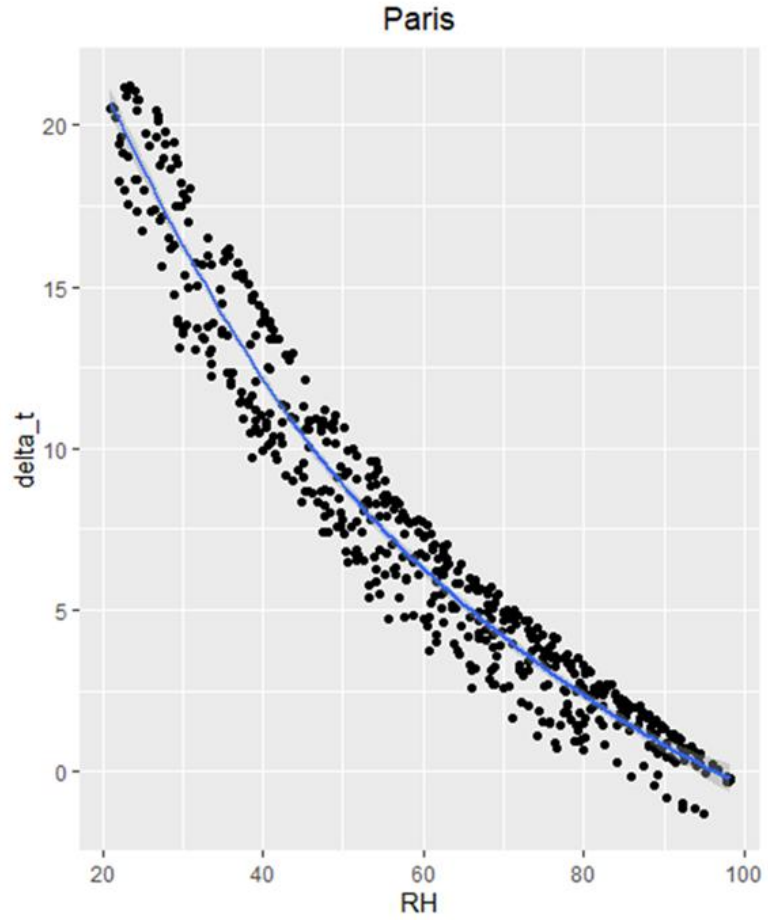
- Paris, France, outdoor air conditions in 2020 summer



IEC parameter optimization

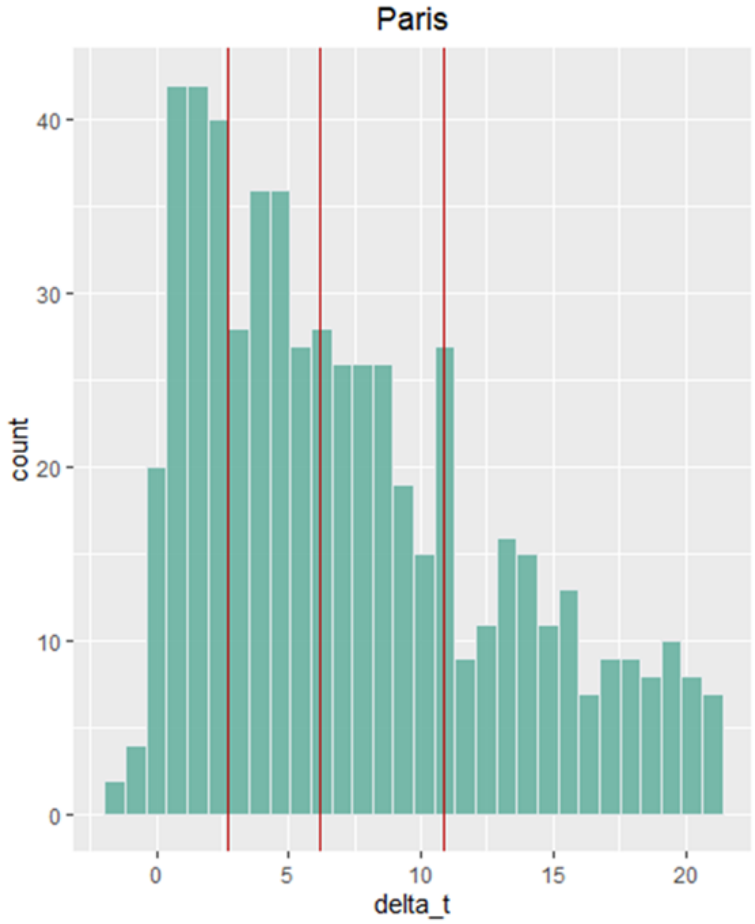
- Paris, France, outlet water temperature in 2020 summer
- The outlet cold water temperature is lower than 18℃ for about 75% hours
- Paris is suitable to use IEC water chillers as the cooling source

