



Development of High Efficiency Solar Cooling with Medium Temperature Solar Collector

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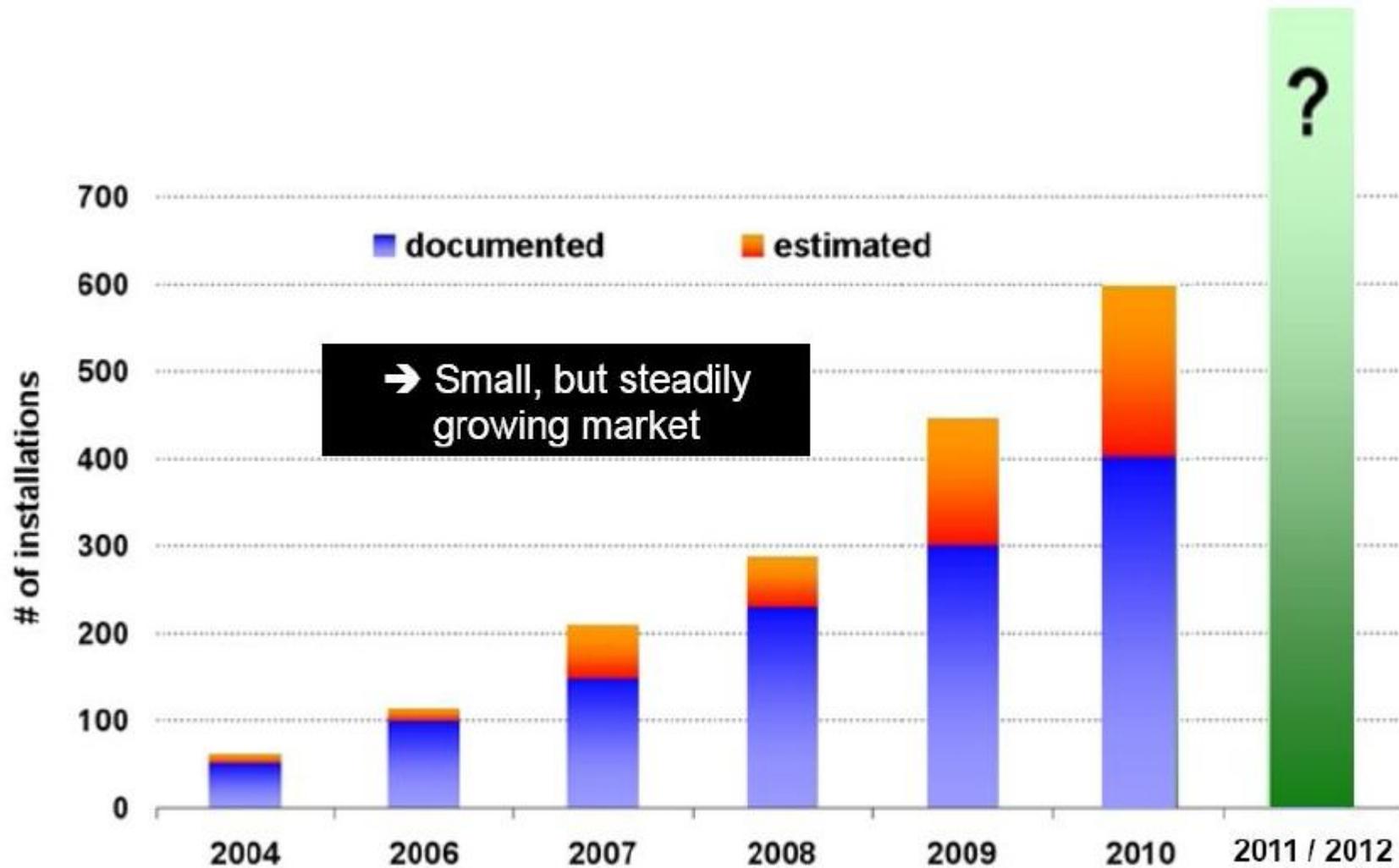
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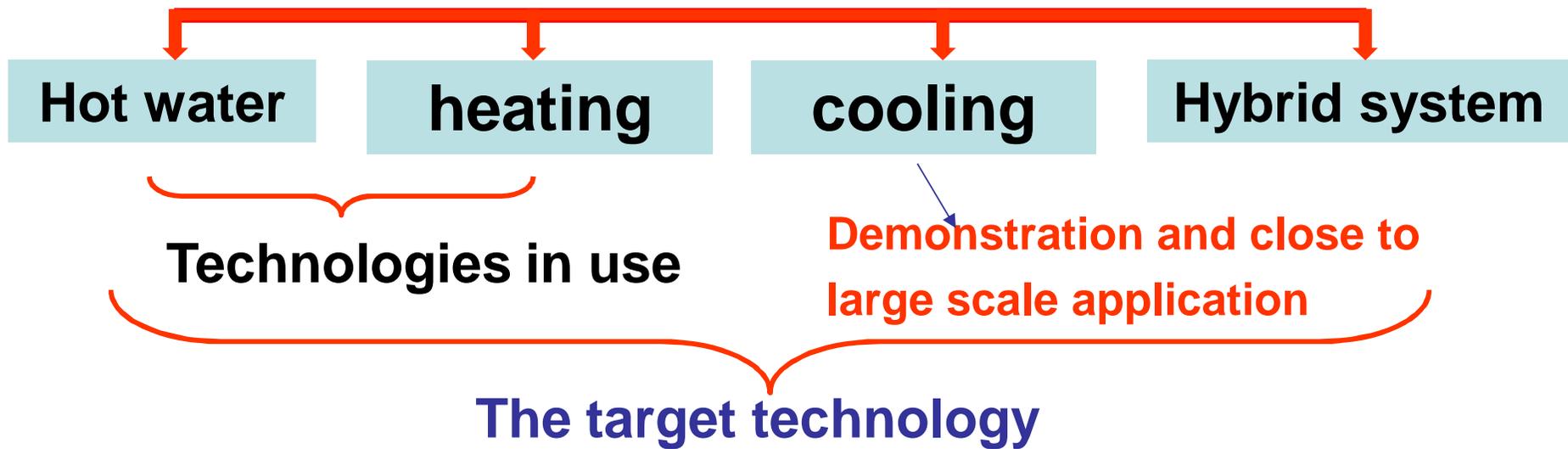
Future activities



Estimation of number of solar cooling installations worldwide

Solar thermal application in China

Solar thermal utilization in buildings





STEP 1: Fundamental research

SETP 2: Chiller products study

SETP 3: System integration optimization

Water saving sorption cooling system

Desiccant cooling system

Solar PV cooling system

Water saving sorption chiller

Air cooled sorption chiller

Desiccant dehumidification unit

Adsorbent and desiccant performance study
(such as silica gel-H₂O, activated carbon-NH₃, etc.)

Absorbent performance study (such as LiBr-H₂O, NH₃-H₂O, etc.)

Solar collector I and component study (such as new concept collector, etc.)

High efficiency heat transfers study

Solar Cooling Research in SJTU



Major technologies in SJTU



Adsorption chiller



Adsorption ice making unit



Single effect LiBr-H₂O



Rotary desiccant cooling



Two stage desiccant cooling



Single/Double effect LiBr-H₂O

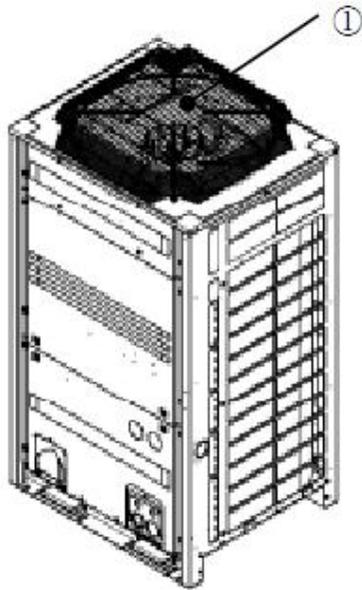


Recent development

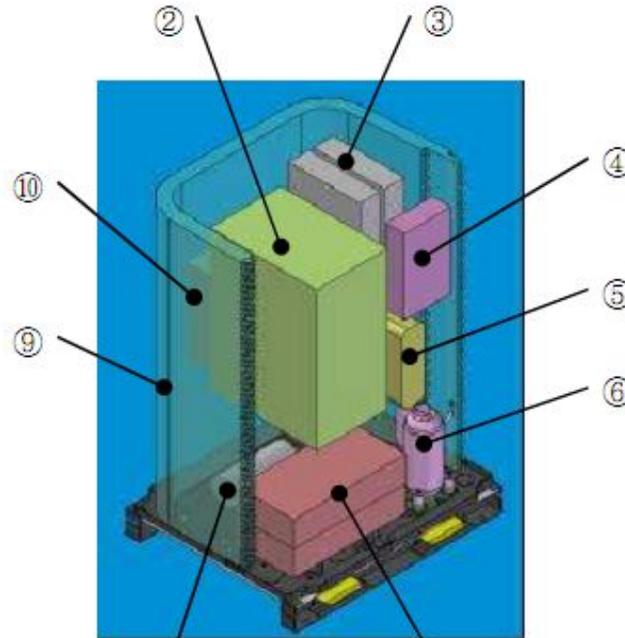
- ④ Solar assisted CO2 heat pump with air cooled absorption cooling;
- ④ Solar driven single/double effect absorption cooling system with Fresnel collector
- ④ Solar driven double effect absorption cooling with parabolic collector
- ④ Desiccant chiller driven by solar air collector
- ④ Use of desiccant coating technology in solar air conditioning.
- ④ Solar combined cooling and heating



I. Solar assisted CO2 heat pump



外觀



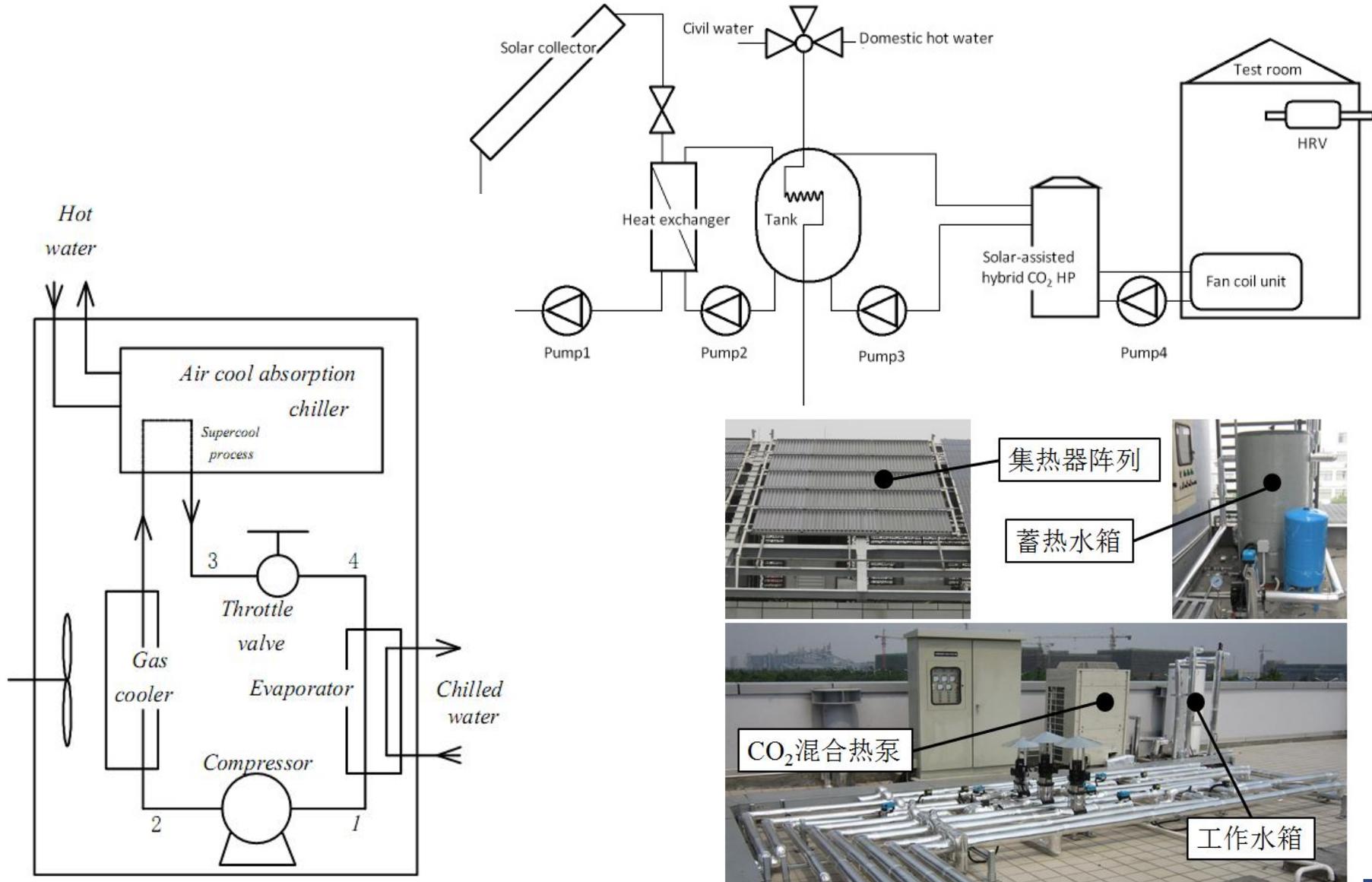
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- | | | | |
|-----------|---------|---------|-------|
| ① 风机 | ④ 电器箱 | ⑦ 水换热器 | ⑩ 冷媒罐 |
| ② 吸收器、蒸发器 | ⑤ 溶液换热器 | ⑧ 溶液泵 | |
| ③ 发生器 | ⑥ 压缩机 | ⑨ 空气换热器 | |



