Technical consideration for solar cooling system

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1. What is our purpose?

To address world

- **Energy**
- **Environmental**
- **Economic**

deliver the better life

In 1974 YAZAKI created the first Solar House (including heating and cooling) in the world.

YAZAKI

2. What is our basic concept?

- the most utilization of renewable Energy
- the highest energy efficiency and user convenience
- the cheapest energy price
- environmental friendly

3. Challenges in solar air-conditioning system

Heat Balance＆Power Consumption

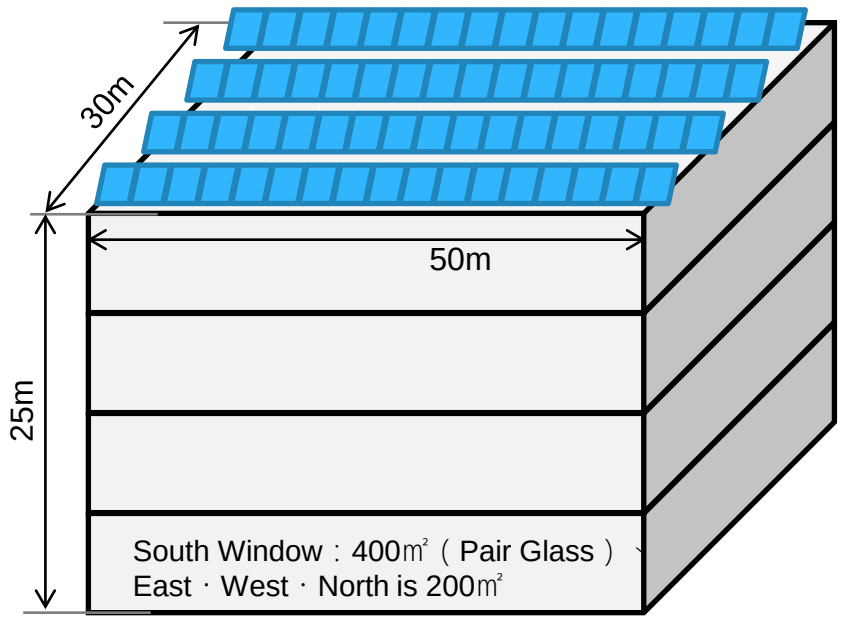
Radiation to the Roof（horizontal radiation）
1927MWh/yr（4.62GJ/㎡・yr）

Effective Collector Area：370㎡
Radiation to Collector → 475MWh/yr

【Collection Condition】

Collector	High Efficient Flat Plate Type
Collector Area	370㎡
Collection Temp.	88℃　Storage start temp.　83℃
Storage Volume	20m³
Direction｜Angle	South｜40°

Thermal loss during Mid Season：85.2MWh/yr



（May ~ Sep）
88℃ Collection：57MWh/yr
（Full effect collection24%）

（Nov ~ Mar）
55℃Collection：68MWh/yr
（Full effect collection33%）

WFC Chilled Thermal Transfer(0.7)　40 MWh/hr(53%)

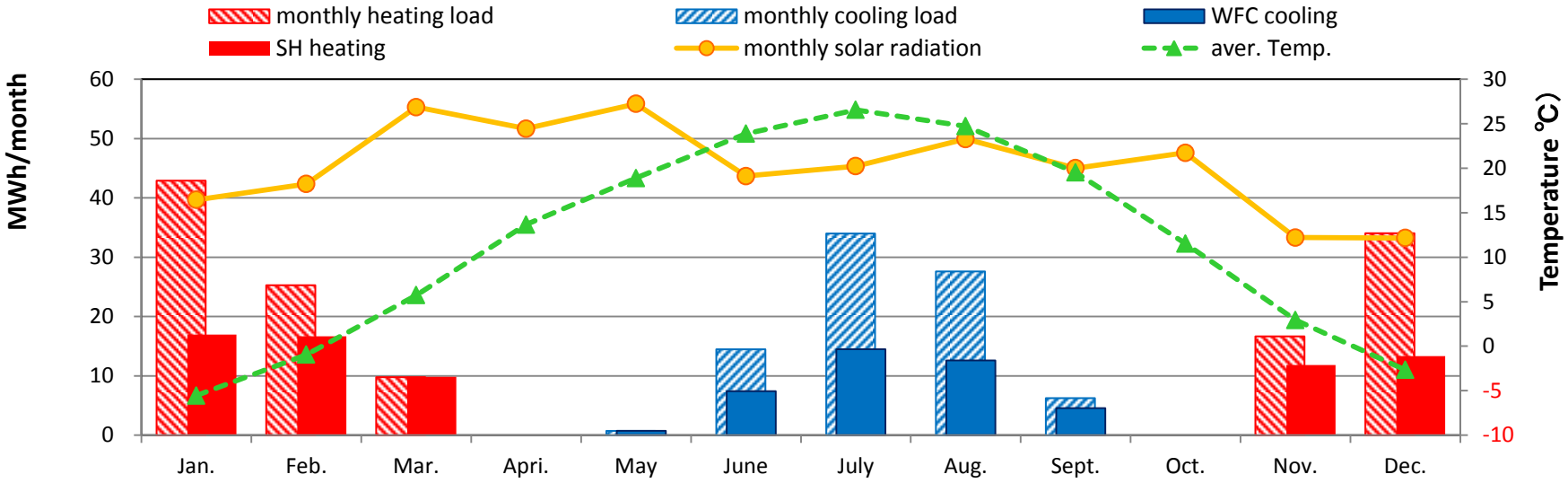
VS

AC Load（Cooling Total）
83 MWh/yr

VS

AC Load（Heating Total）
129　MWh/yr

Yearly phenomena analyses in solar air-conditioning operation



	Heat demand(yearly)	System Output	Solar Fraction
cooling	83.1MWh	39.9MWh	**48%**
Heating	128.8MWh	68.6MWh	**53%**

➢ **Does our system utilize the most of renewable Energy?**
And high energy efficiency? No!