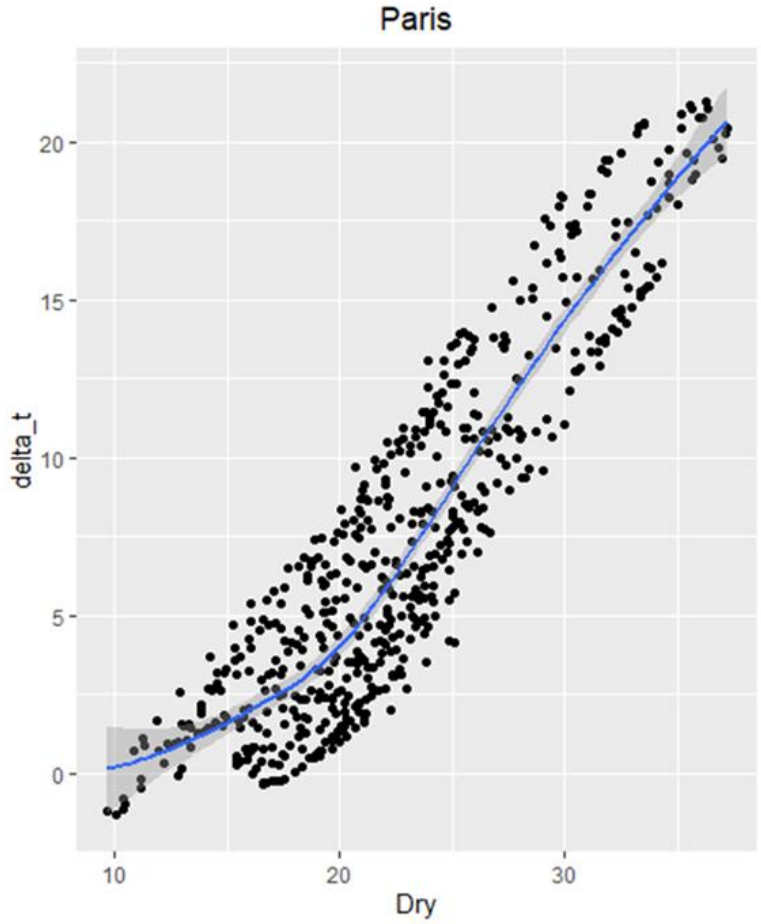




IEC parameter optimization

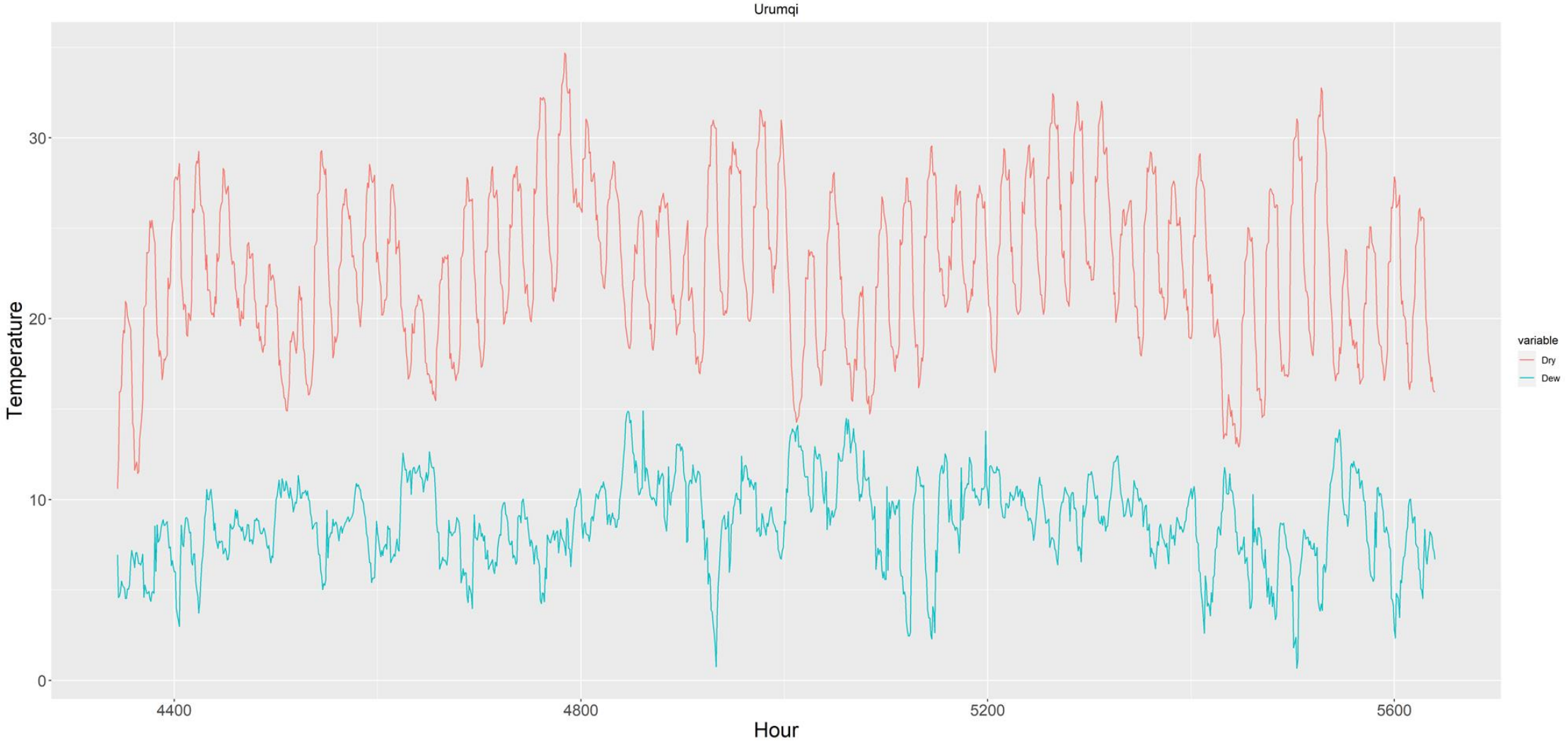
- Paris, France, 2020 summer
- The higher the outdoor dry bulb temperature , the higher the temperature difference between outdoor dry bulb temperature and output cold water temperature.
- IEC processes could be used for well for Paris climate, and the cooling capacity could fit with heat loads.