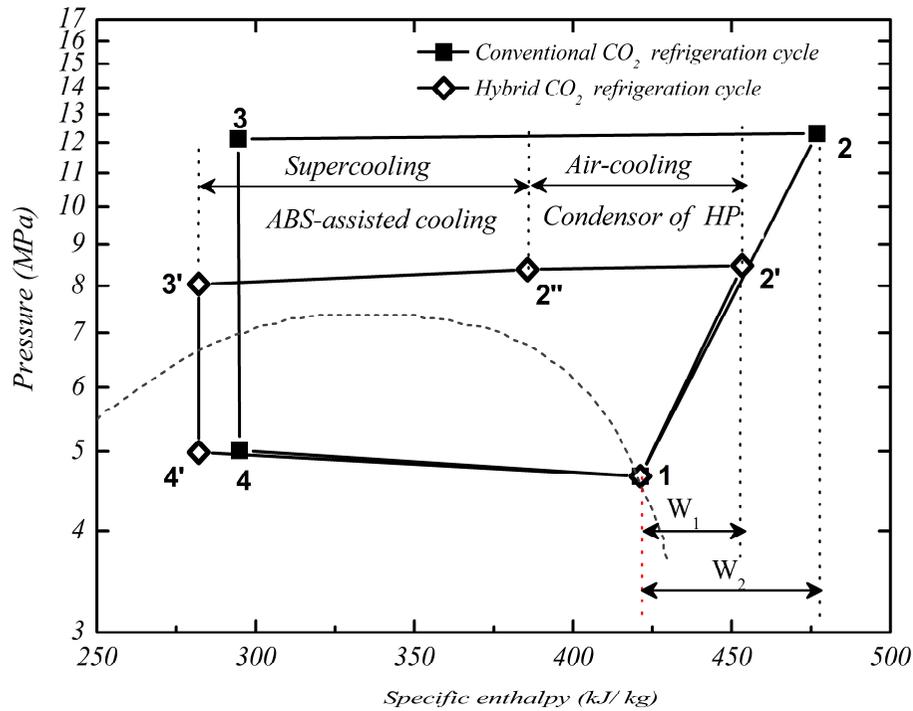


System configuration

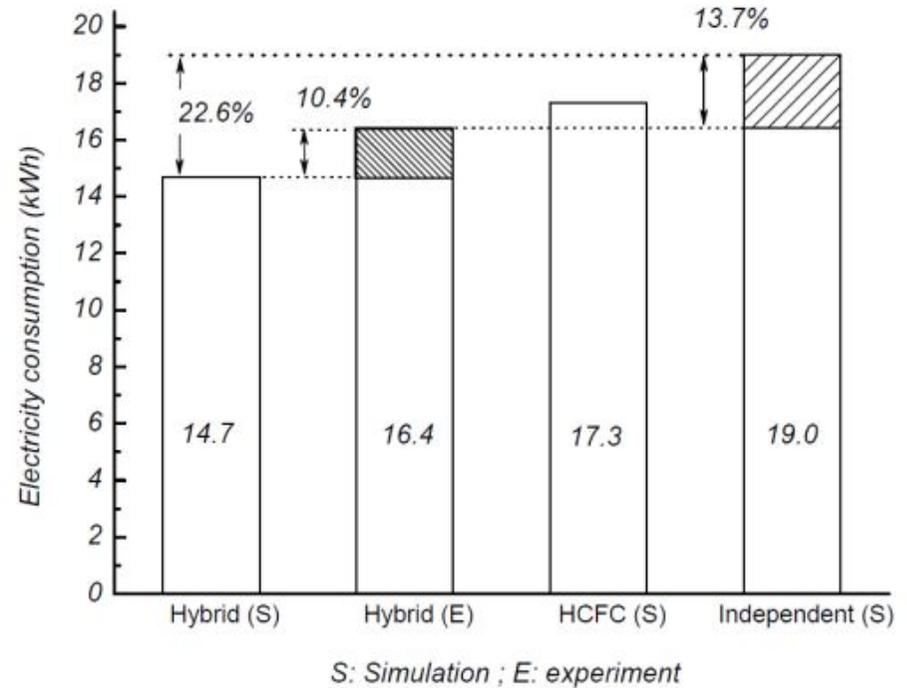




System performance

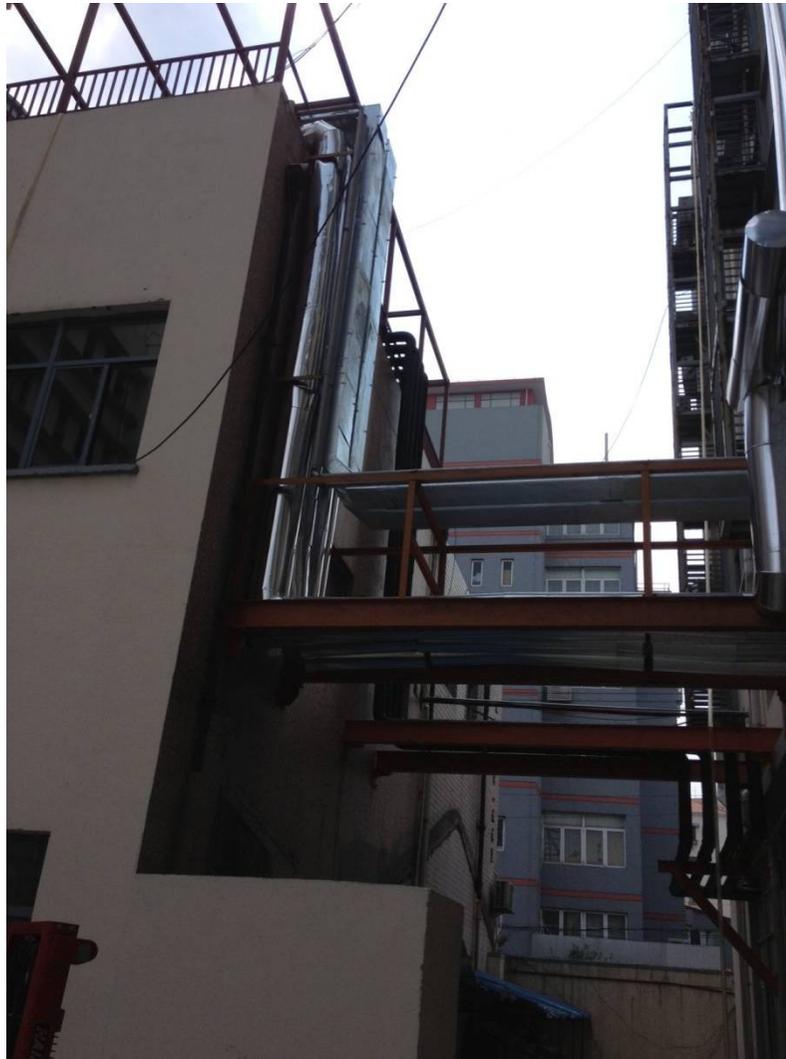


Comparison of two refrigeration cycles of proposed CO₂ heat pump on p-h diagram

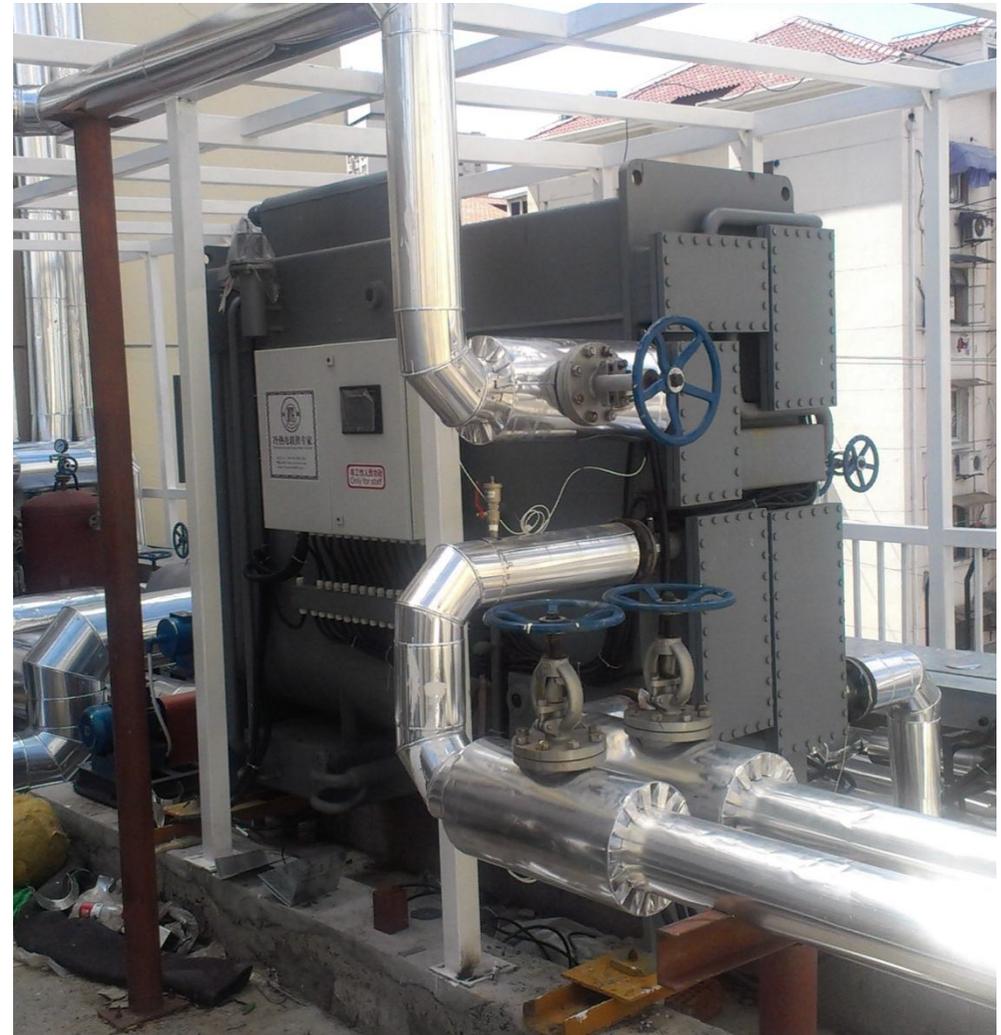


Comparison between experiential and simulation results in hybrid mode

II. Solar driven single/double effect absorption cooling system with Fresnel collector



pipng



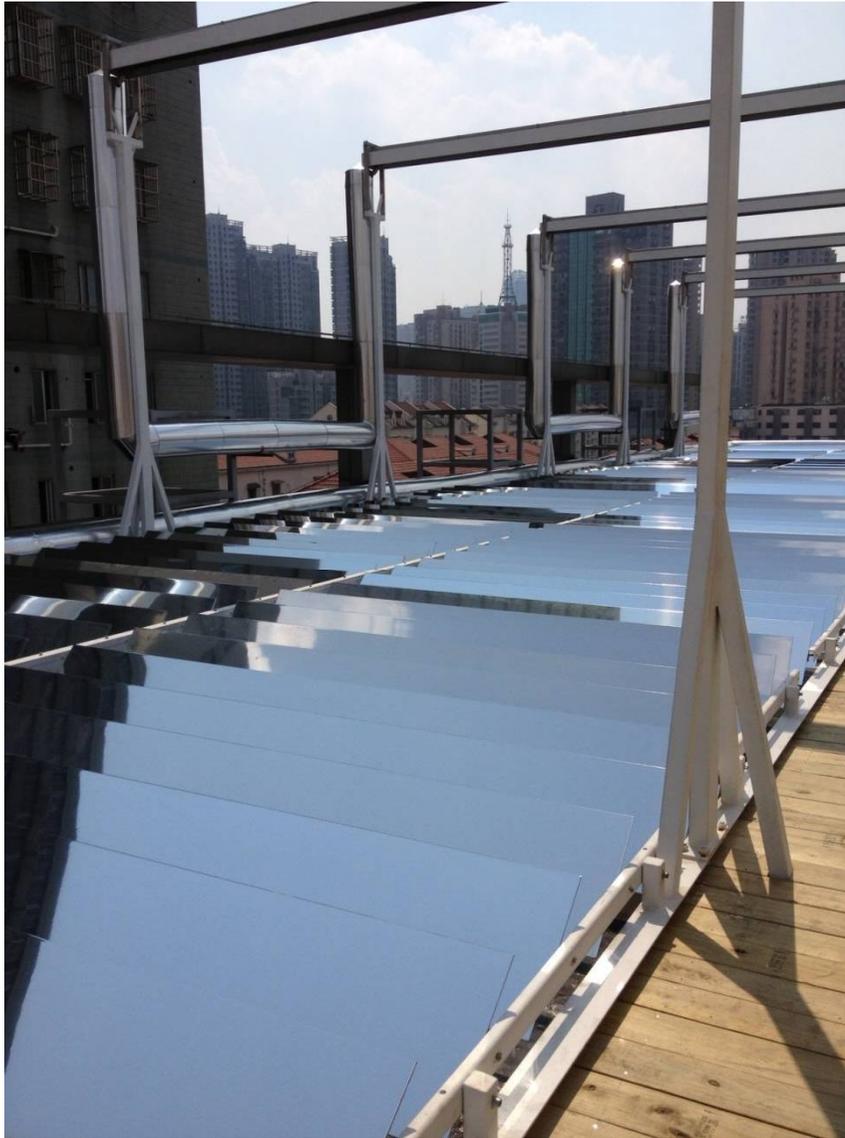
Single / double effect absorption cooling



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Fresnel solar collector

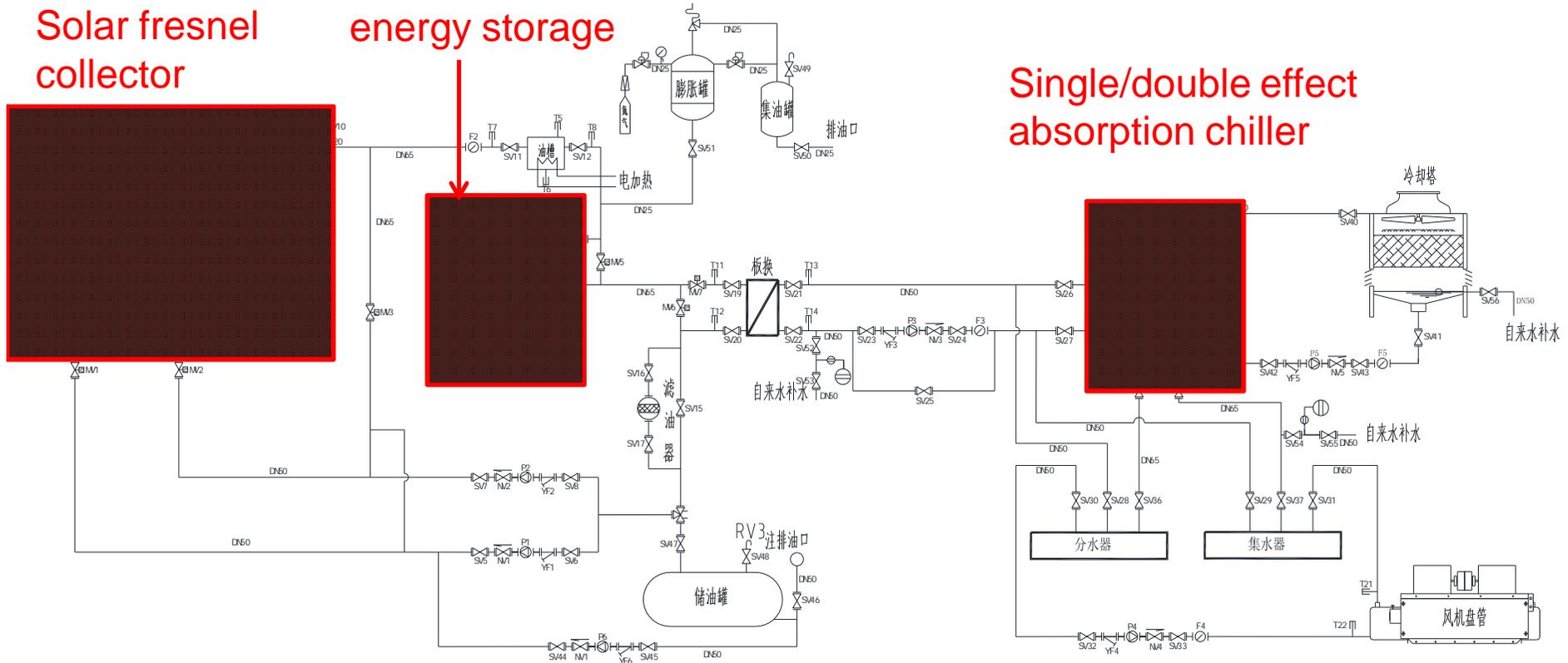


Solar cooling in Shanghai Electric Co.

Solar fresnel collector

Molten salt energy storage

Single/double effect absorption chiller



