Innovative Cooling for the Tropics: Practices and Applications

Natflow Pte Ltd

technologies for people & environment

Passive Displacement Cooling (PDC)

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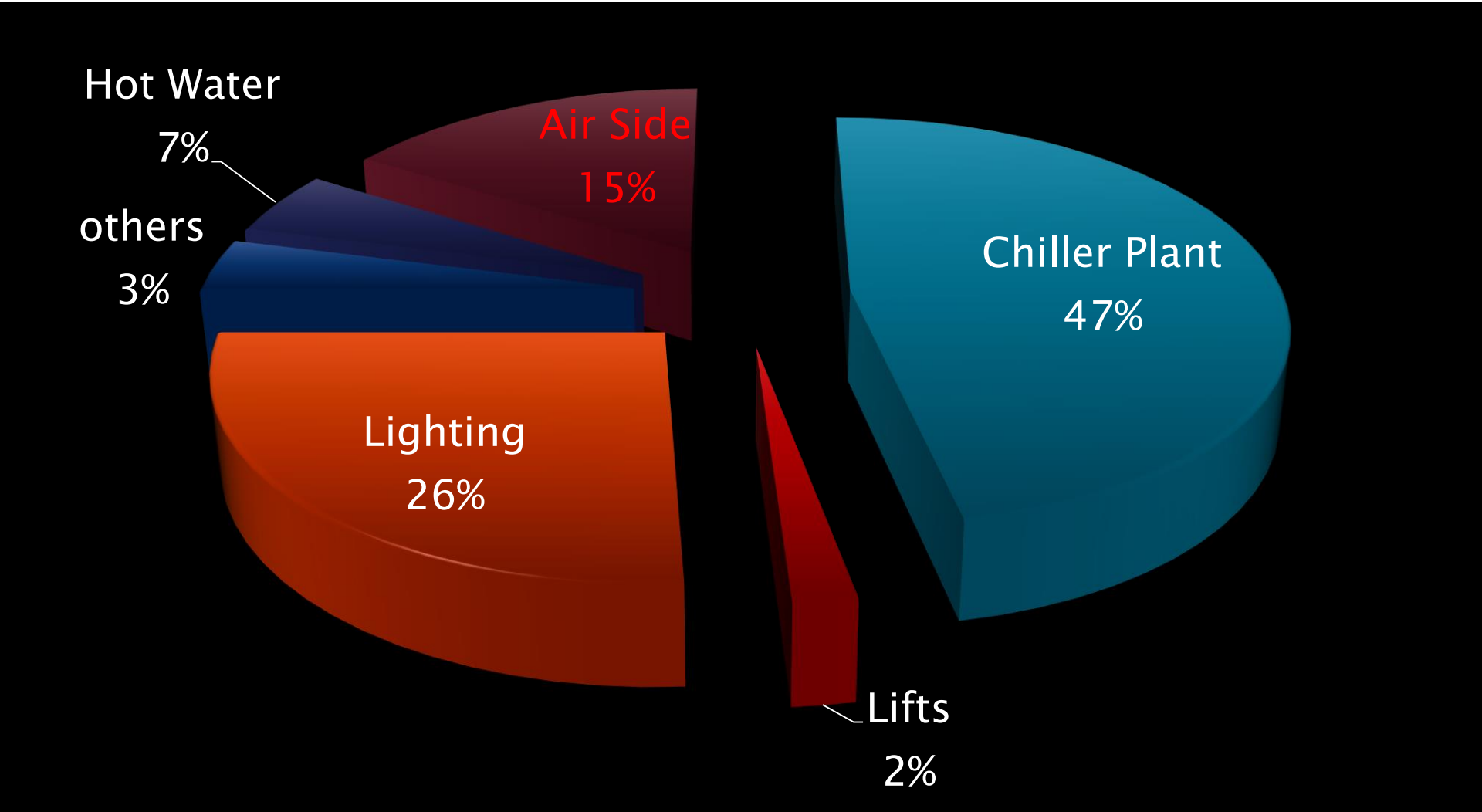
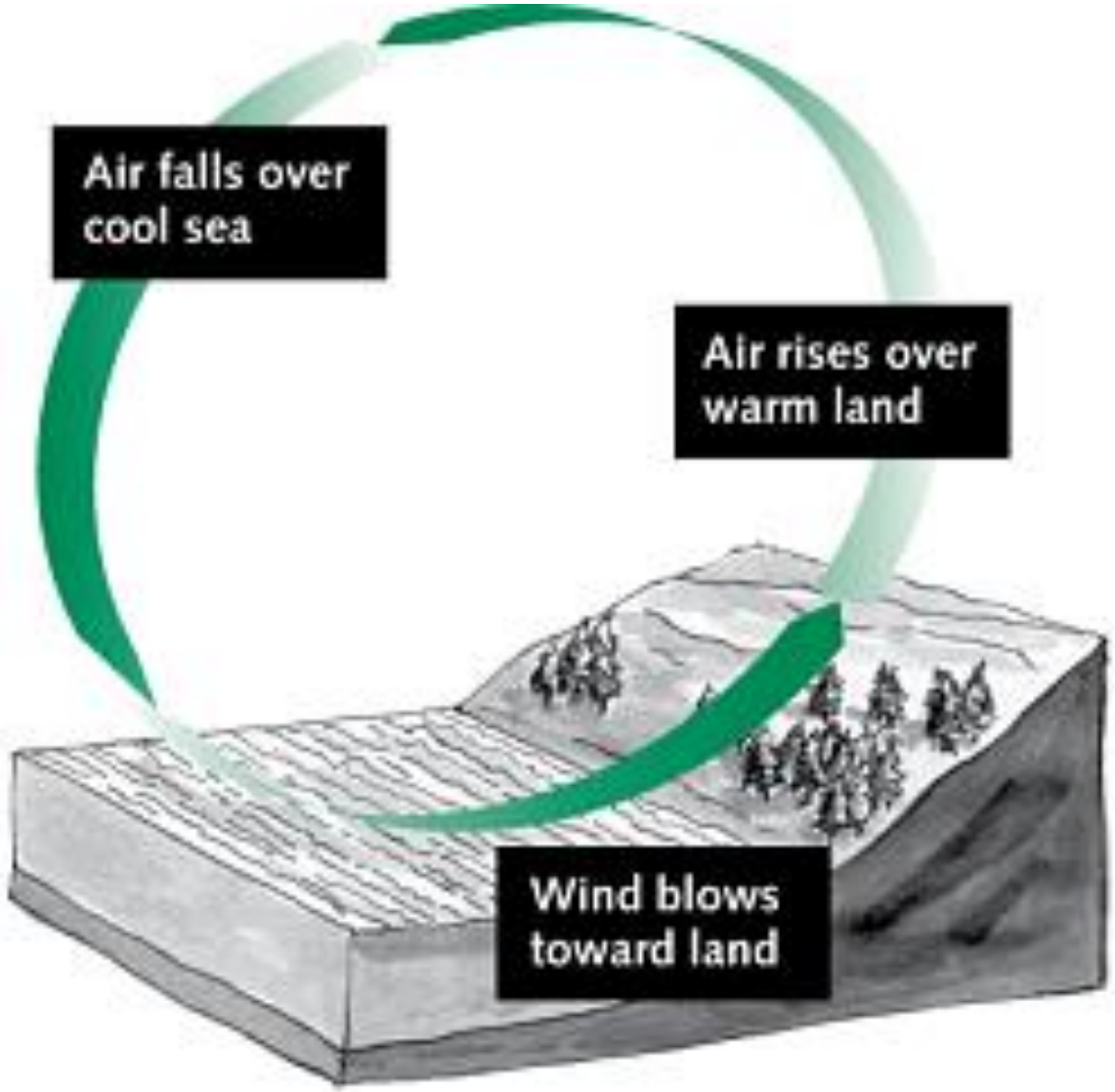
April 1, 2019