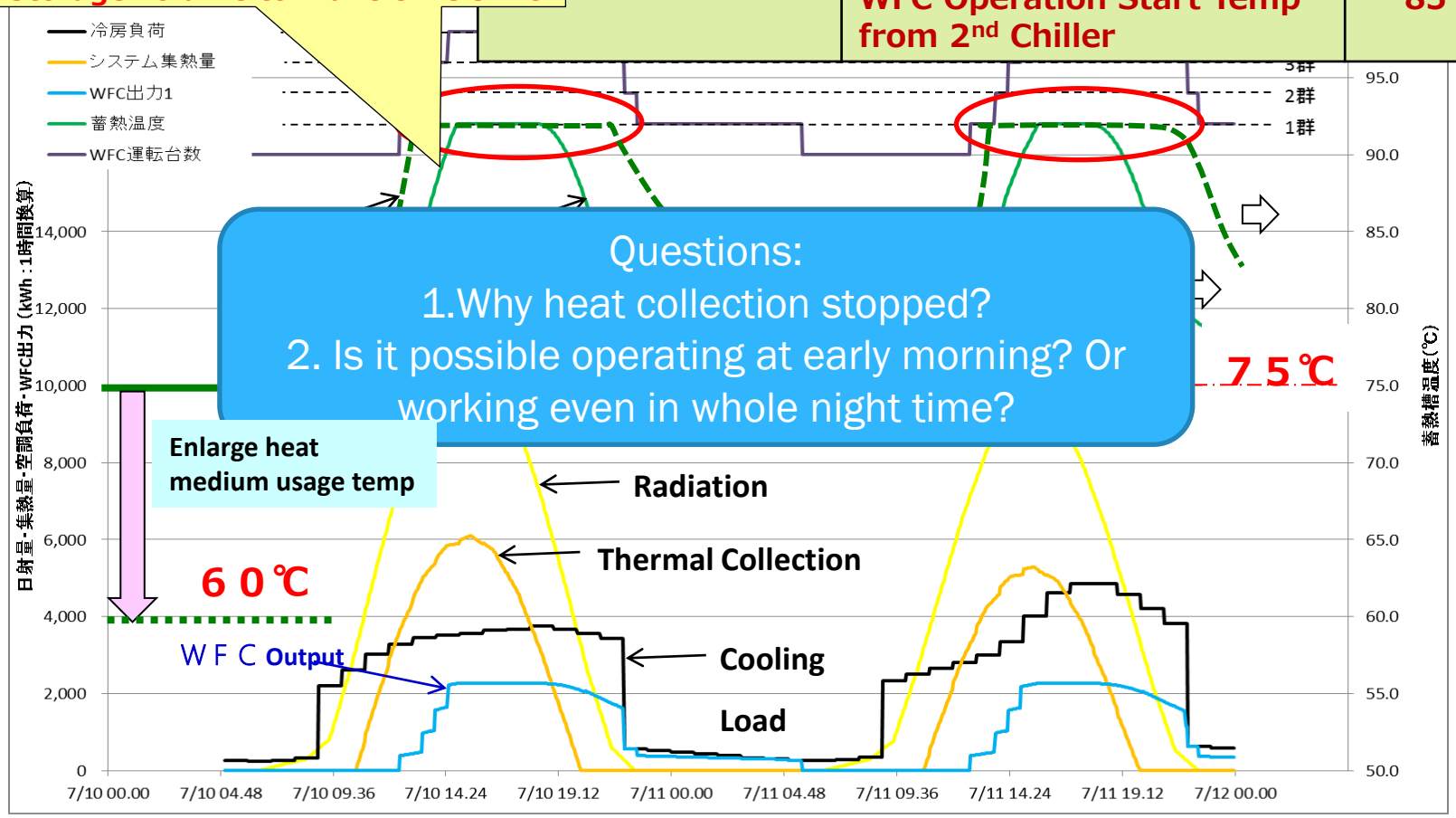
System design and control technology shall optimized

Daily phenomena analyses in solar air-conditioning operation

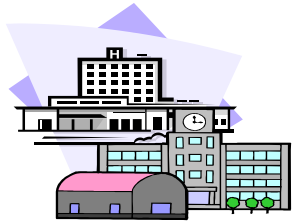
Using current design, heat collection is larger than cooling load and heat collection stopping and unused solar thermal energy would occur.

➢ **General Measure :**
optimized system design
Increase Storage volume to make time shift

rationcondition		
	WFC All Stop Temp	75℃
	WFC Operation Start Temp	80℃
	WFC Operation Start Temp from 2nd Chiller	85℃



Technology approach (focus on component design)



【Cooling Season : May～Sep】

Full Effect Collection Efficiency 24%

Transfer Efficiency : 70%

Solar Fraction : 48%

Radiation : 240Mwh ⇨ Collection : 98Mwh ⇨ Store : 57Mwh ⇨ Chilled Transfer : 40Mwh ⇨ Cooling Load : 83Mwh

Collection loss : 142MWh

Unused loss : 41MWh

Transfer loss : 17MWh

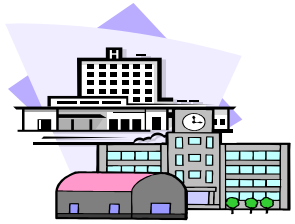
To increase system energy efficiency, we consider

1. Collector operation in lower temperature
2. Use large storage
3. Lower temperature and large temperature drop driven WFC