- ◆ 550 m² Fresnel solar collector; (150 ~ 200°C
- ◆ Salt thermal energy storage (PCM, 146°C)
- ◆ Double/Single effect absorption chiller(100kW)





Single/double LiBr-H₂O chiller

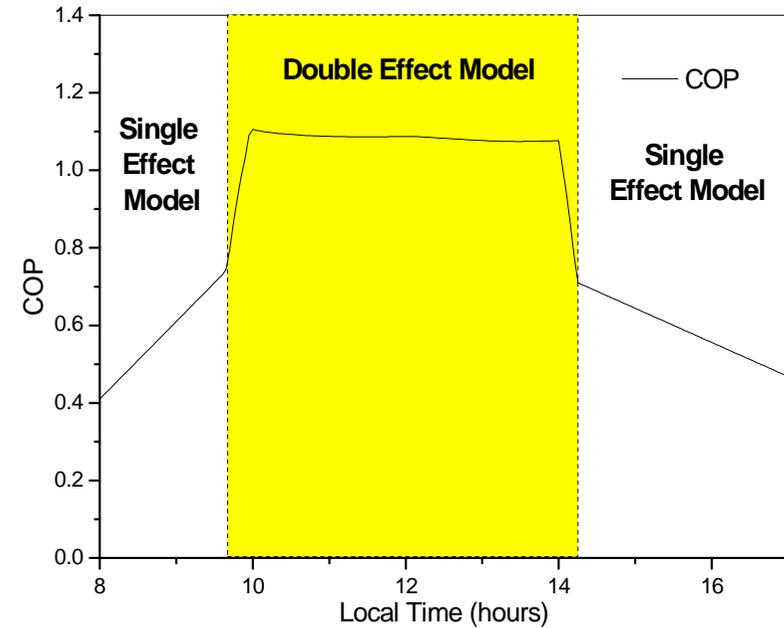
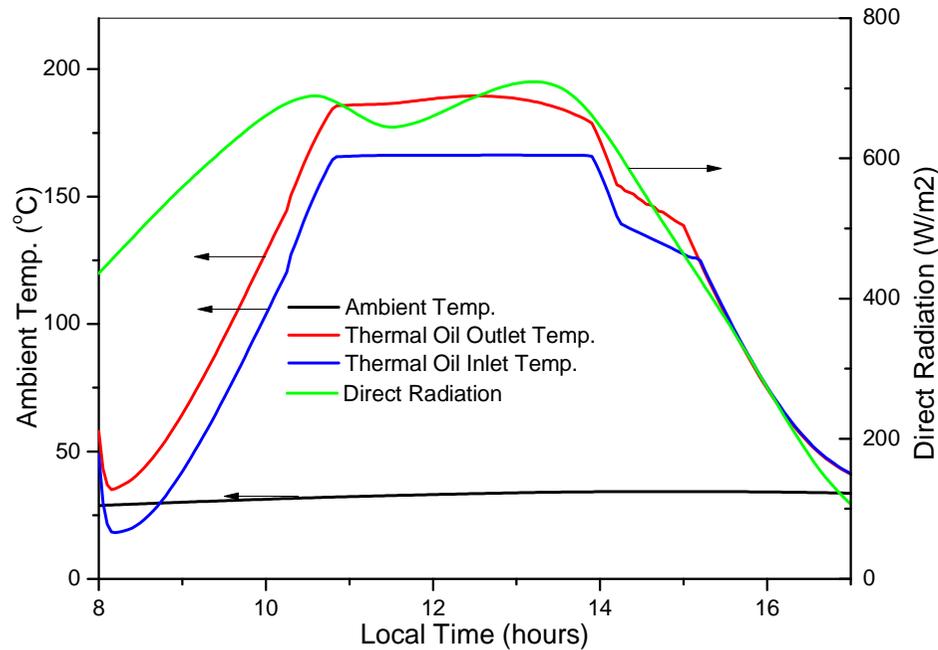


Single/double LiBr-H₂O chiller

		double effect	Single effect
Cooling capacity		134 kW	91 kW
Hot water	Flow rate	11.0 m ³ /h	
	Inlet/Outlet Temp.	150 /140 °C	105/95 °C
Cold water	Flow rate	23.0 m ³ /h	
	Inlet/Outlet Temp.	12/7 °C	12/8.4 °C
Cooling water	Flow rate	44 m ³ /h	
	Inlet/Outlet Temp.	31/36 °C	31/35.3 °C



Performance analysis

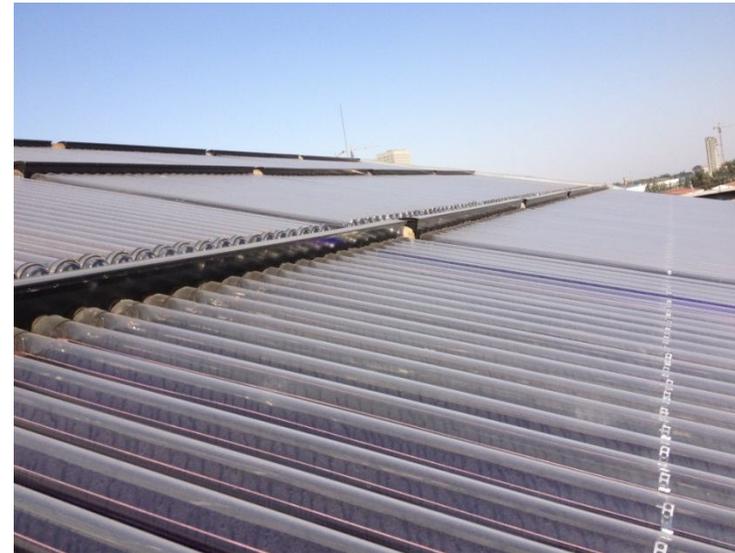


- Under sunny days , double effect mode from 10am -14 pm
- Single effect mode for the other time.
- Daily average COP is about 0.8
- Cooling production for 6-8 hours