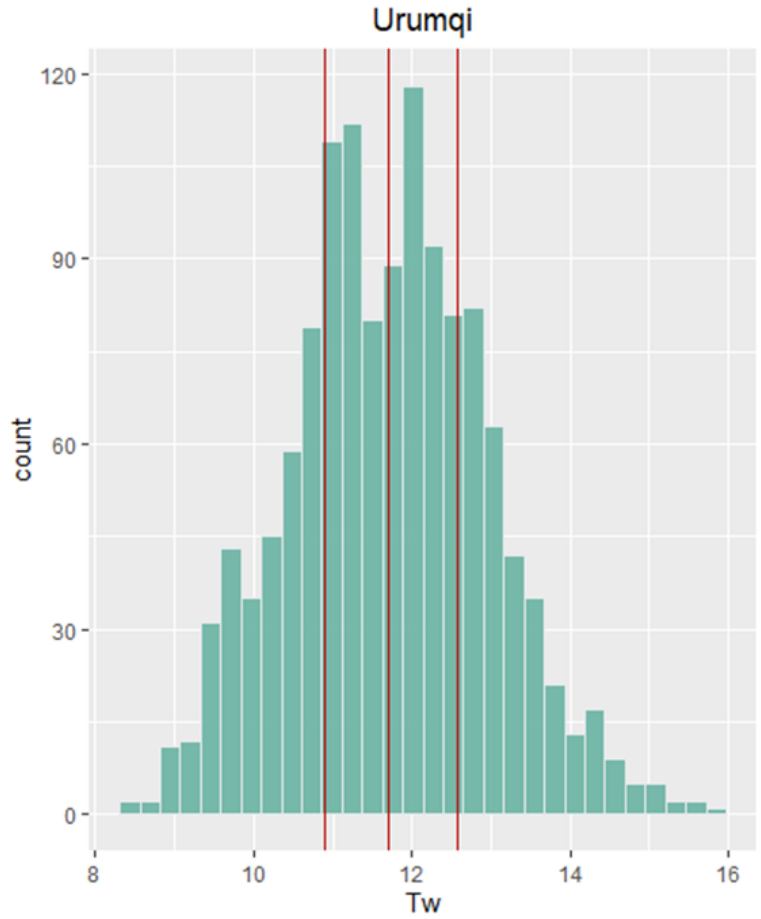
IEC parameter optimization

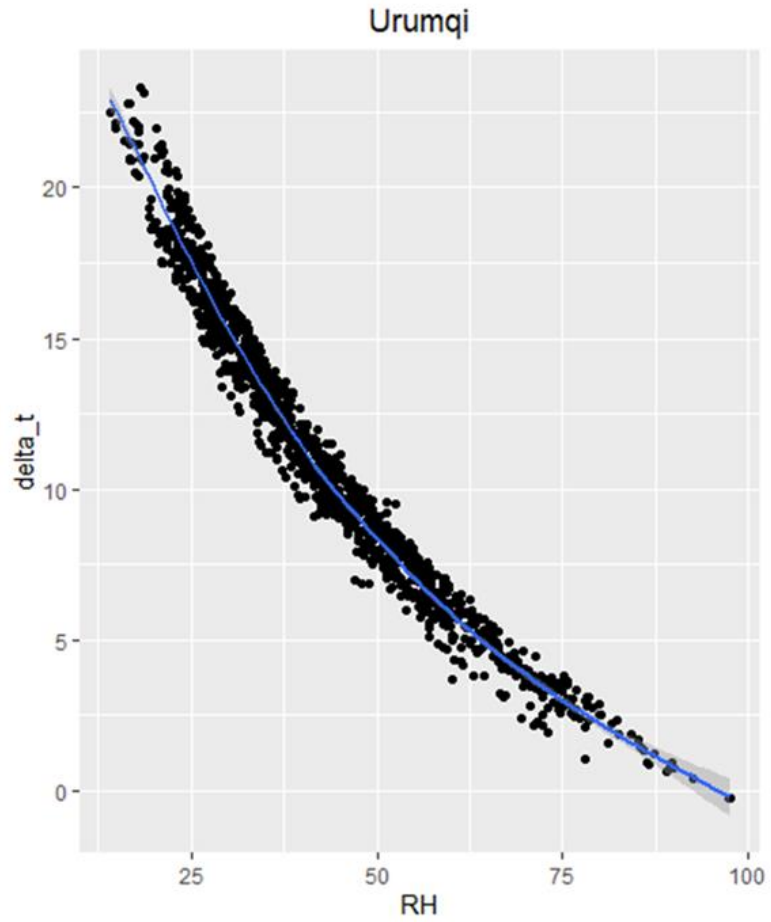
- Urumqi, China, outdoor air conditions in 2020 summer



IEC parameter optimization

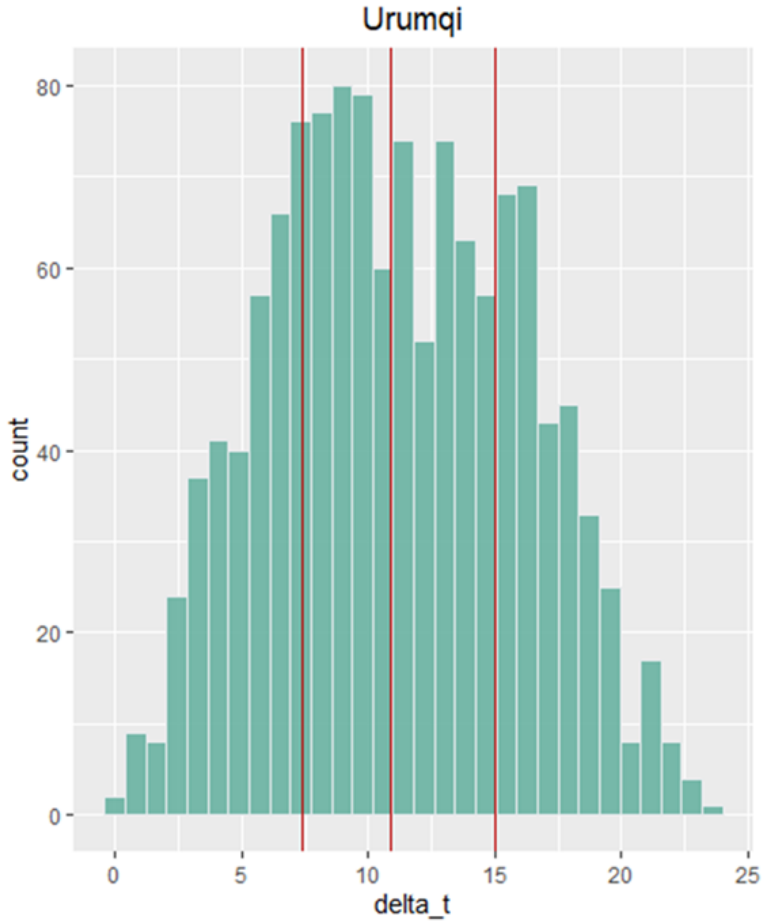
- Urumqi, China, outlet water temperature in 2020 summer
- The outlet cold water temperature is lower than 16℃ for all the summer
- Urumqi is suitable to use IEC water chillers as the cooling source