Removing the AHUs from this Chart

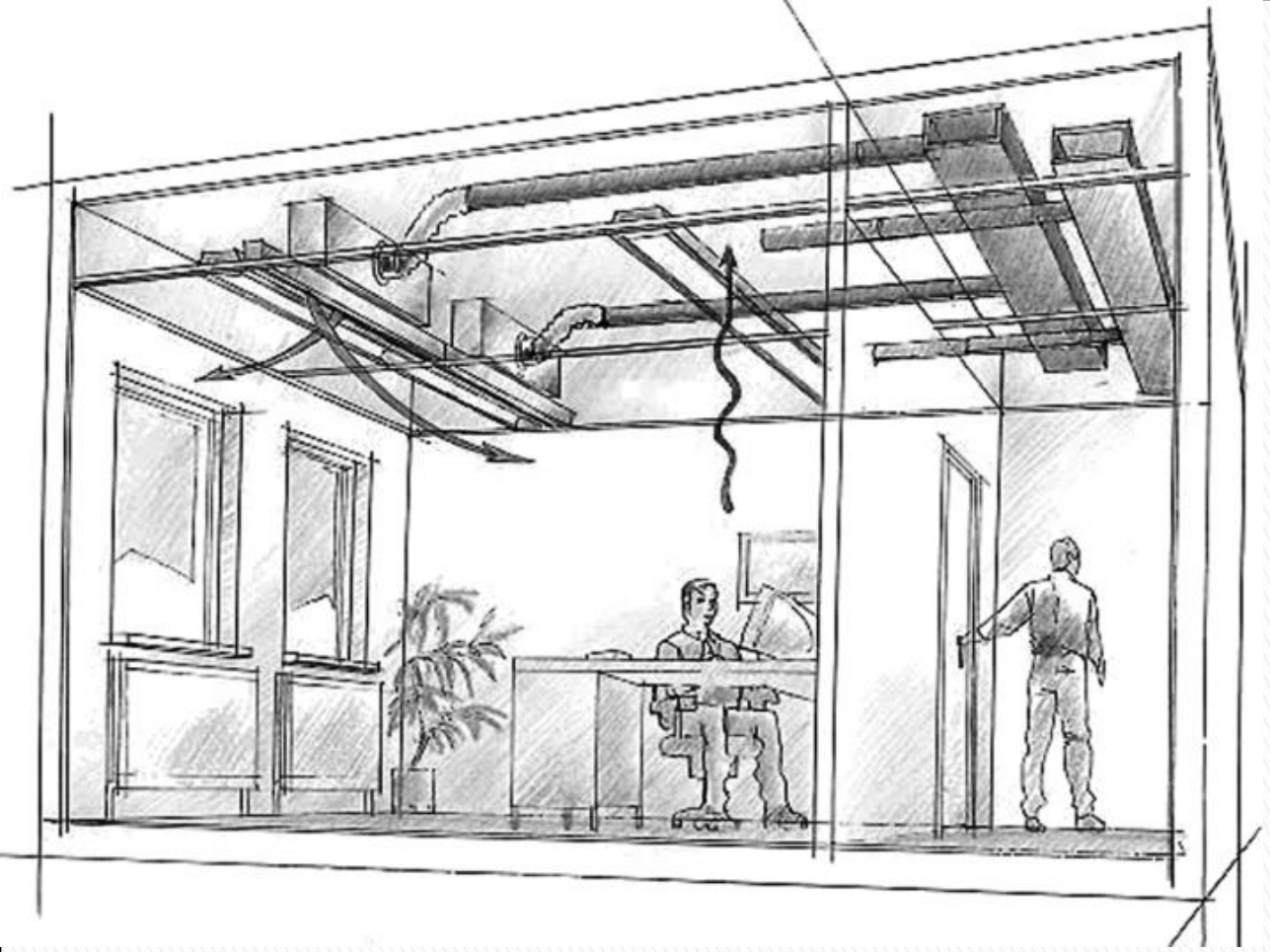


nature
at work



how it works

- ✓ nature at work
- ✓ hot air rise, cold air sink
  - kongming lantern
  - hot air balloon



No air duct

- the PDC system uses no duct and therefore reduces the provision of space above the false ceiling; in a building protected with sprinklers, there may not be a need for a second layer of sprinkler points if the ceiling space is kept below a 800mm-height. Many end-users are also happy with the indoor space with a high ceiling

No noise

– the PDC system needs no silencer nor a host of acoustic treatment in the duct and indoor space.

No draft

– since fans are not used, occupants seated anywhere in the room will not experience the draft effect commonly associated with AHUs / FCUs. PDC promises thermal comfort that is hard to match