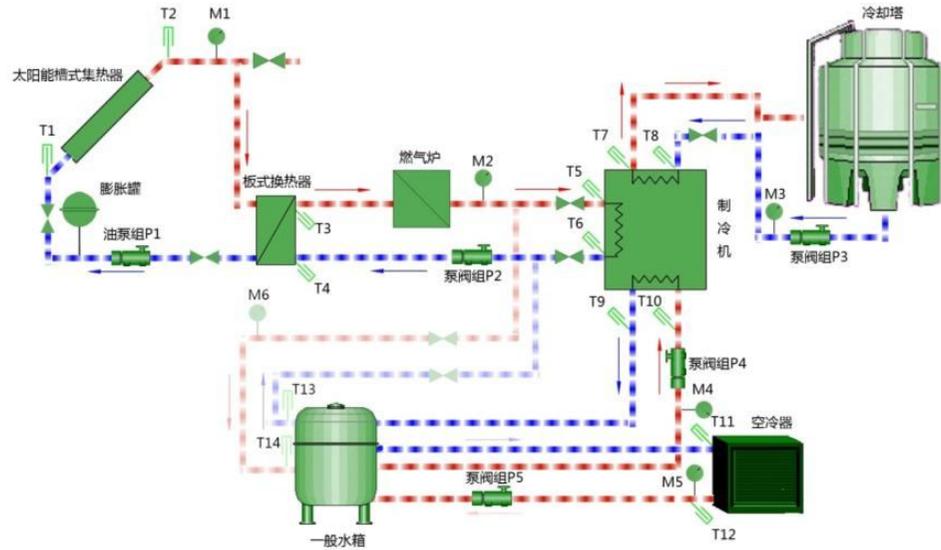


Single/double effect LiBr-H₂O Chiller (Changle Shandong)

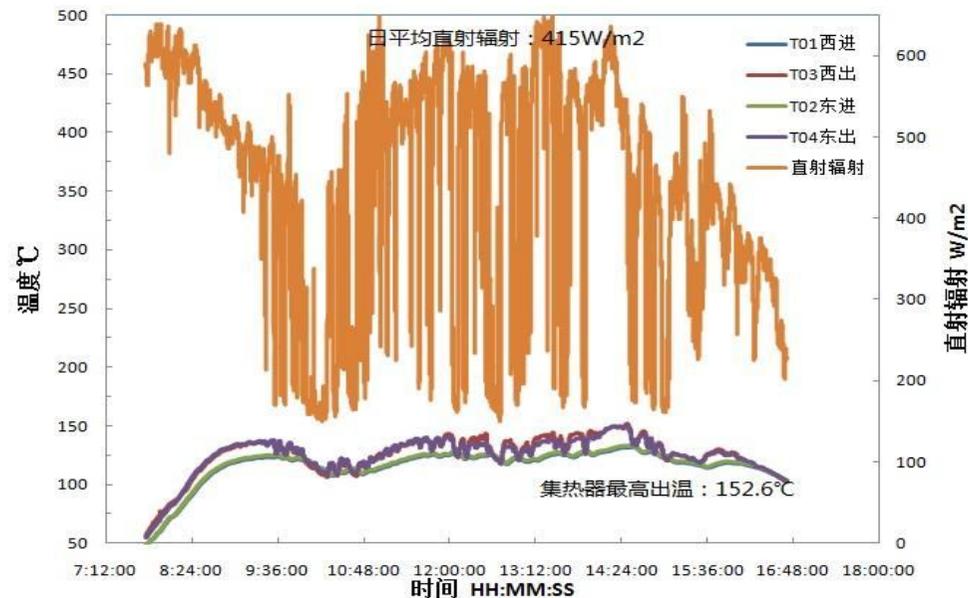
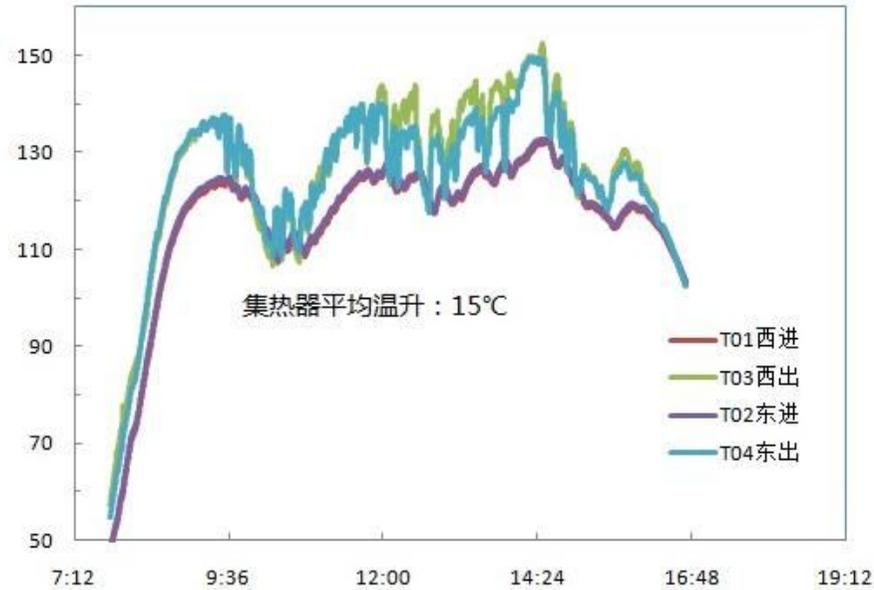
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III. Solar driven double effect absorption cooling with parabolic collector



System Performance



Daily solar thermal efficiency of the collector is about 40%.

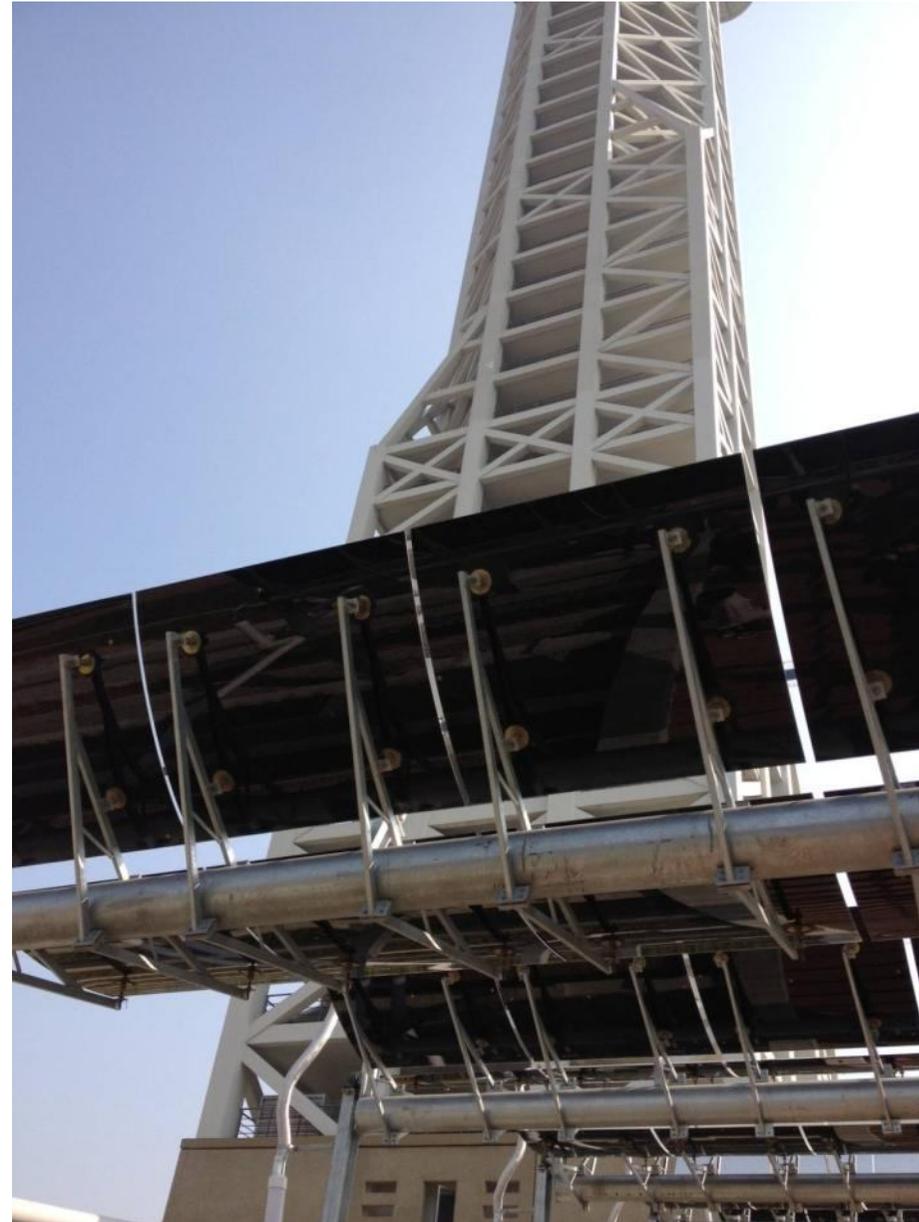
Temperature increase is about 12-15°C.

COP is about 1.0.



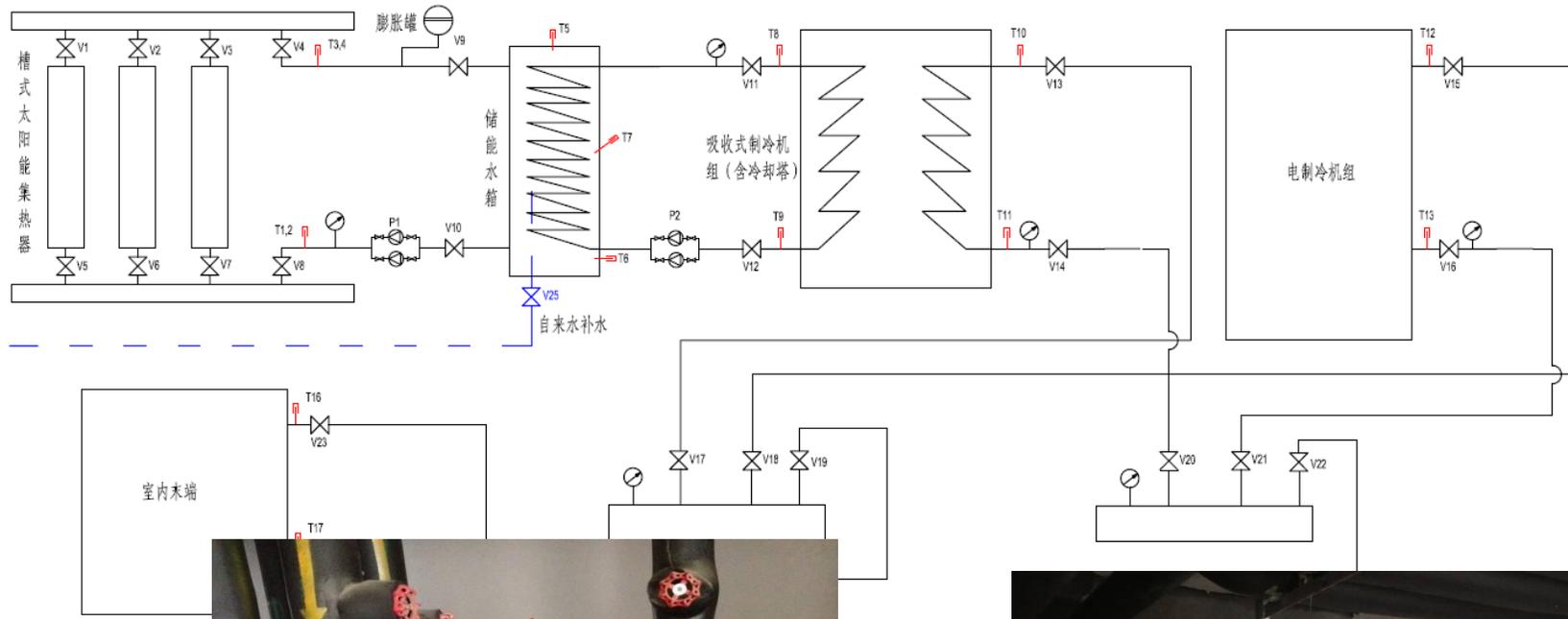
Solar driven air cooled absorption cooling