Thermal Energy losses and inhibitory factors







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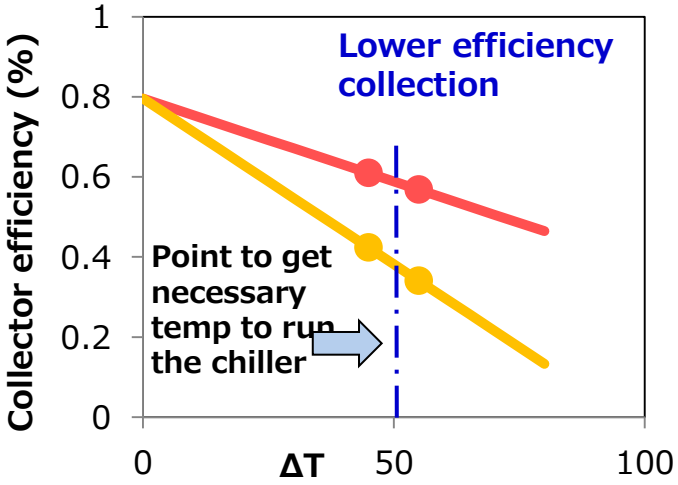
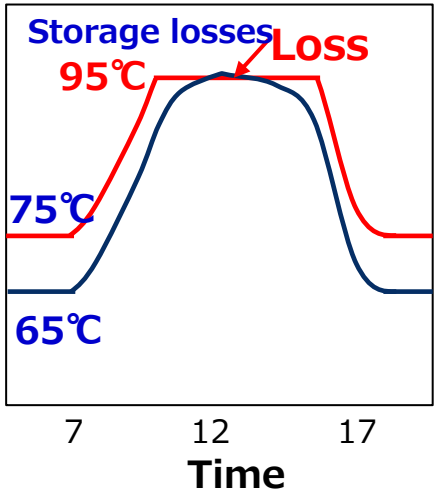
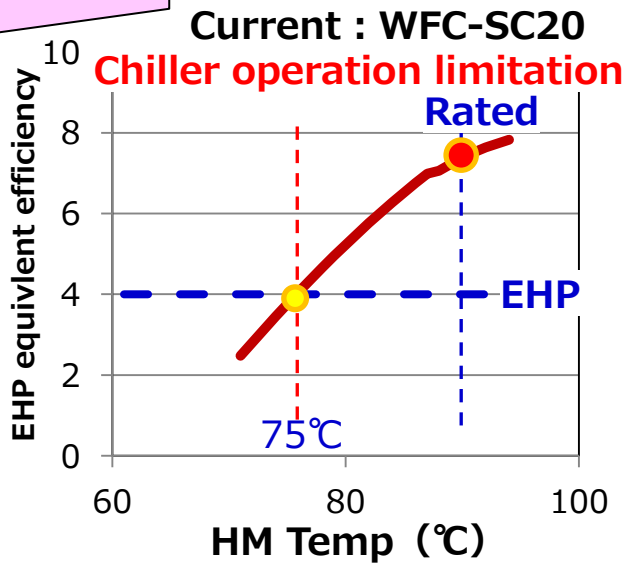


(℃ : Collection Temp－Outside temp)

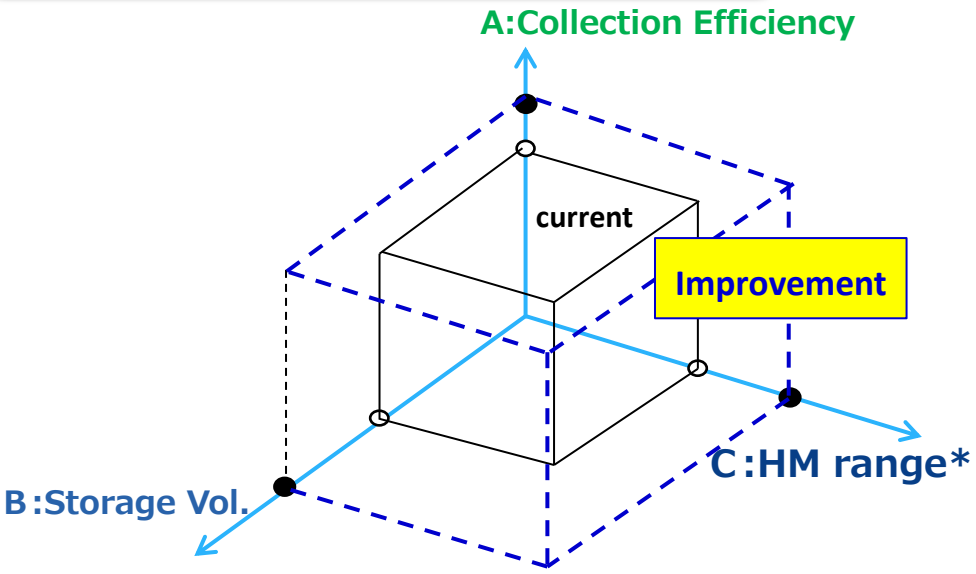


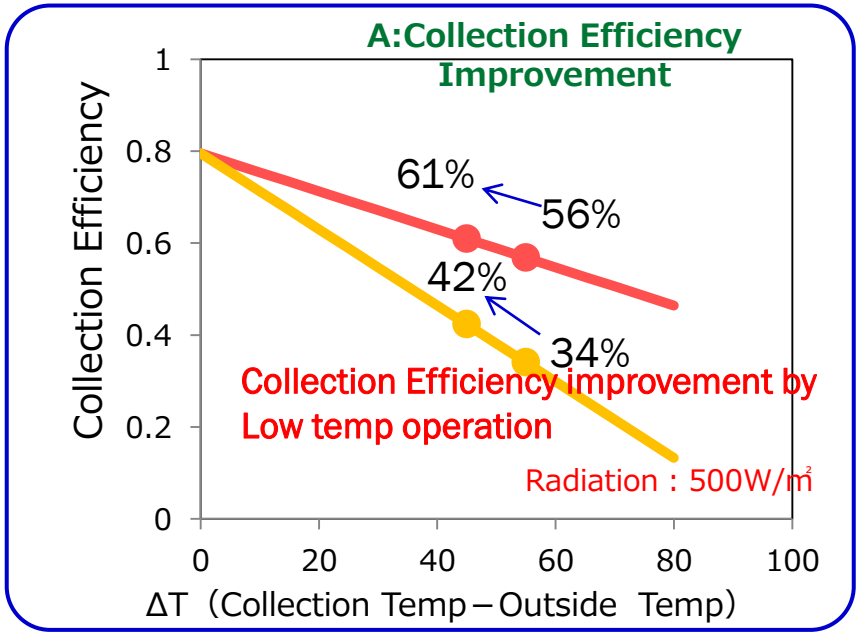


- **Collection operation is limited in the low efficiency side** due to the Chiller's operation start temp(85℃) and Stop Temp (75 ℃).
- **storage loss occurs during low cooling demand season** due to chiller's narrow operation temp range.
- Technology trend towards to mid-high temperature collection for double effect chiller **(Yearly energy loss＝opposite of passive)**

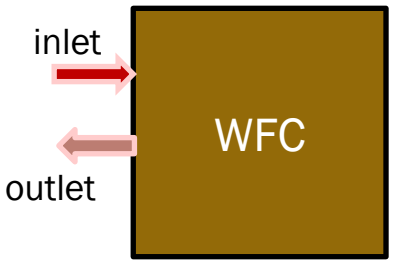
Collector efficiency improvement based on thermal energy flow

【Evaluation Indicator】
Thermal energy provided to the demand side from thermal collection and storage