common maintenance problems

Dust

common maintenance problems

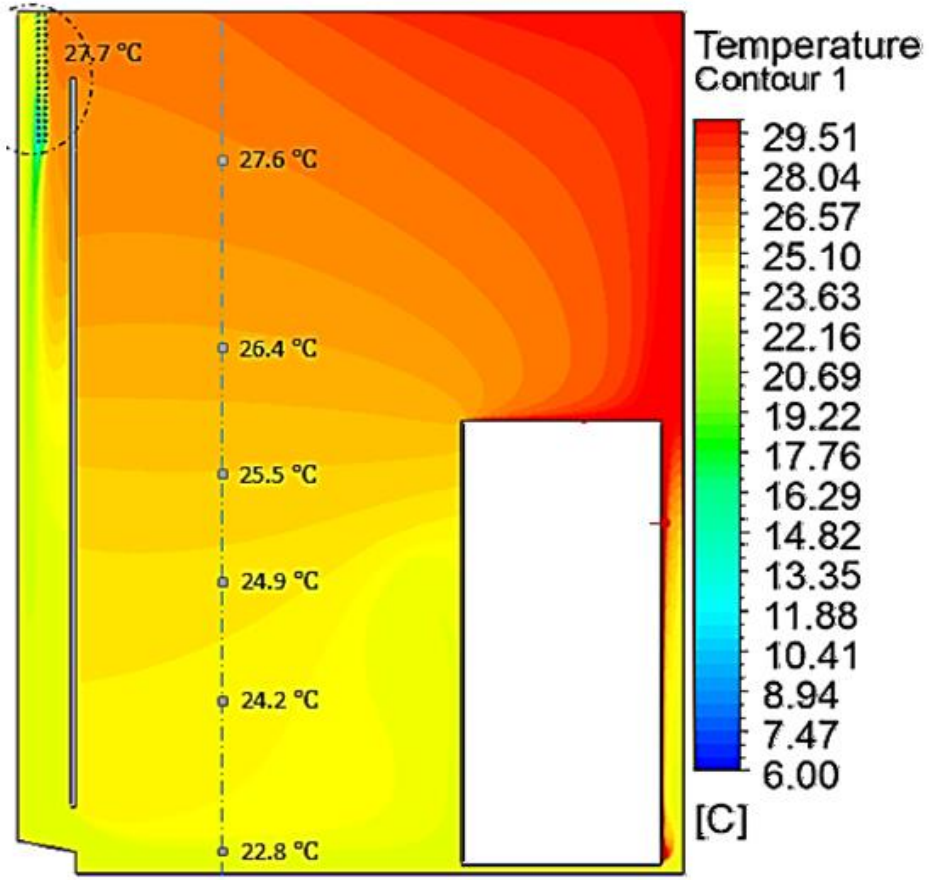
condensation

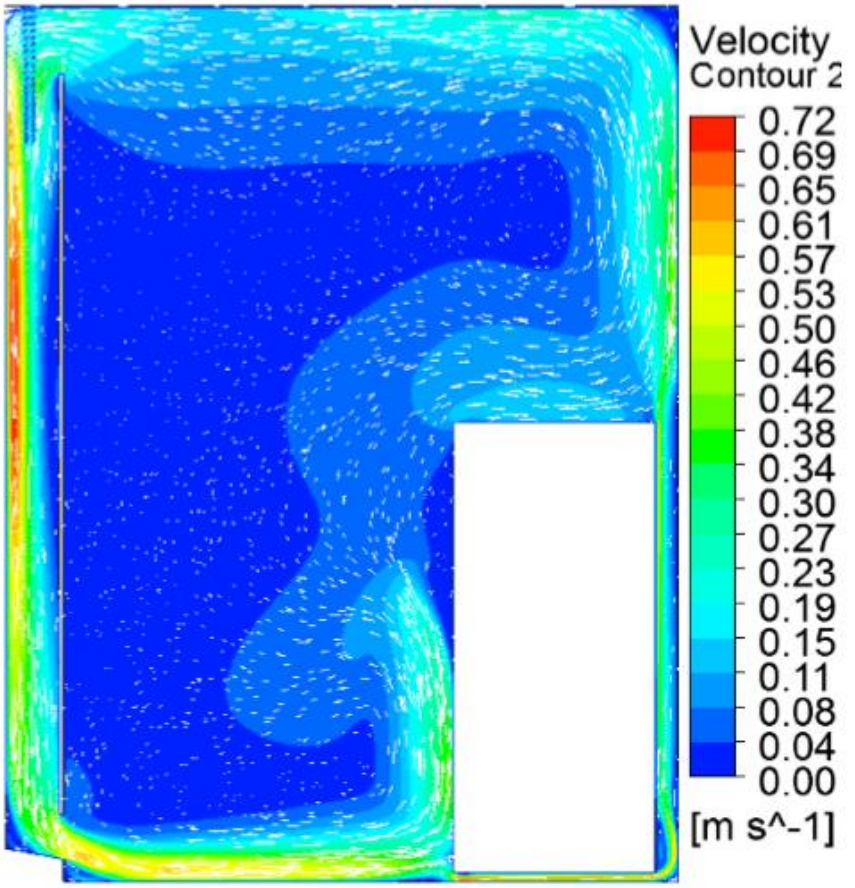
Less maintenance with PDC

– experience has shown that little, if any, dust is found on the