- Solar driven hybrid Air cooled absorption chiller + VC air conditioning system
- Trough collector is about 135 m²
- About 25kW air cooled absorption chiller
- Vanke real estate Co. , research center

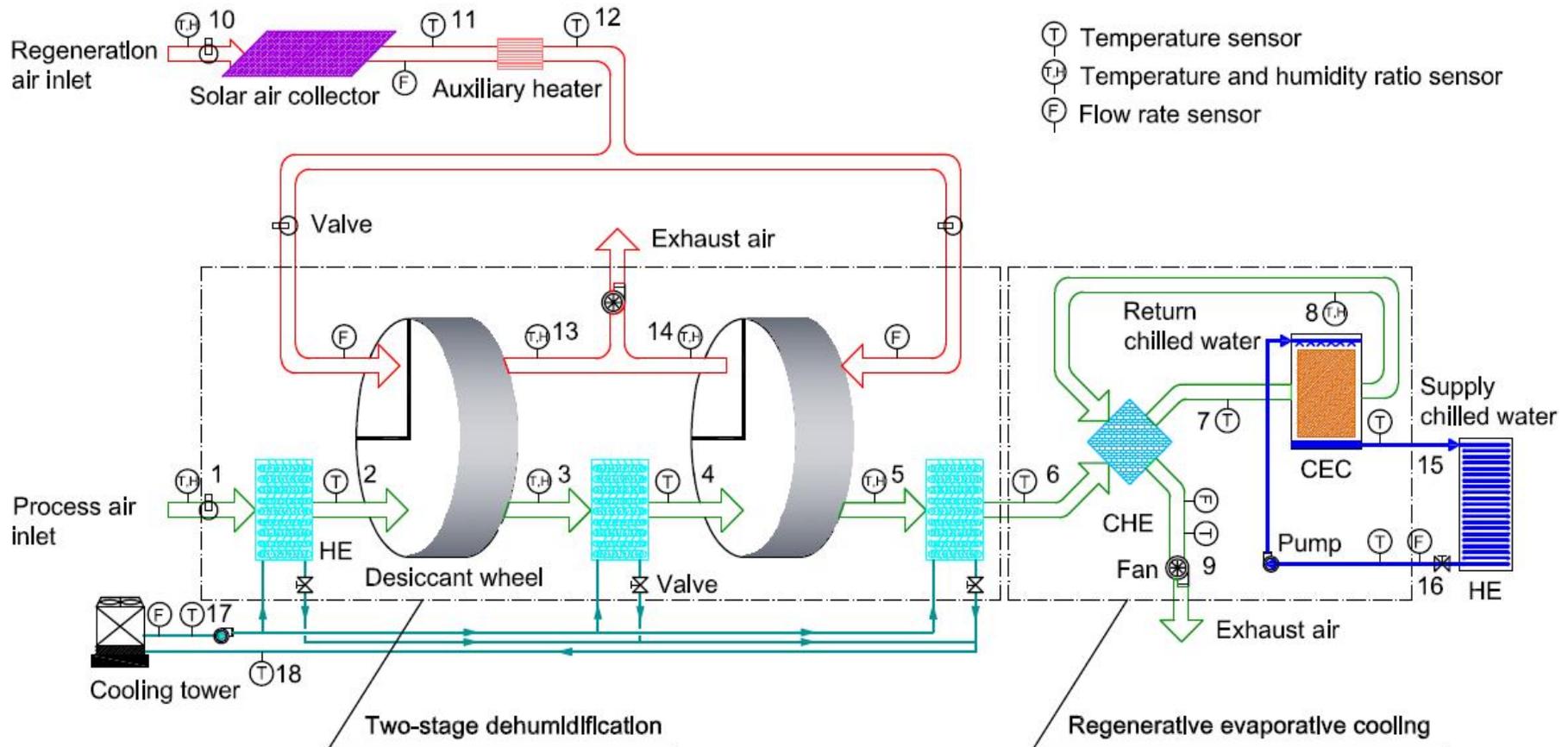




Solar driven air cooled absorption cooling

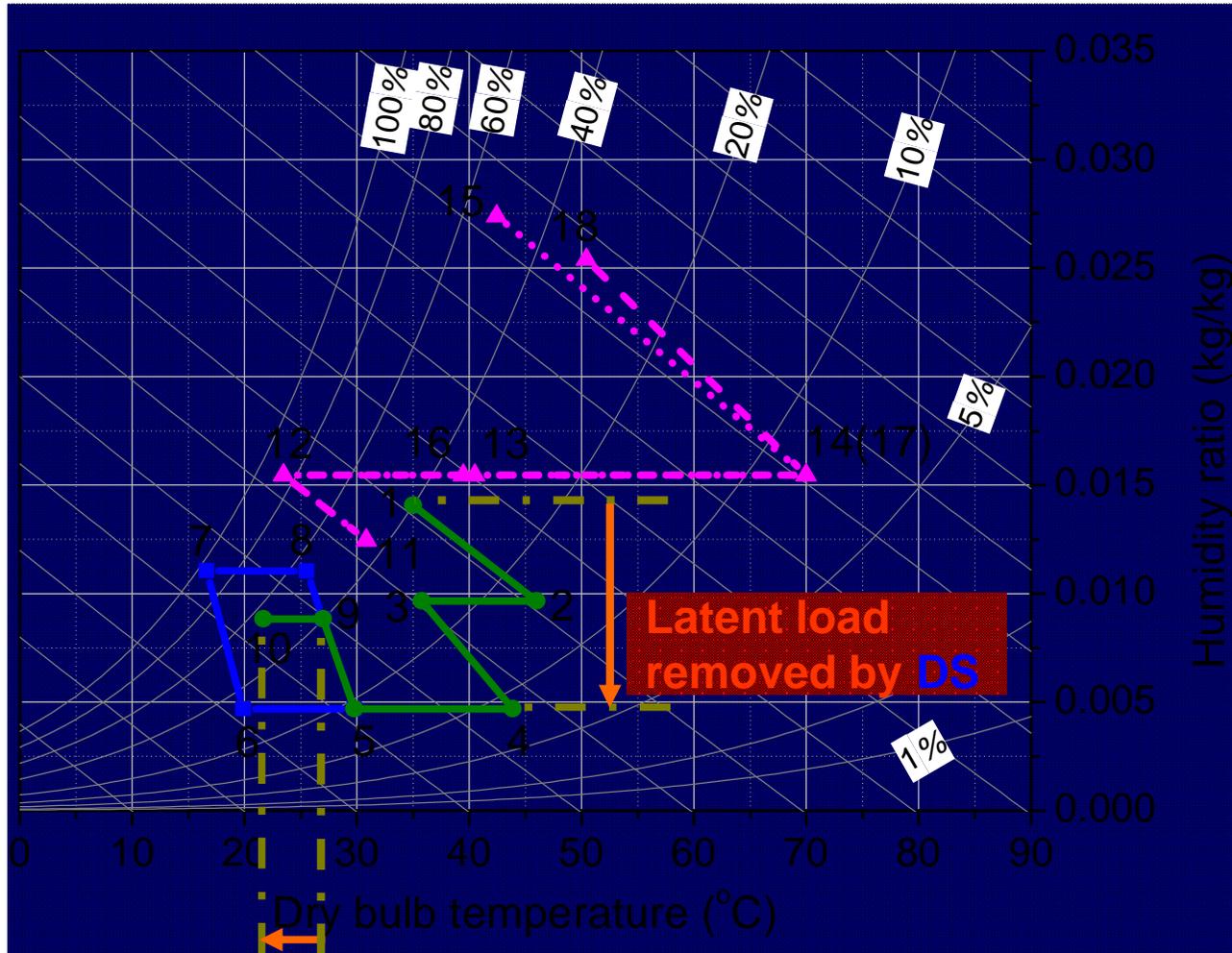


IV. A novel chiller with desiccant dehumidification and regenerative evaporative cooling





System Operation



Dehumidification subsystem (DS)

- process air cycle: 1-2-3-4-5
- Regeneration air cycle: 11-12-13-14-15
11-12-16-17-18

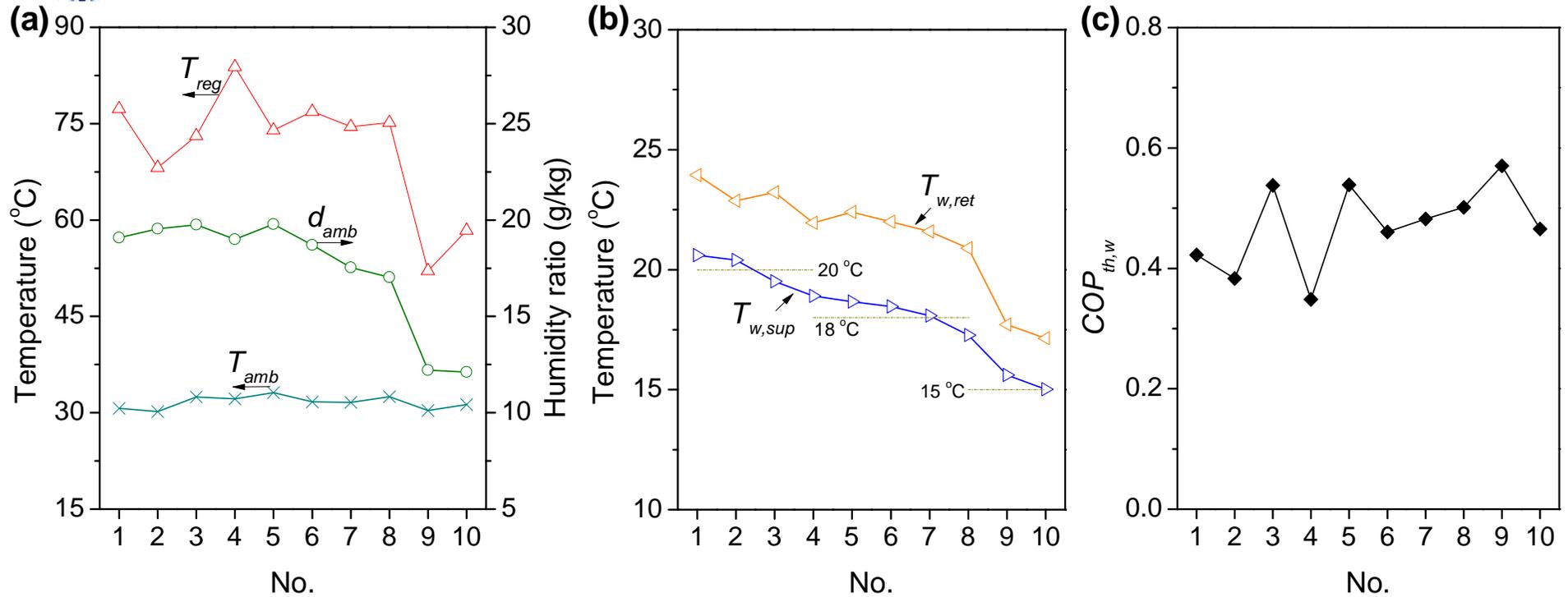


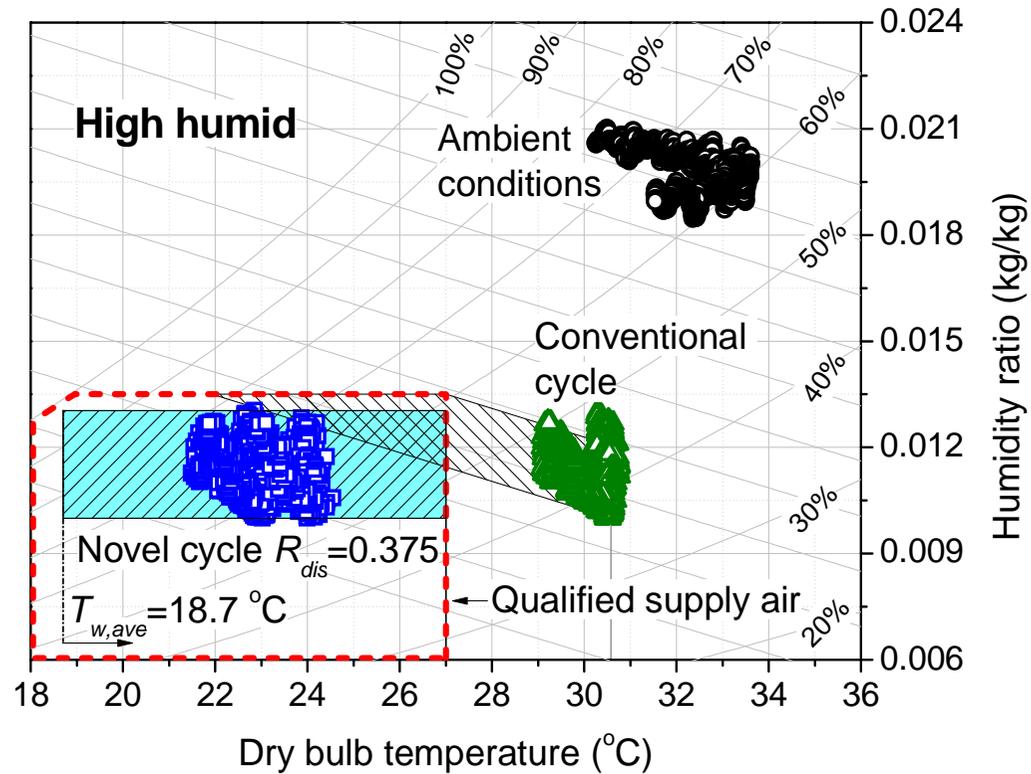
REC subsystem (RS)

