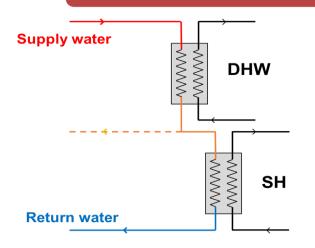
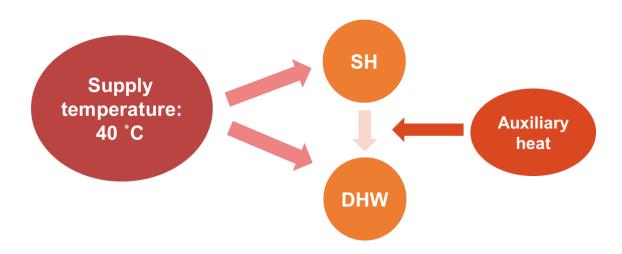
## INTRODUCTION

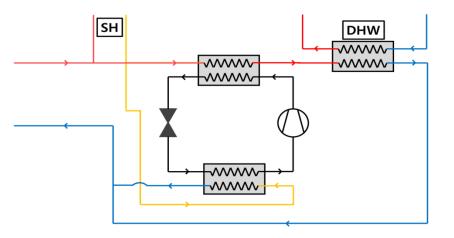
### **Cascaded Heat Supply**



- More energy-efficient way
- Low return temperature
- Auxiliary heat supplier is needed
- However if the system is poorly designed, cascaded heat supply would cause more energy use
- It is important to determine how to design the cascaded heat supply and how to control the auxiliary heat supply

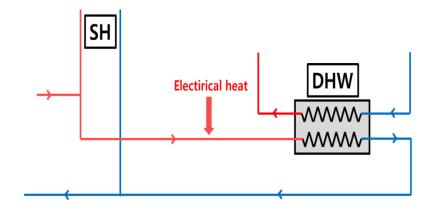


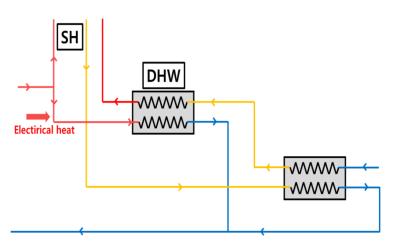
# **System Configurations**



S1: heat pump with cascade

S2: electrical heater with cascade



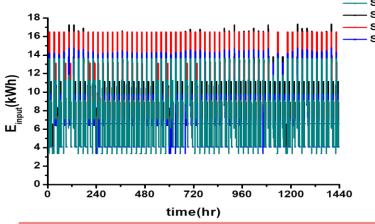


S3: electrical heater without cascade

S4: electrical heater with cascade for preheat

#### Results

#### Primary energy use



	110 -					rict heating tricity
ر آ	100 -					
	90 -					
	80 -					
	70 -					
E <sub>input</sub> (kWh)	60 -					
	50 -					
⊒ّس	40 -					
	30 -					
	20 -					
	10 -					
	0 -	S1	S2	<b>S</b> 3	\$4	_

	` '	
Scenario	Peak energy input(kWh)	Accumulated energy input(kWh)
<b>S1</b>	9.12	79.5
<b>S2</b>	17.3	97.5
<b>S3</b>	16.5	86.8
<b>S4</b>	14.7	79.8

- Although S1 needs more mass flow for heat source of heat pump, S1 shows the best system performance
- As shown in S3 and S4, the cascaded heat supply yields more benefit in the point of view of energy use

	Re	turn temperature	
	<sup>36</sup> 7	—— \$1 —— \$2	2
(၁	32 -		
	28 -	MID HADDIAAA TAAMAD MAADAA AA LAAHA HA HA LAAHA LAAHA L	
	24-	7 <sup>*</sup> 70,129,50,94444,1444,144,174,174,174,174,174,174,17	
T <sub>refur</sub>	20 -	W + L()     L   L   L   L   L   L   L   L   L	
	16-	Louter attending to controduction definition	
	12-		
	0	240 480 720 960 1200 1440	
		time(hr)	

Scenario	Return temperature(°C)	Heat loss(W/m)
<b>S1</b>	22.6	8.77
<b>S2</b>	30.95	10.49
<b>S3</b>	27.78	9.84
<b>S4</b>	26.26	9.53

- S1 has the lowest return temperature because of heat pump and cascaded heat supply
- S4 has lower return temperature than S3 because of cascaded heat supply