cooling coils and therefore eliminating the need for regular cleaning or chemical cleaning.

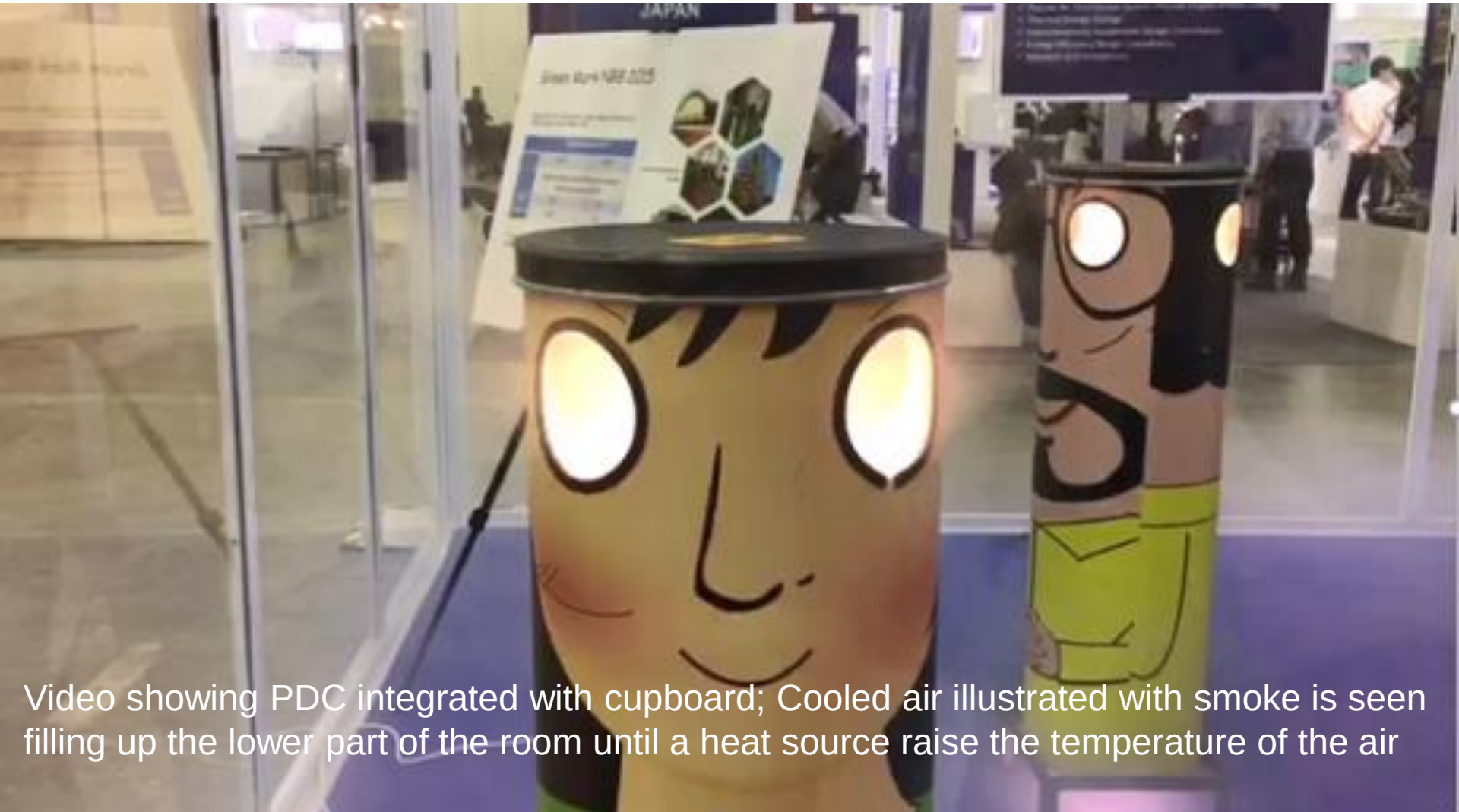
- *zero fan power;*
- *removed parasitic load;*
- *thermal stratification*

Computational Fluid Dynamics (CFD)