- dry air for producing chilled water cycle: 5-6-7-8
- reused air cycle: 8-9-10
- process air cycle: 5-9-10

Sensible load removed by RS

Performance in producing chilling water

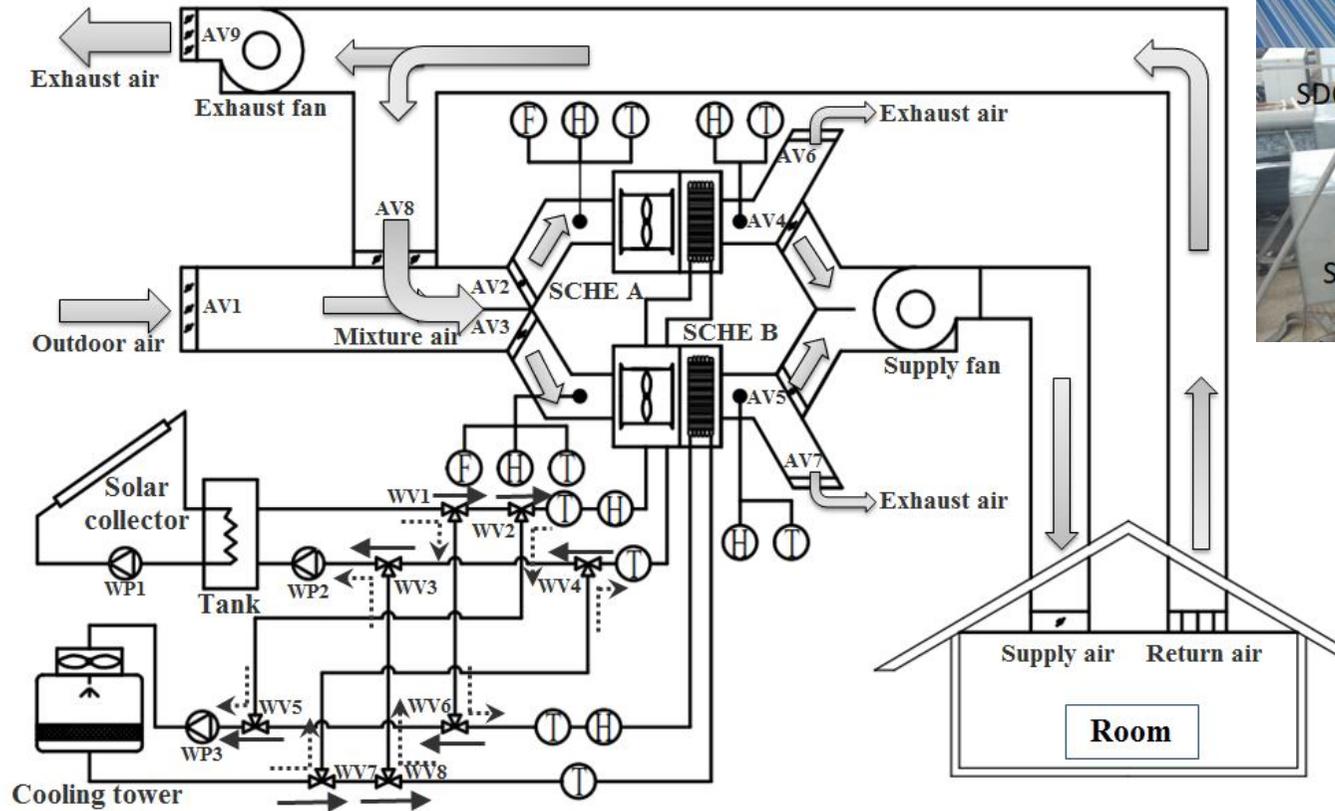




Comparison between the supply air condition of the novel cycle and that of the conventional cycle under high humid climate (1130.6 m³/h, 674.2 m³/h, 1.04 m³/h, July 22, 2011)



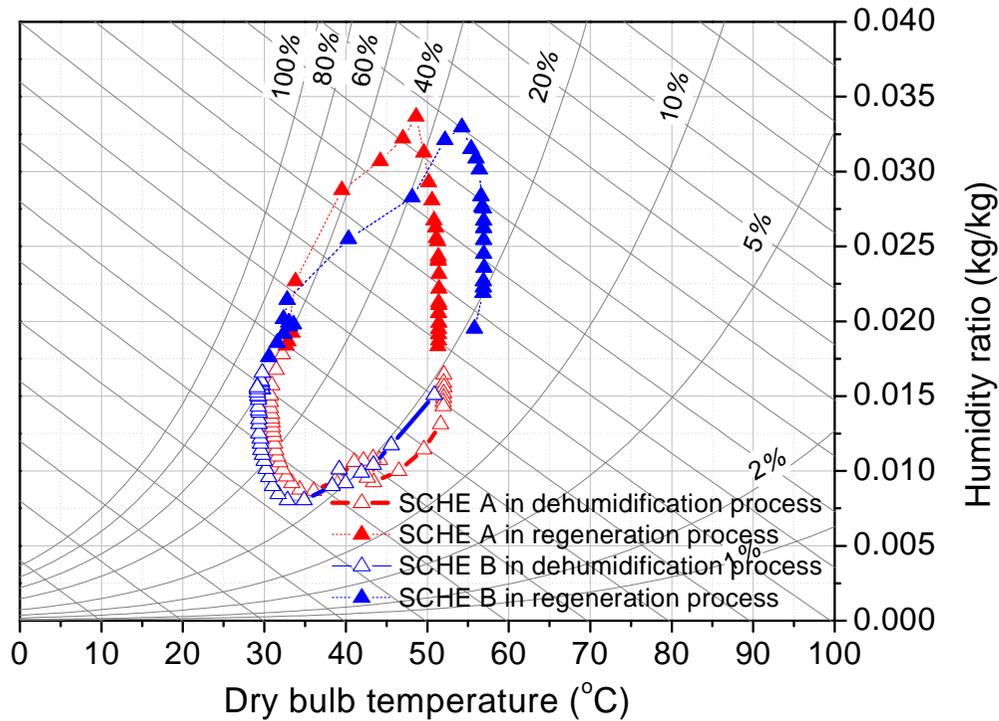
V. Desiccant heat exchanger units



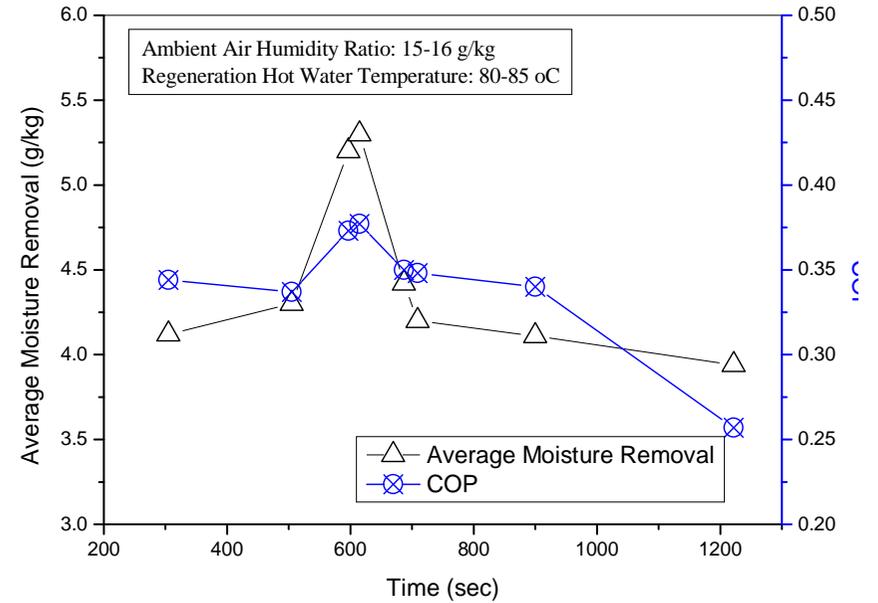
Legend

- ⊕ Flow meter ⊕ Humidity sensor ⊕ PT100 ⊕ 3-way water valve (WV) ▨ Air valve (AV)
- ⊕ Water pump (WP) → First half cycle ····· Second half cycle





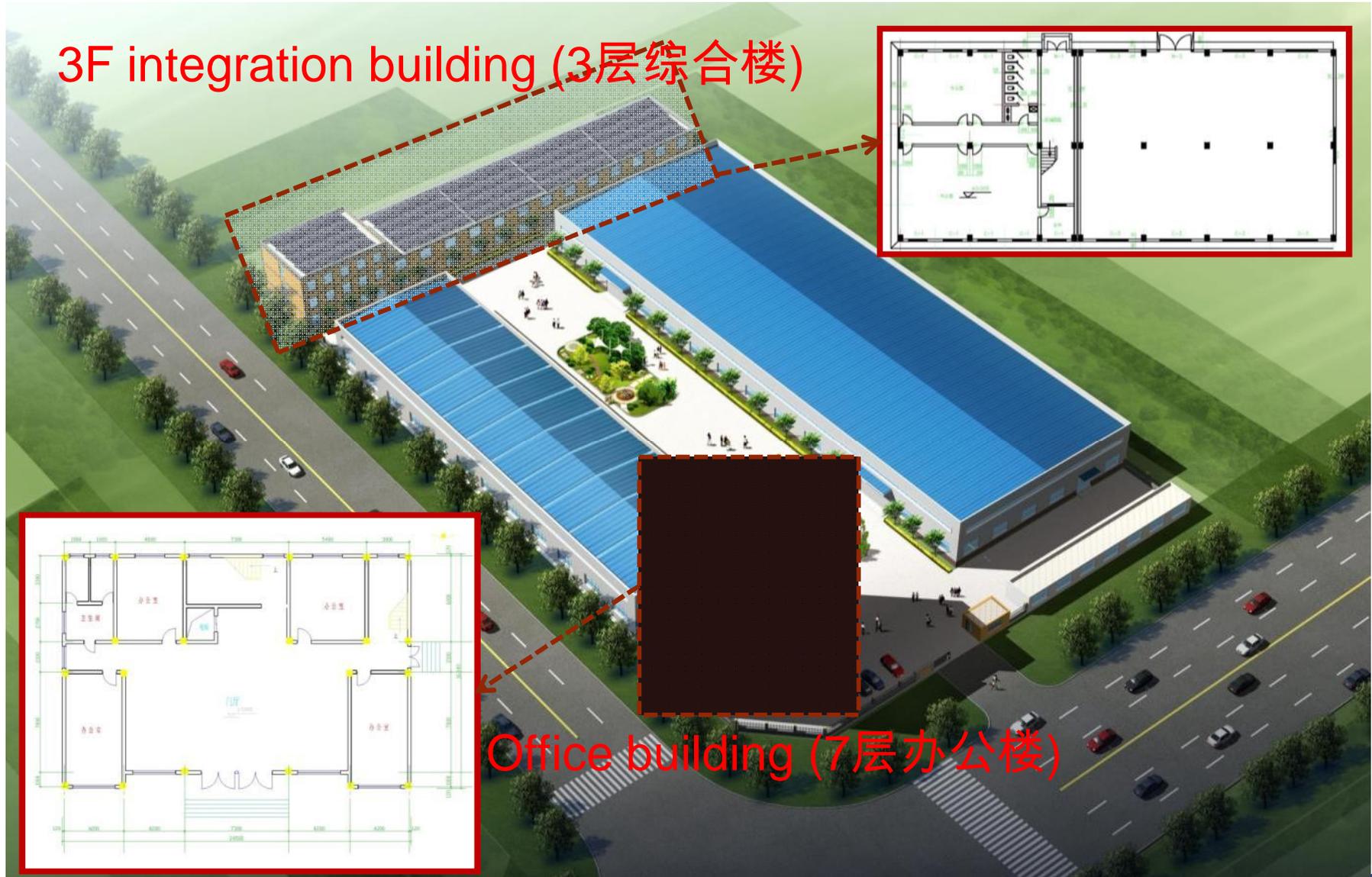
Dynamic analysis of two SCHEs in one cycle