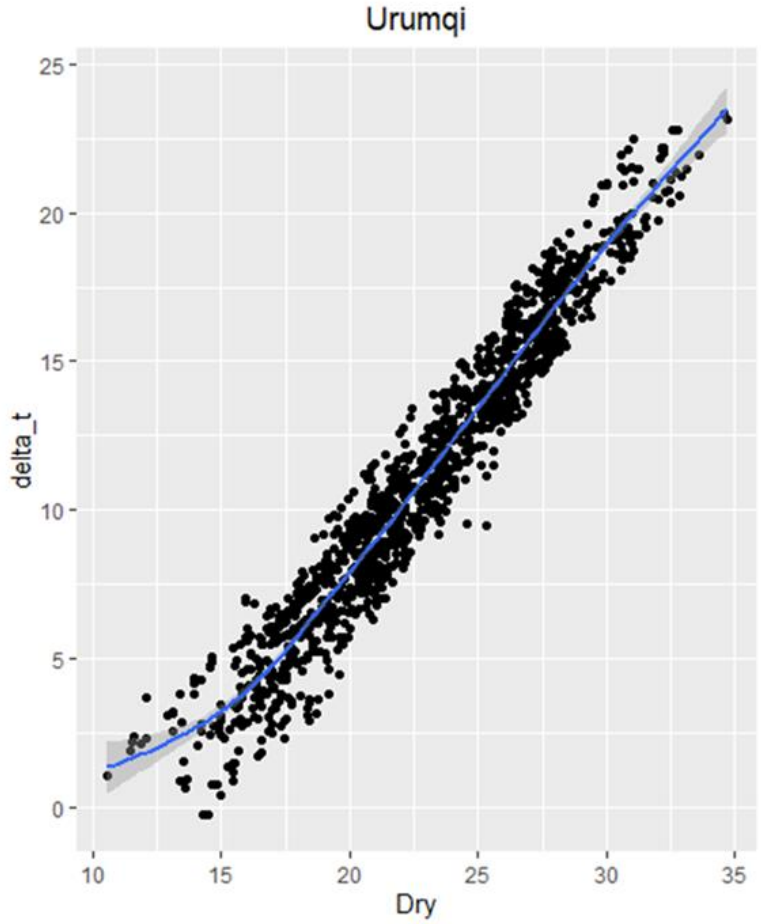




IEC parameter optimization

- Urumqi, China, 2020 summer
- The higher the outdoor dry bulb temperature , the higher the temperature difference between outdoor dry bulb temperature and output cold water temperature.
- IEC processes could be used for well for Urumqi climate, and the cooling capacity could fit with heat loads.





Future research

IEC parameter optimization

- Finished:

Country	City
America	Seattle
	Denver
Egypt	Cairo
Australia	Canberra
	Adelaide
Belgium	Brussels
	Liege
Denmark	Odense
	Copenhagen
France	Brest
	Paris
Turkey	Ankara
	Istanbul
China	Urumqi
	Beijing

- Not finished:

Country	City	Country	City	Country	City
America	San Francisco	Algeria	Tebessa	Spain	Madrid
	Los Angeles	South Africa	Johannesburg	Turkey	Erzurum
	Miles city	Niger	Niamey	China	Xining
	Sheridan	Australia	Perth		Lanzhou
	New York City		Darwin		Kunming
	Washington D.C.	Austria	Vienna		Shanghai
	Miami	Denmark	Aalborg		Guangzhou
	Rapid City	British	London		Qingdao
	Pierre	Ukraine	Kiev	India	Poona
	Altus	Finland	Tampere		Nagpur
	Midland		Helsinki		Kolkata
	North Platte	Norway	Oslo	Iran	Tehran
	Garden City	German	Berlin	Saudi Arabia	Riyadh
	Sanderson	Russia	Moscow	Yemen	Mukalla
	Amarillo		Kyakhta	Oman	Salalah
	Lubbock	Spain	Granada		
	Tucumcari		Santander		

Thank you very much for your attention!

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