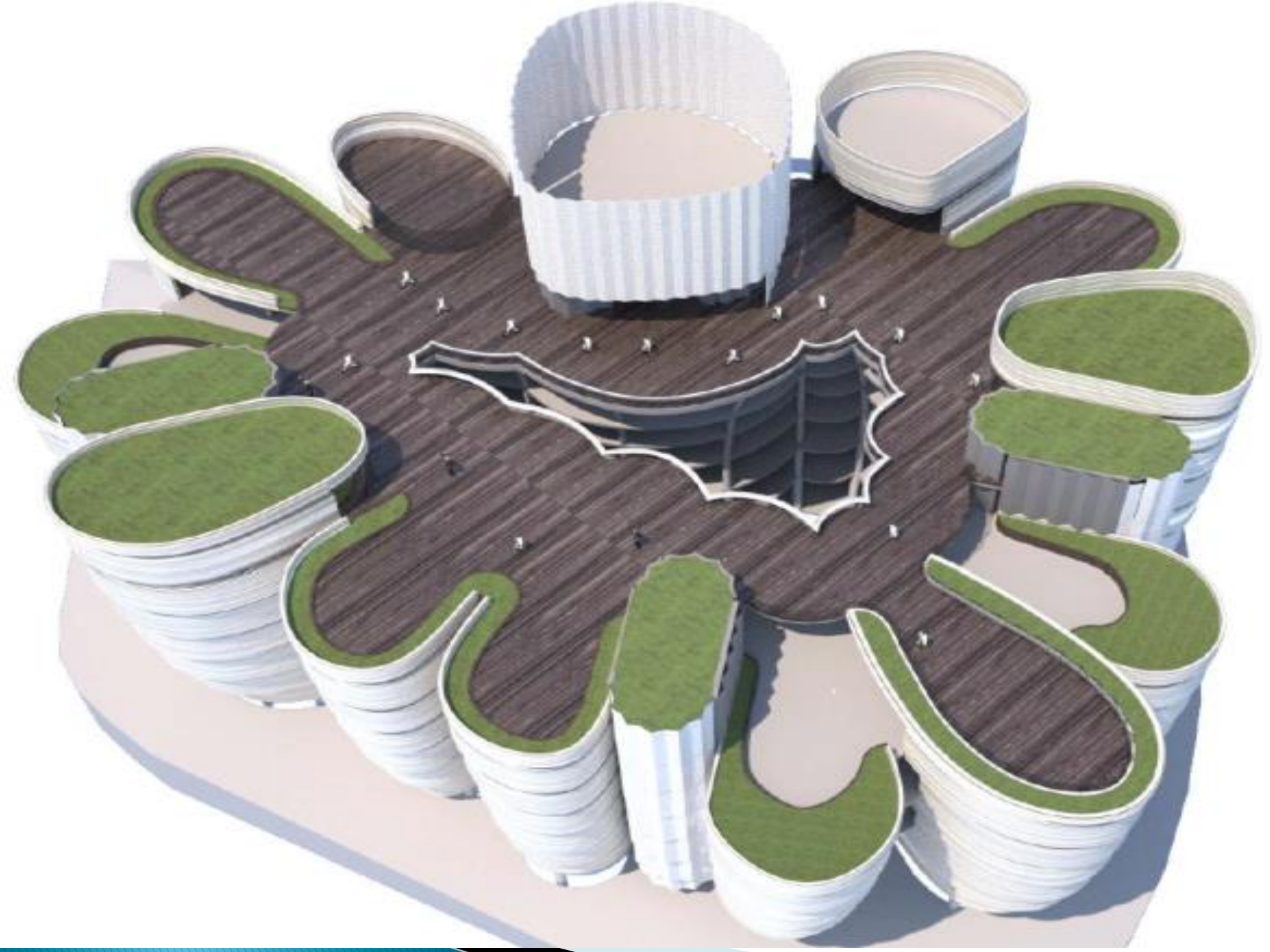
BEX Asia 2018

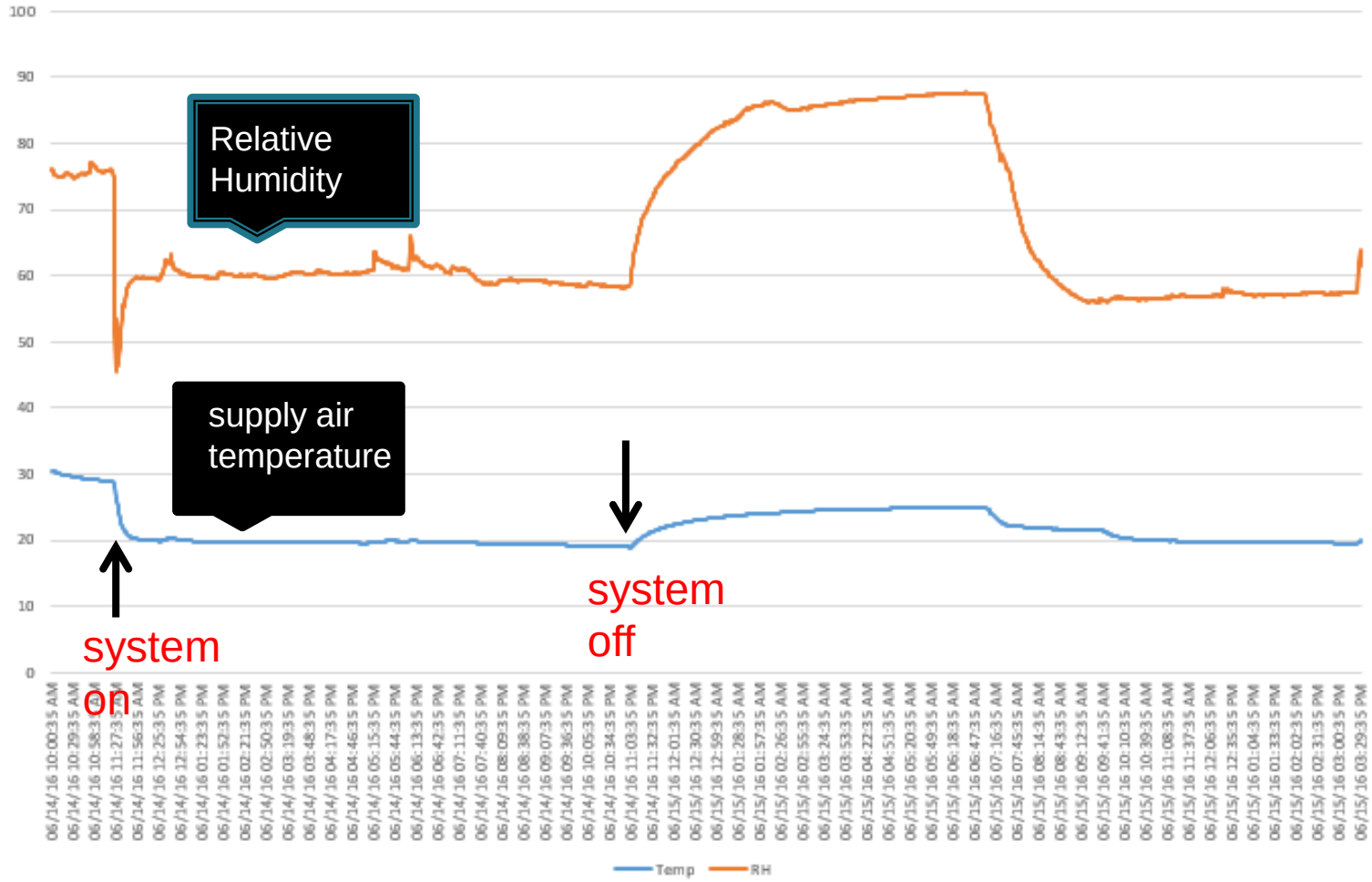


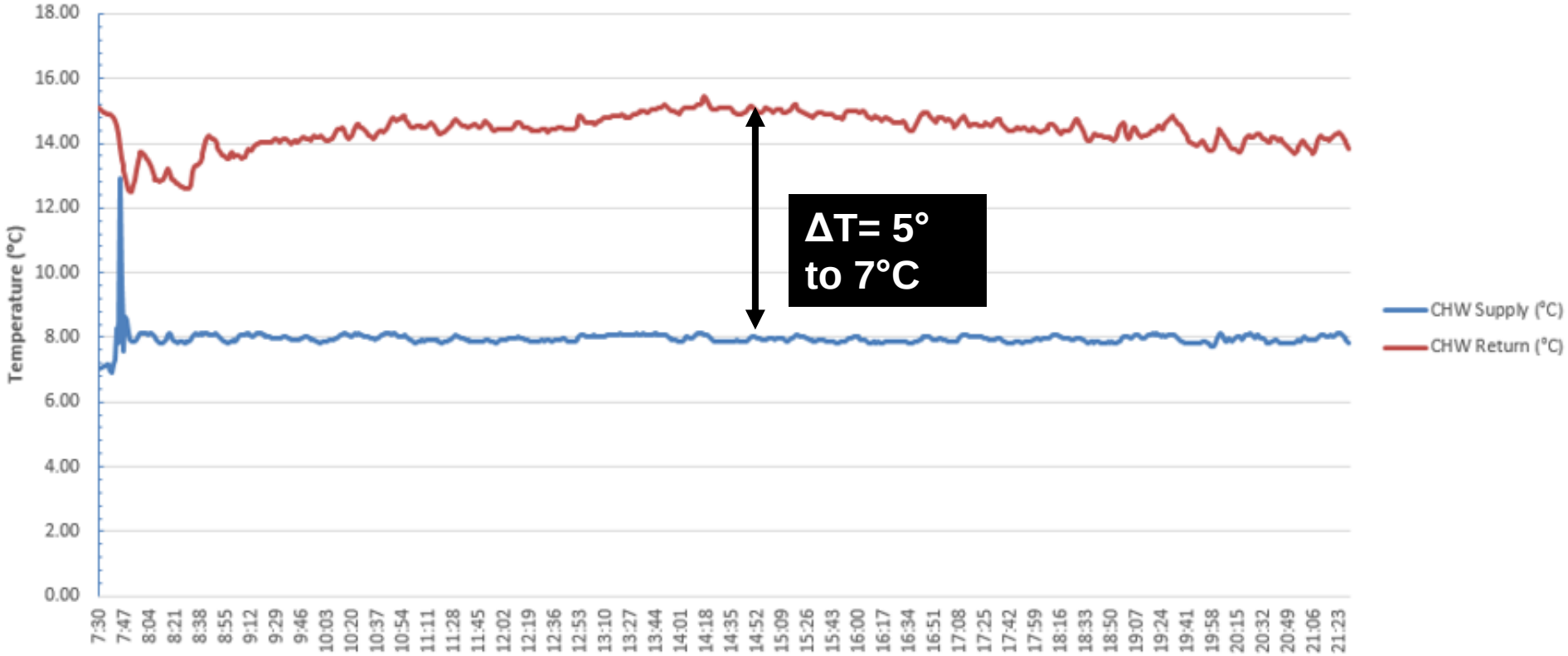
Video showing PDC integrated with cupboard; Cooled air illustrated with smoke is seen filling up the lower part of the room until a heat source raise the temperature of the air