HM range*; heat medium temperature drop between inlet to and outlet from WFC



Tank losses decrease based on thermal energy flow

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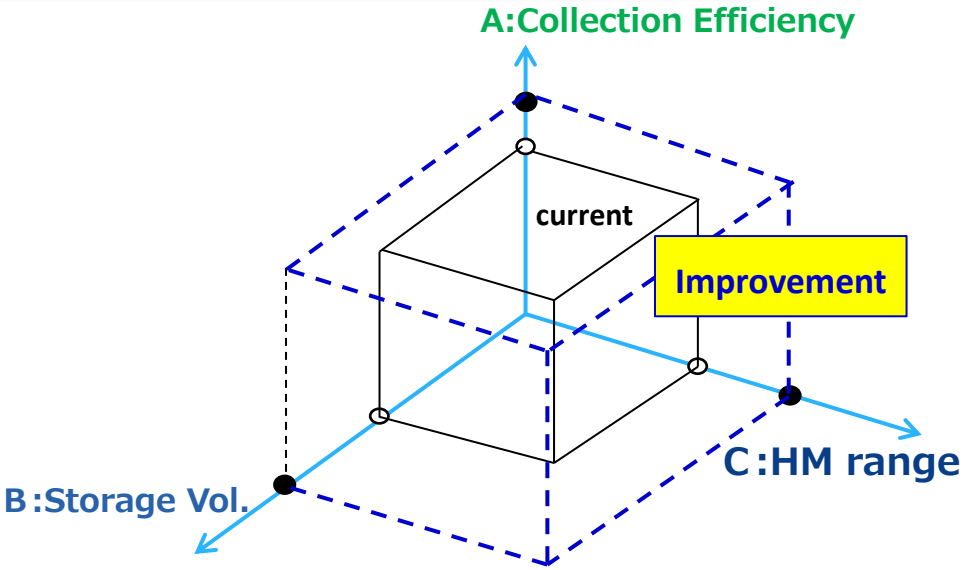
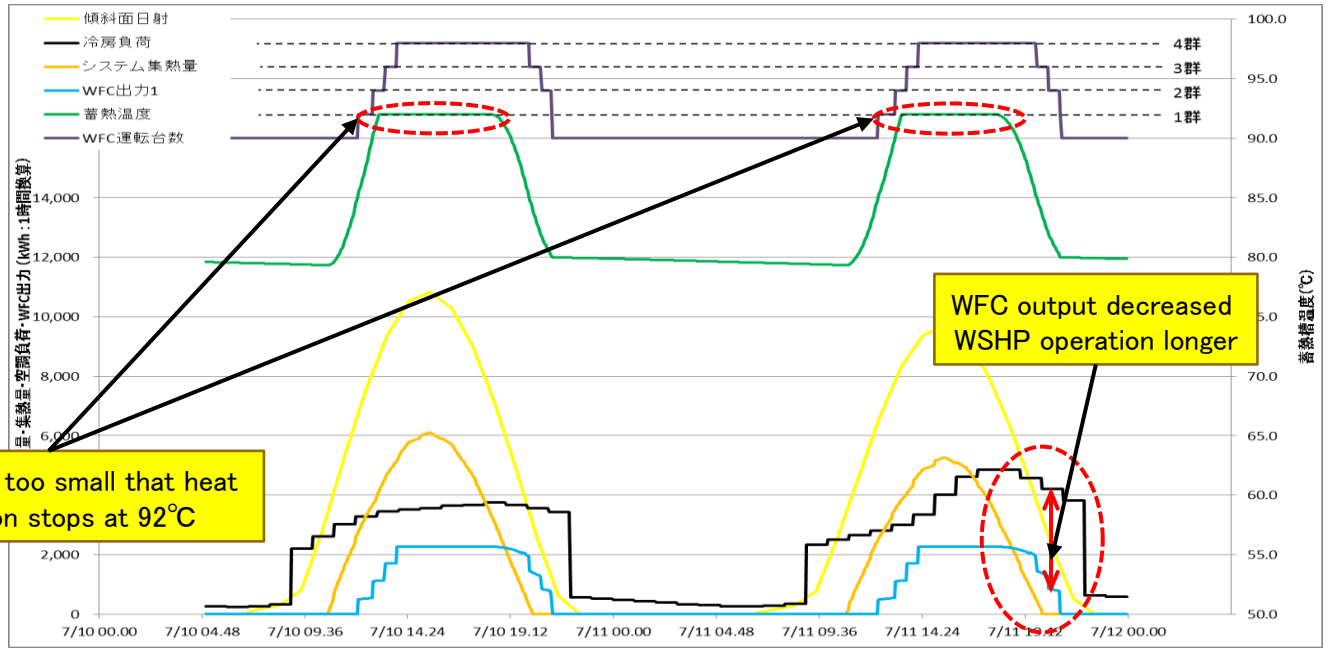


Tank volume optimization and stratification

HM range*; heat medium temperature drop between inlet to and outlet from WFC

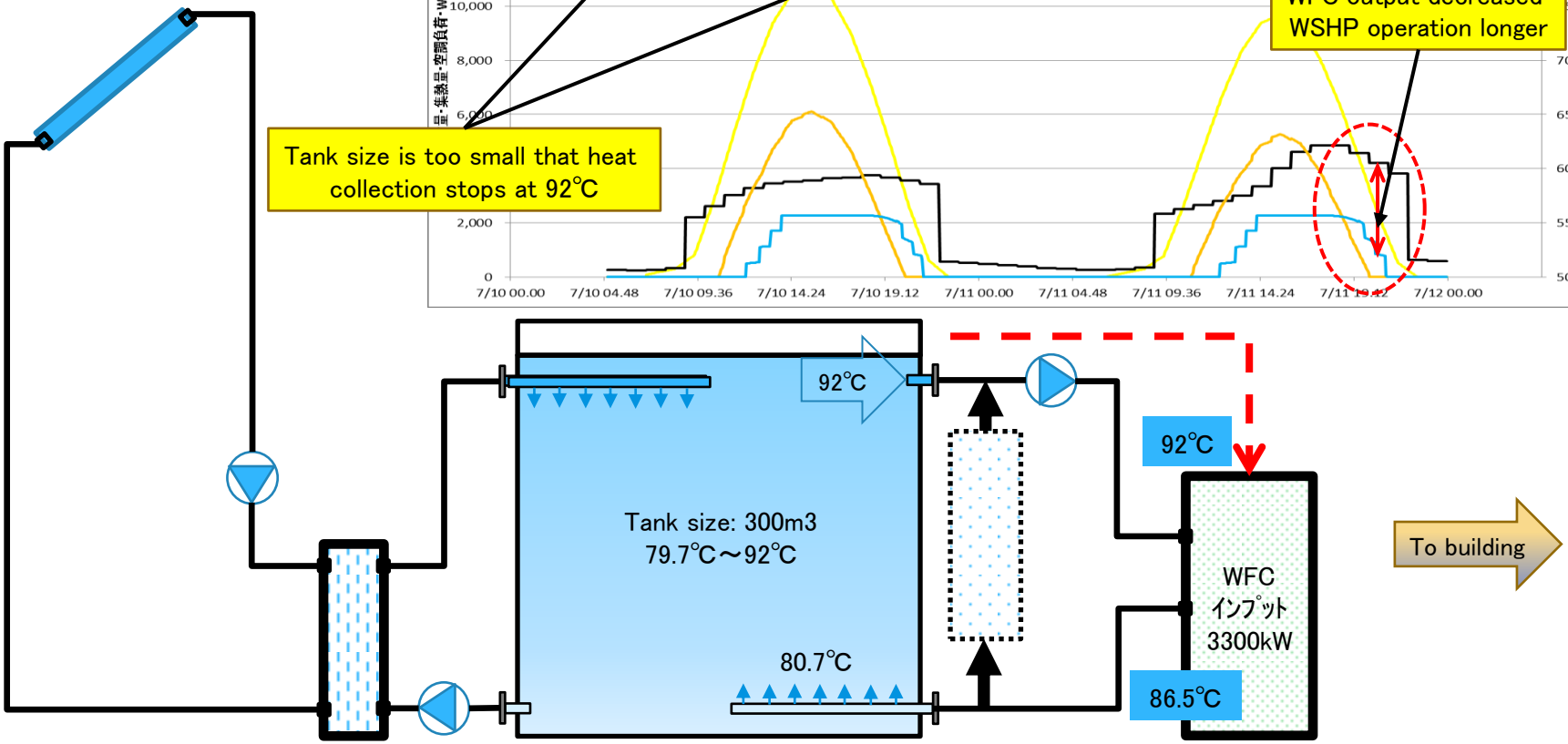
Phenomena analyses in solar air-conditioning operation