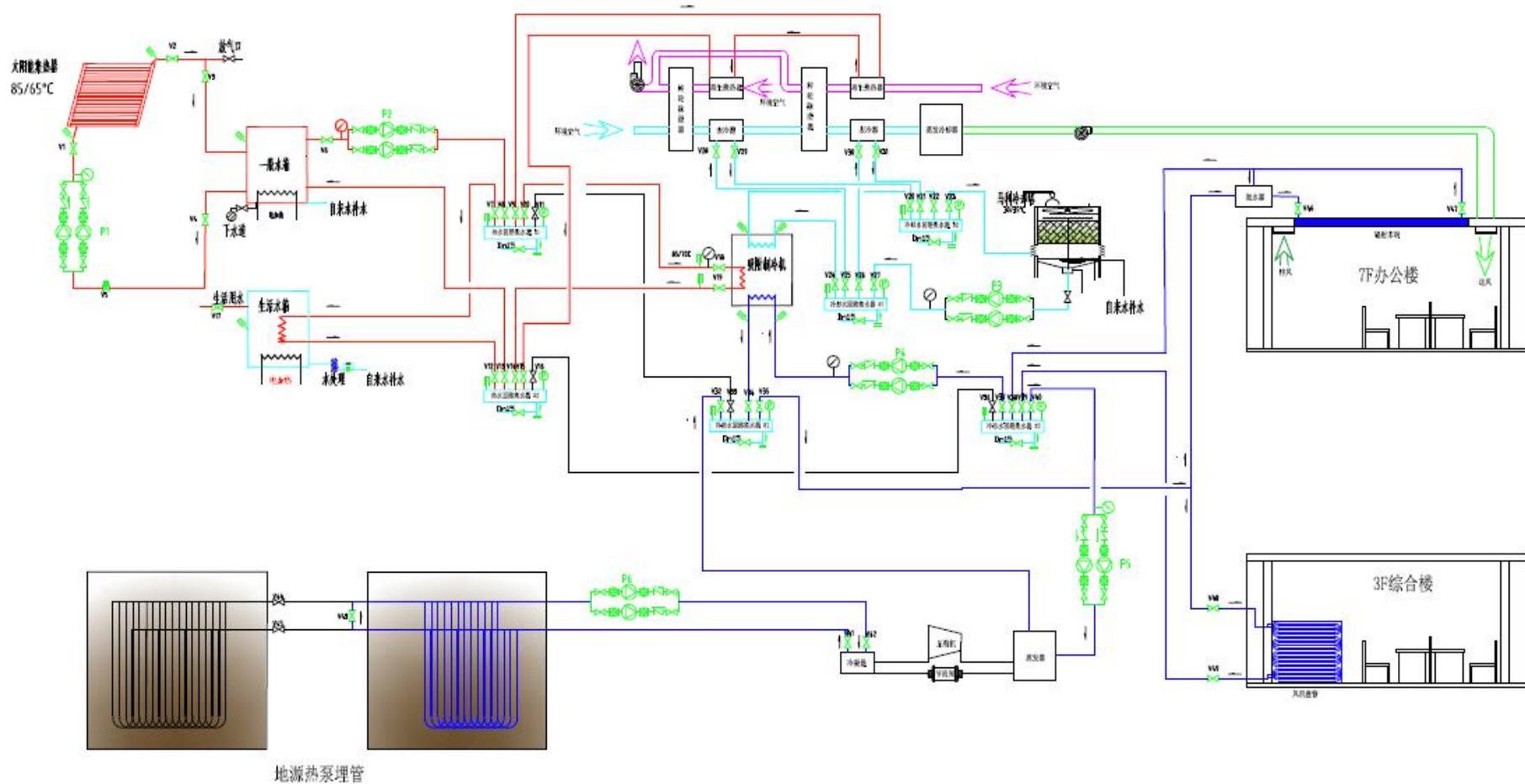
Effect of cycle time on average moisture removal and COP_{th}



Solar heating and cooling system in Auhua Co., Ltd.



System design (Sino – Denmark joint Project)





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50kW adsorption chiller





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80kW desiccant cooling system

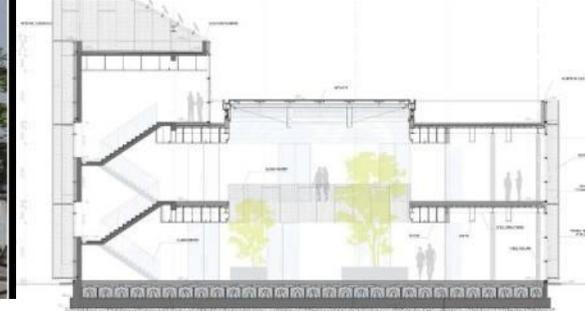




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Green Energy Lab (GEL)



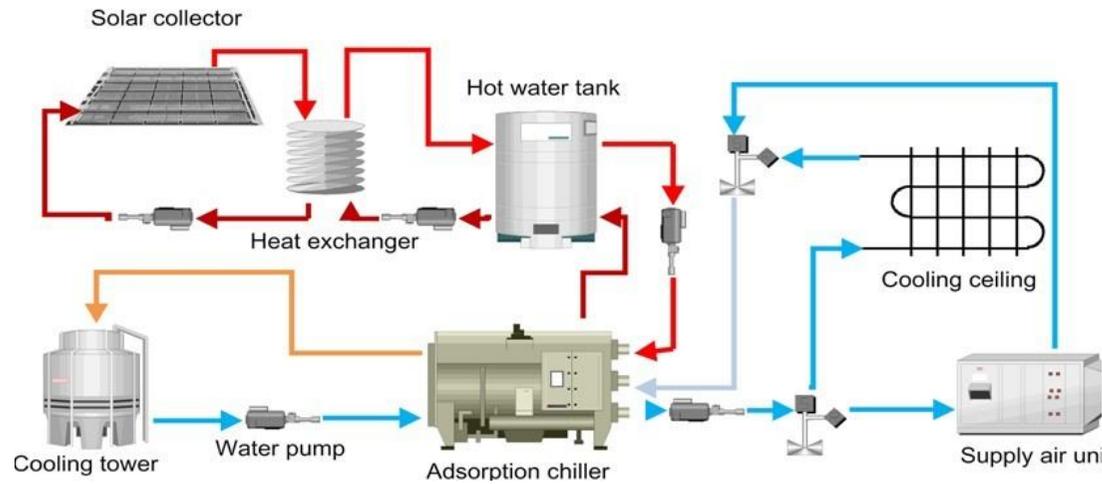
Gold Medal – LEED certification



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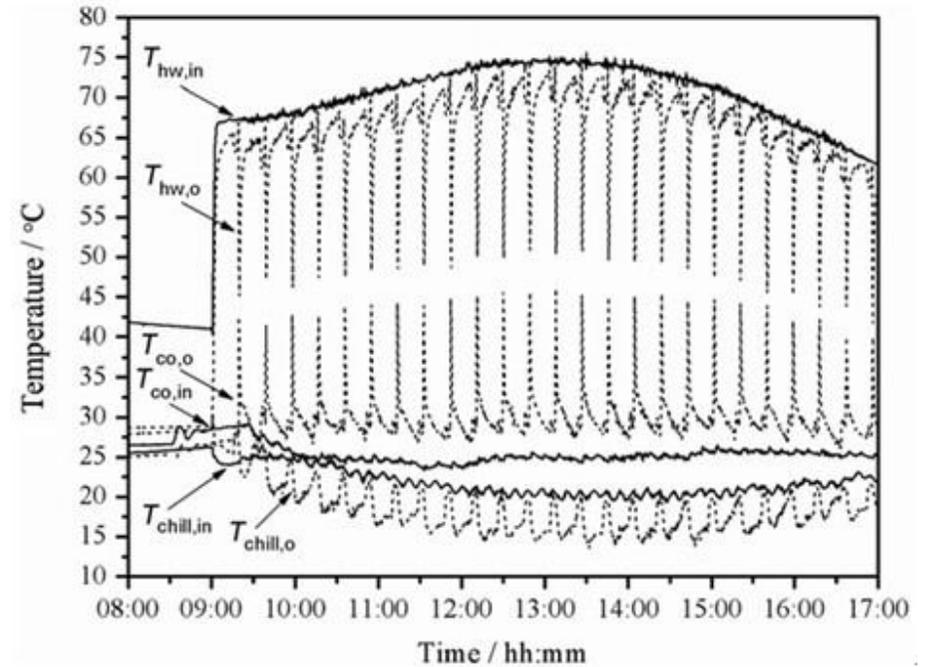
Solar driven adsorption chiller



- 60 m² heat pipe solar collector
- 15 – 20kW adsorption chiller
- Cooling ceiling



Radiant cooling



Chilled water 15°C , radiant cooling

COP is about 0.5.