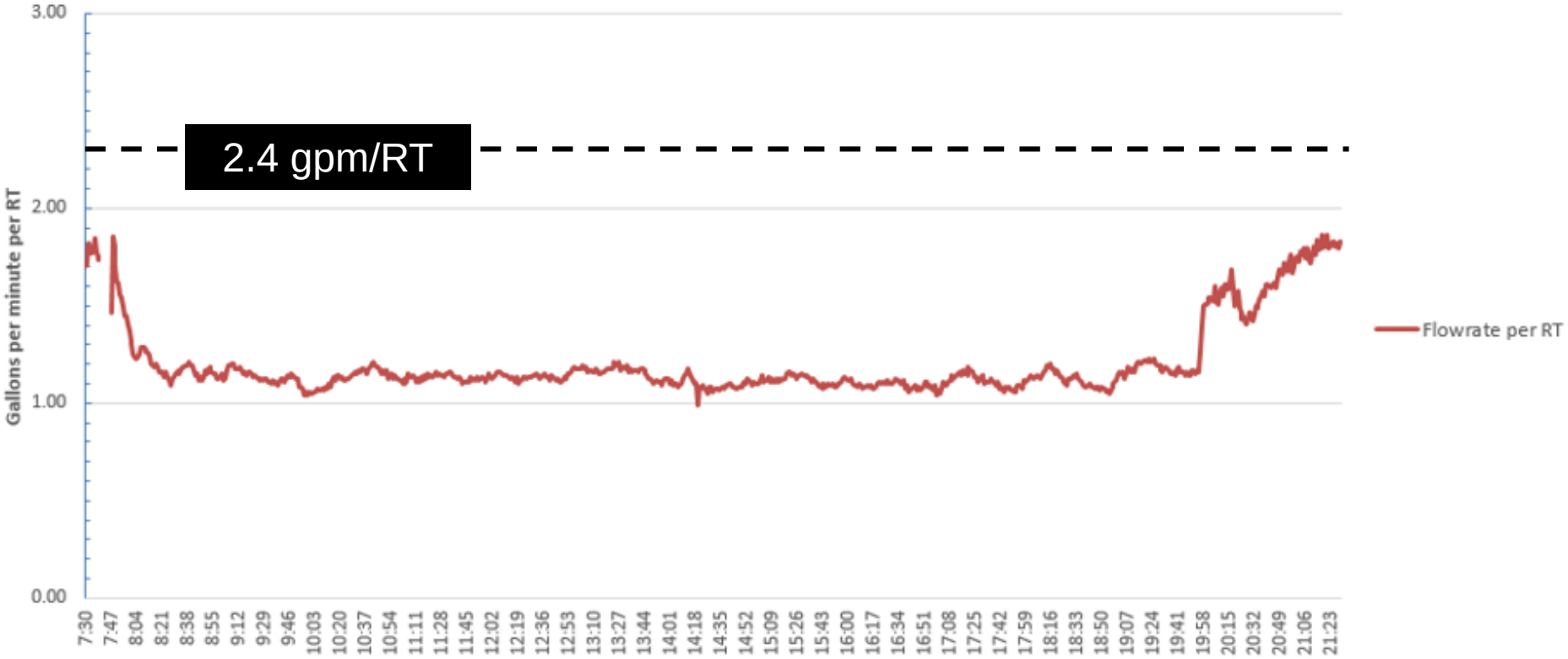
Performance

The Hive @ NTU




Relative Humidity
supply air temperature
system on
system off
Temp
RH


18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Temperature (°C)
7:30
7:47
8:04
8:21
8:38
8:55
9:12
9:29
9:46
10:03
10:20
10:37
10:54
11:11
11:28
11:45
12:02
12:19
12:36
12:53
13:10
13:27
13:44
14:01
14:18
14:35
14:52
15:09
15:26
15:43
16:00
16:17
16:34
16:51
17:08
17:25
17:42
17:59
18:16
18:33
18:50
19:07
19:24
19:41
19:58
20:15
20:32
20:49
21:06
21:23
ΔT= 5° to 7°C
CHW Supply (°C)
CHW Return (°C)


3.00
2.00
1.00
0.00
Gallons per minute per RT
2.4 gpm/RT
Flowrate per RT
7:30
7:47
8:04
8:21
8:38
8:55
9:12
9:29
9:46
10:03
10:20
10:37
10:54
11:11
11:28
11:45
12:02
12:19
12:36
12:53
13:10
13:27
13:44
14:01
14:18
14:35
14:52
15:09
15:26
15:43
16:00
16:17
16:34
16:51
17:08
17:25
17:42
17:59
18:16
18:33
18:50
19:07
19:24
19:41
19:58
20:15
20:32
20:49
21:06
21:23

PDC Performance (water-side)

- Chiller efficiency : 0.520 kW/rt
- Chilled water pump η : 0.035 kW/rt
- Condenser water pump η : 0.035 kW/rt
- Cooling Tower Fan η : 0.018 kW/rt
- Plant efficiency (water side) : 0.608 kW/rt

The total air-conditioning design system efficiency shall not exceed the following:

Table P.28-1 Air Conditioning Total System Efficiency for Water Cooled Chilled Water plants

	Building Cooling Load (RT)	
	<500RT	⩾500RT
	Minimum Design System Efficiency including air distribution system (kW/RT)	
Gold^{PLUS}	0.95	0.9
Platinum	0.93	0.9

Table P.28-1 Air Conditioning Total System Efficiency for Air Cooled Chilled Water plants & Unitary Systems