July 10–11



Tank size is too small that heat collection stops at 92℃

WFC output decreased
WSHP operation longer



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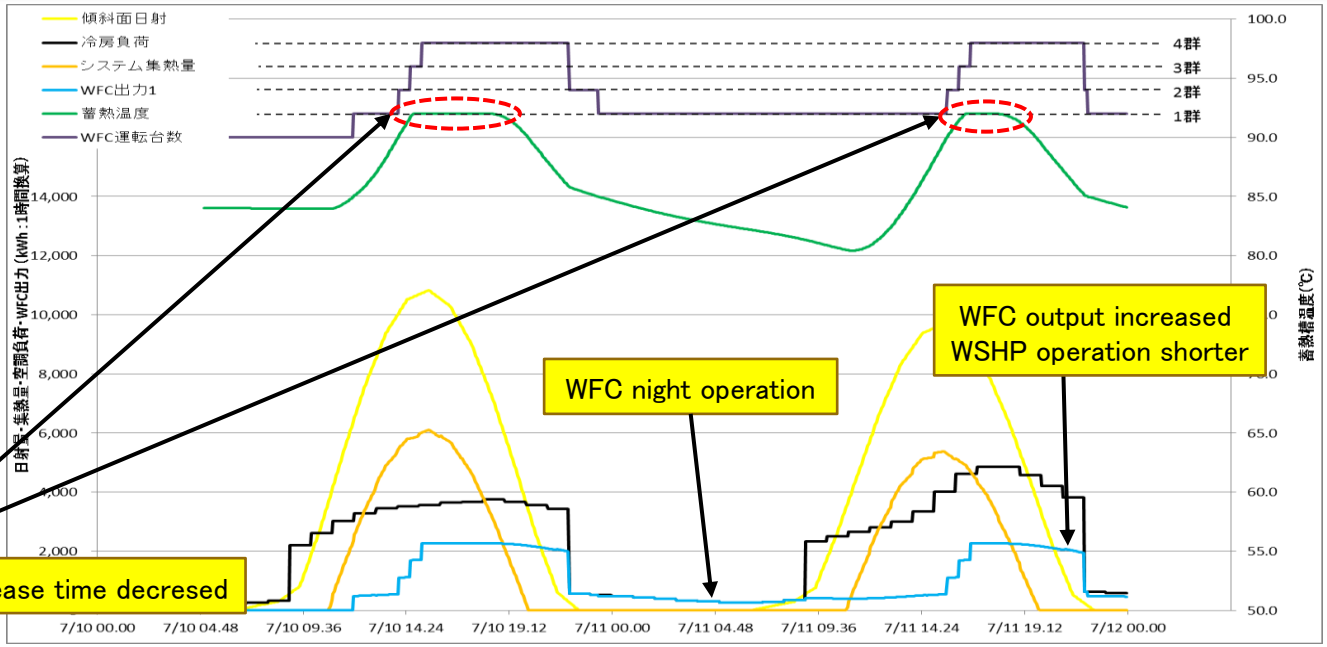
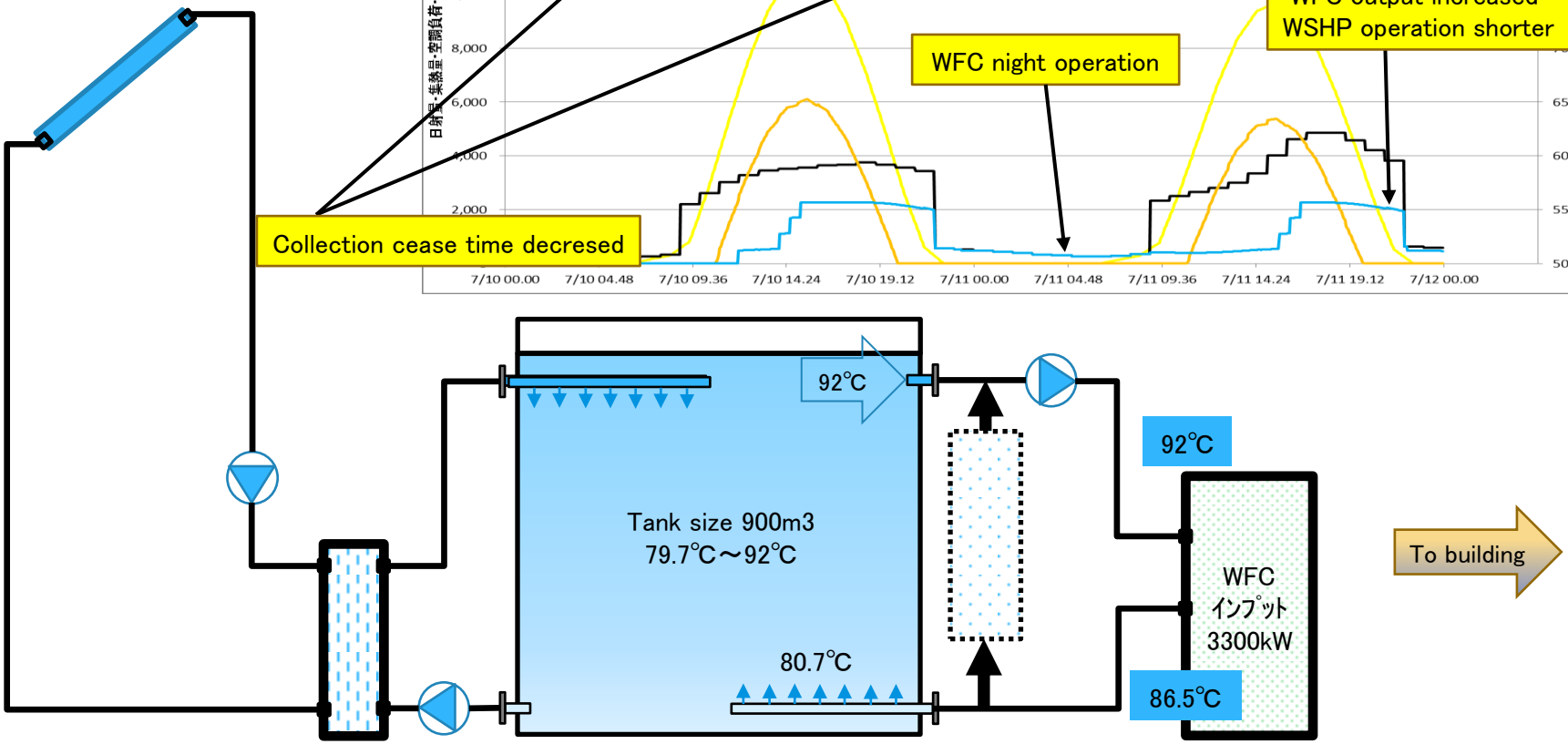