上海交通大学 CPC solar collector + absorption chiller

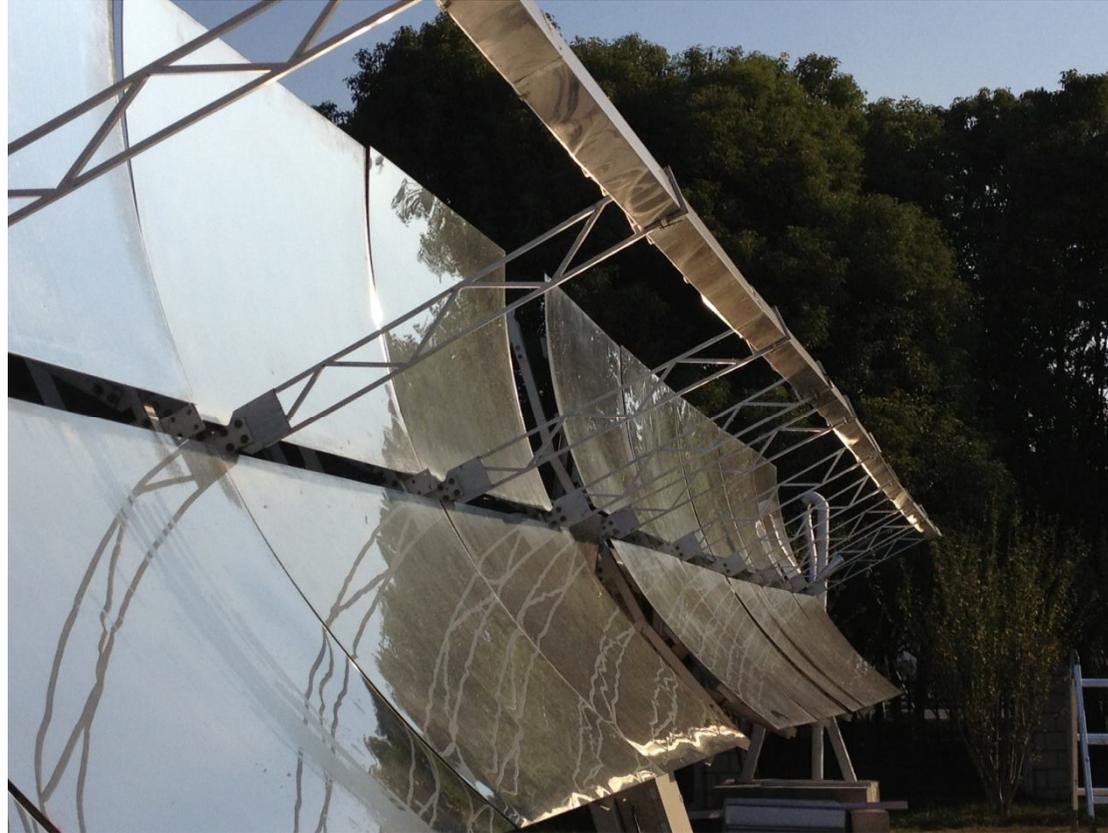
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- ❁ CPC solar collector, 110~130°C.
- ❁ LiBr-H₂O Chiller
- ❁ Capacity: 17kW



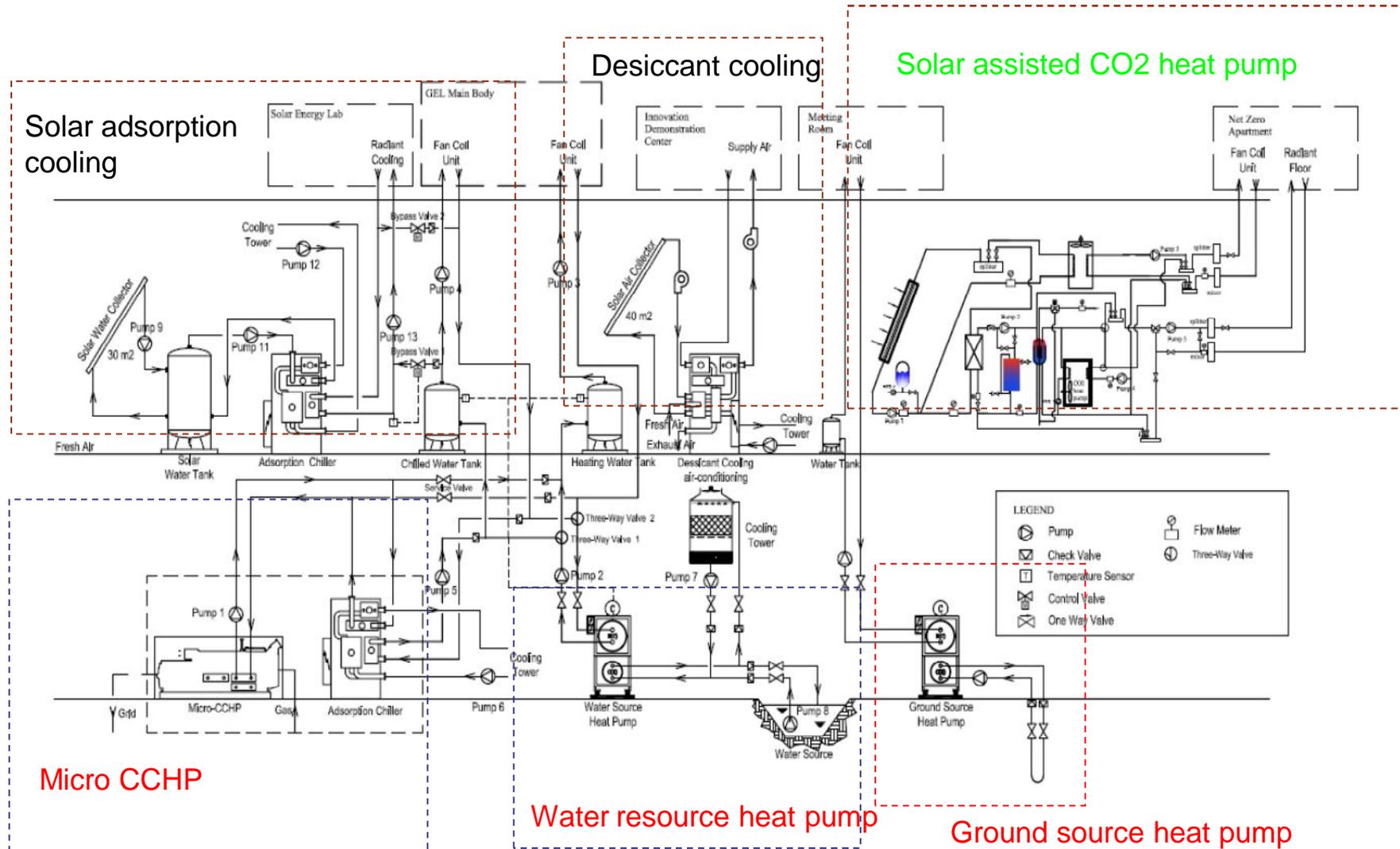
Solar ice making system



Solar trough collector : 130 - 150°C
Adsorption ice maker
COP=0.3



Solar air conditioning system in GEL



Main system



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Solar PV cooling



Lennox

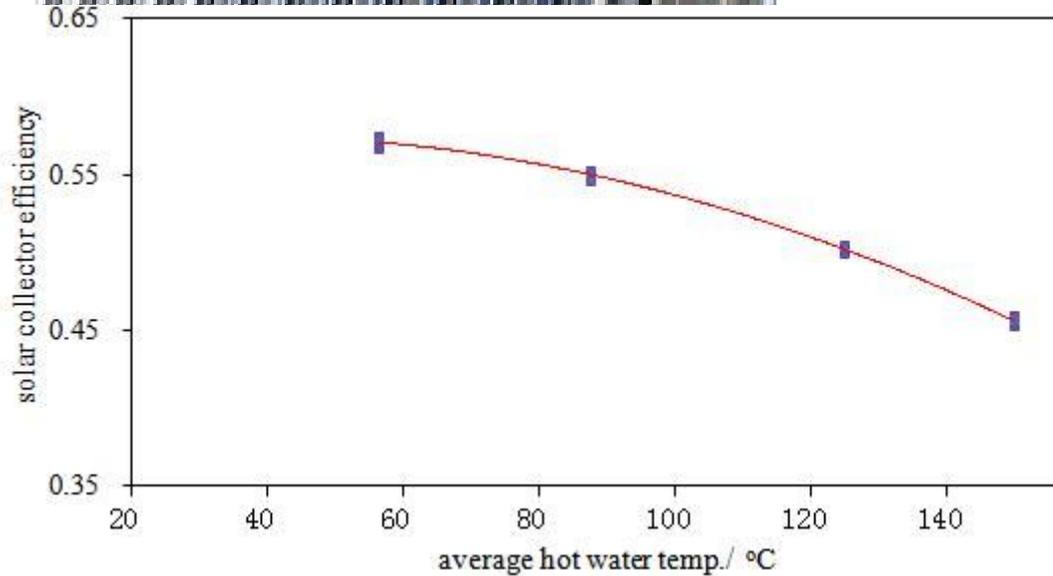


PV air conditioning becomes more competitive with the PV cost goes down.



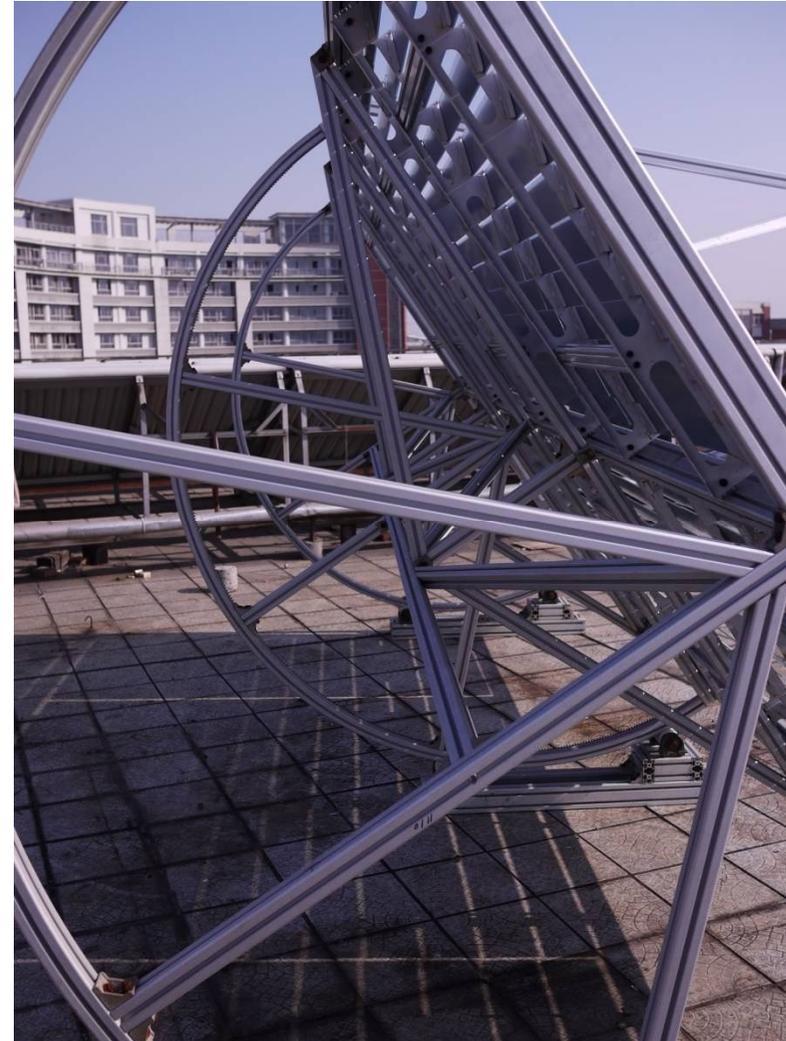
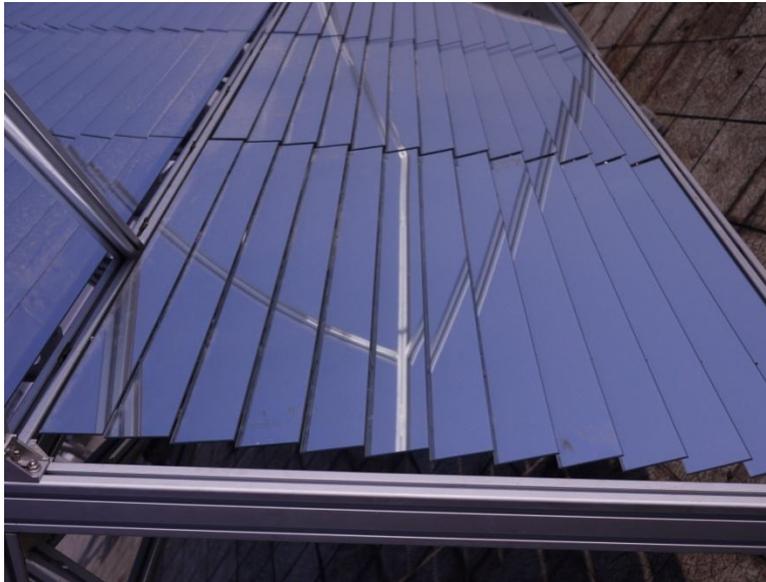


Medium temperature solar collector





Solar Fresnel Collector





Novel solar collector





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Factory of solar cooling machine





Future Activities



Compact solar adsorption chiller

- Silica Gel- H₂O, 5,10,20,50 kW
- Chemical adsorption ice making unit
- Multi slats and multi effect sorption cooling



Efficient desiccant dehumidification and cooling

- Desiccant wheel
- Desiccant coating
- Advanced materials



Multi effects absorption cooling



Solar collector and Thermal storage



Solar combined system and simulation

SINO-ITALIAN GREEN ENERGY LABORATORY

中意绿色能源实验室

Thanks for your attention

谢 谢 ！



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