Collection cease time decresed

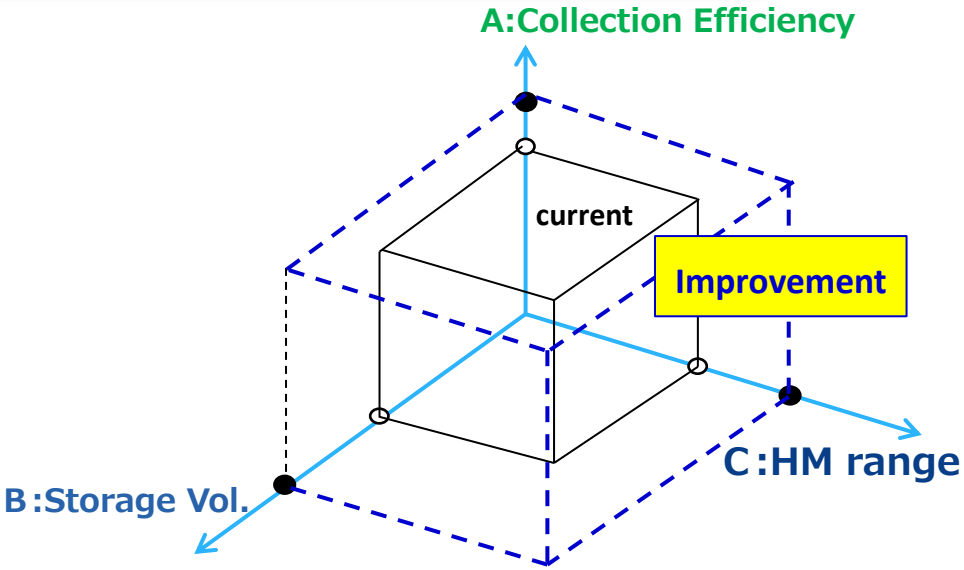
WFC night operation

WFC output increased
WSHP operation shorter



Next generation chiller concept based on thermal energy flow

【Evaluation Indicator】
Thermal energy provided to the demand side from thermal collection and storage



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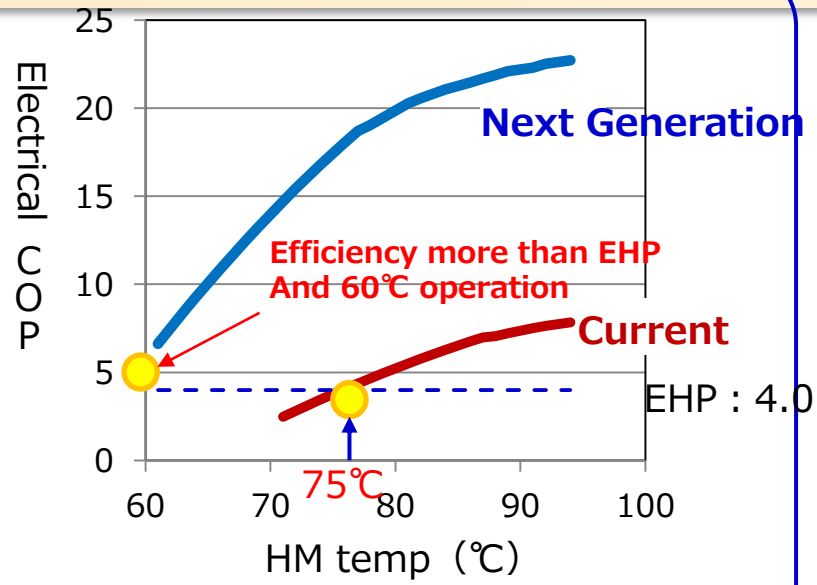
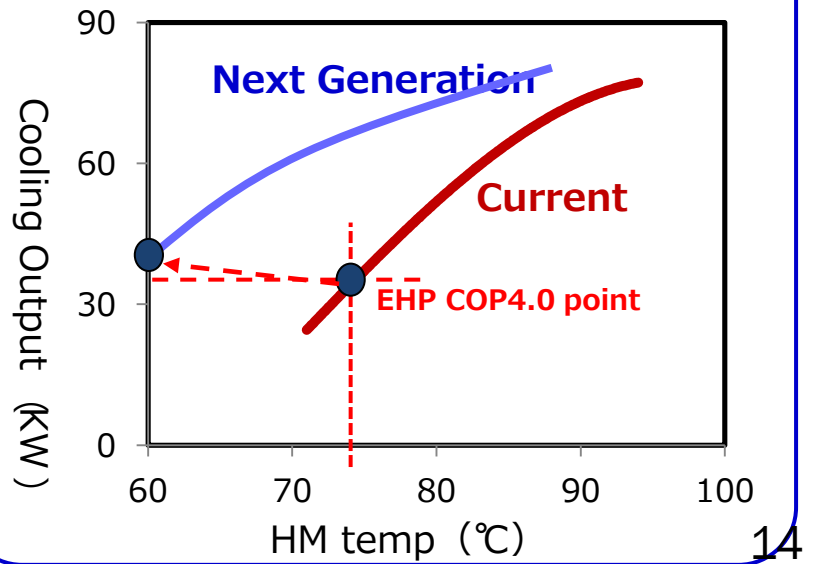
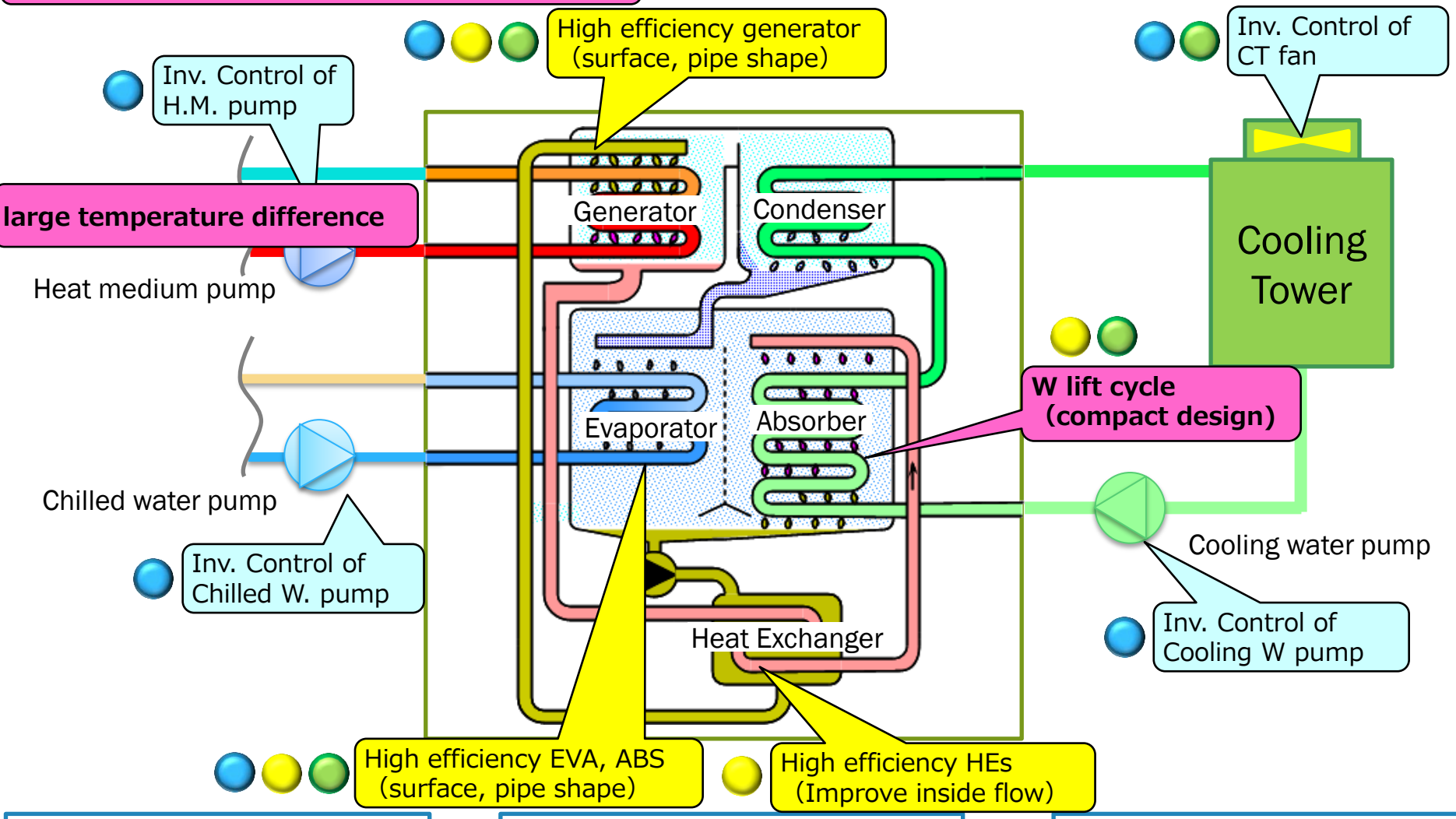


C:HM temperature



Next Generation WFC, Low-Temp. Driven Absorption Chiller

Low temperature H.M. by new solution

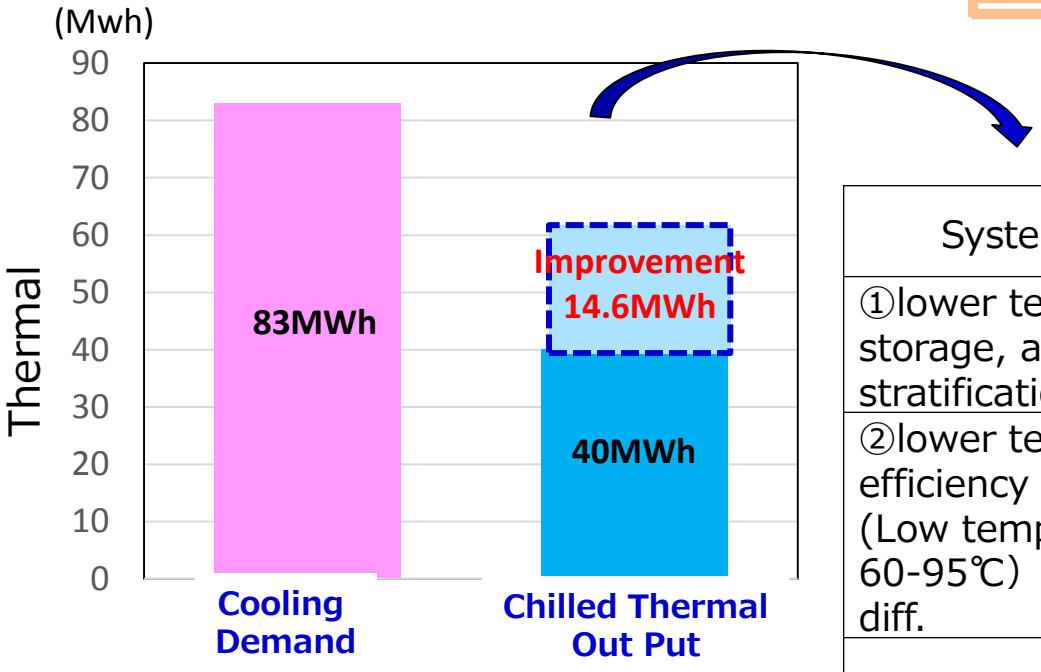


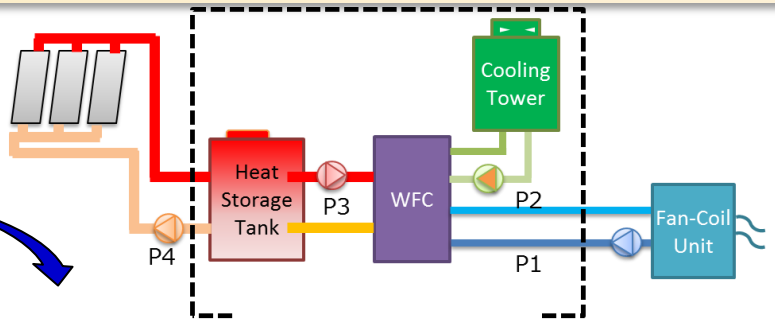
Increasing heat energy consumption in WFC

Improve efficiency of transfer Heat to Cooling

Reducing carrier power

System Improvement by Utilizing Unused Energy





System Improvement	Thermal Improvement
①lower temp. collection, large storage, and storage stratification	7.1MWh
②lower temp. driven and high efficiency WFC system COP (Low temp operation chiller 60-95℃) without large temp. diff.	7.5MWh
Total	**14.6MWh**

Solar Fraction：48% → 66%

Towards >90%

Further improvements are considering;

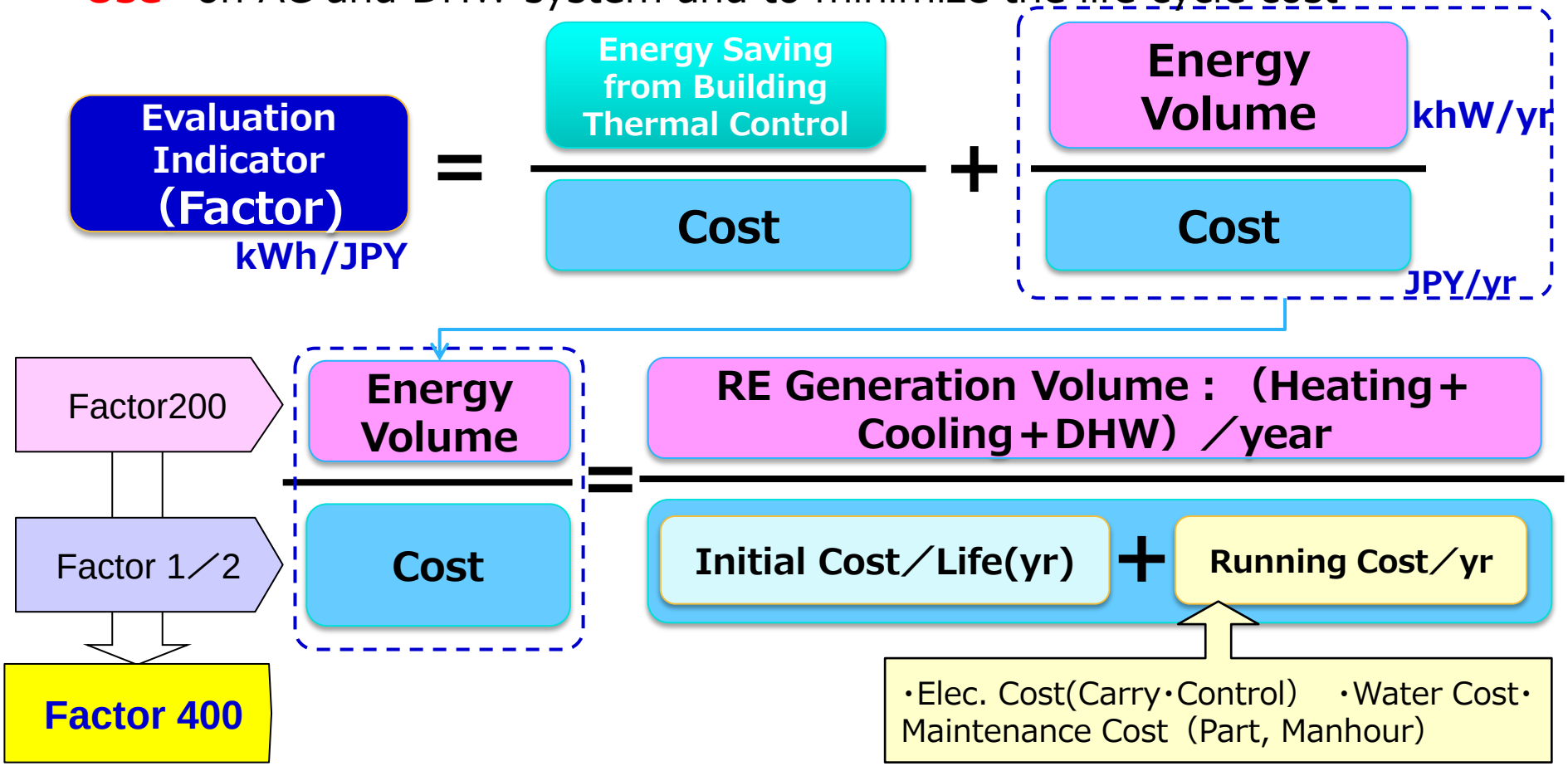
ex: lower flow rate operation system

ex: interchange thermal system etc..

4. Conclusions

【Concept : Challenge towards Factor400】

to maximize thermal energy value by adjusting the factor according to market needs and Maximize usage volume of RE thermal energy by considering **4 factor on thermal "Generate", "Carry", "Store" and "Use"** on AC and DHW system and to minimize the life cycle cost



Thank you!