	Building Cooling Load (RT)	
	<500RT	⩾500RT
	Minimum Design System Efficiency including air distribution system (kW/RT)	
Gold^{PLUS}	1.10	Total System Efficiency must demonstrate equivalency with Table P.28-1
Platinum	1.03	

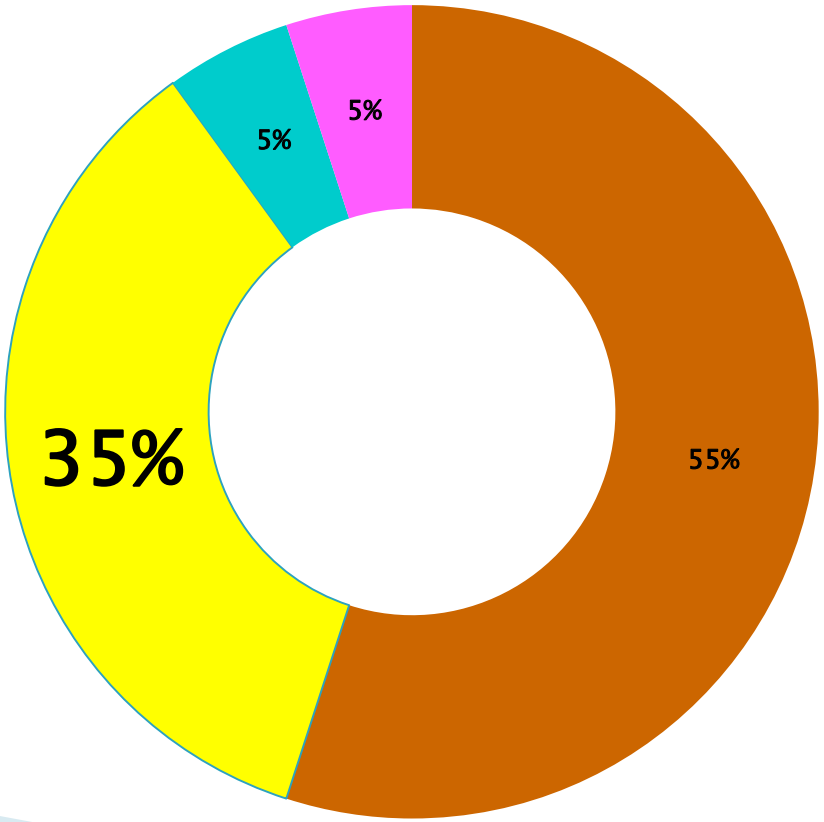
The air distribution system efficiency for Gold^{PLUS} and Platinum projects should not exceed 0.25kW/RT Except where there are instances of systems with high pressure drops, in which case with BCA's approval, the fan system input power can be adjusted based on table 2a and 2b under SS553: 2015. The total system efficiency (kW/RT) will be adjusted accordingly

Air Conditioning Total System Efficiency

- water side efficiency : 0.608 kW/rt
- air side efficiency[1] : 0.000 kW/rt (passive systems)
- air conditioning
  total system efficiency : 0.608 kW/rt

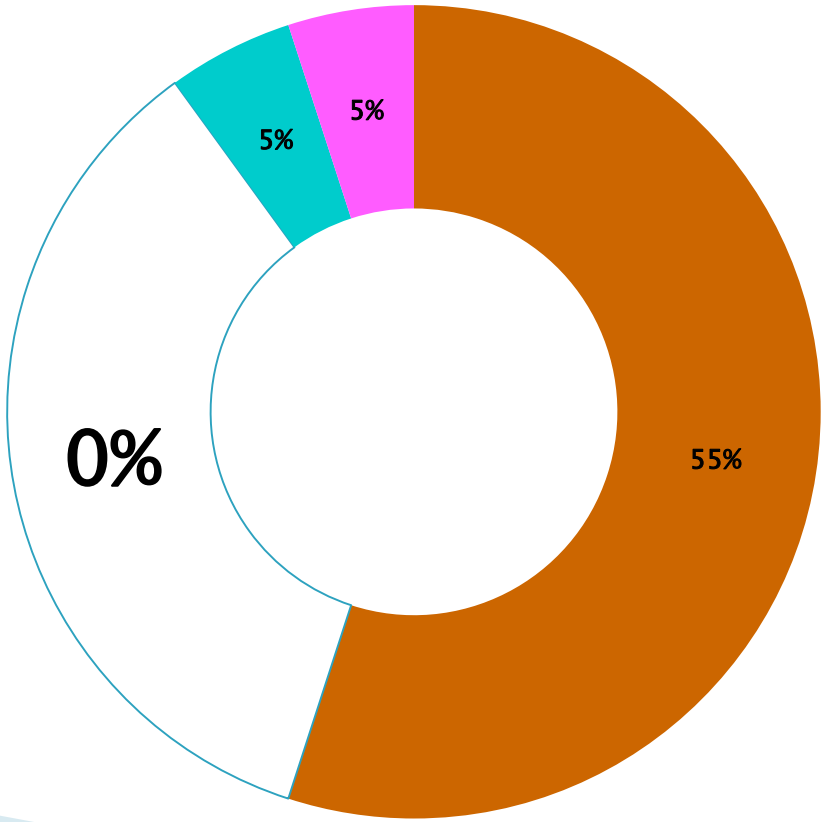
[1]not including fan for fresh air intake

Zero Energy on Air Side



- fans are known to consume as much as 15% of all energy used in buildings;

Zero Energy on Air Side



- ***No fan*** –the PDC system uses no fan which means a potential savings of as much as 15%

Early Adopters

MOM Services Centre

Multiple Purpose Hall

Entrance Lobby

The Hive @ NTU

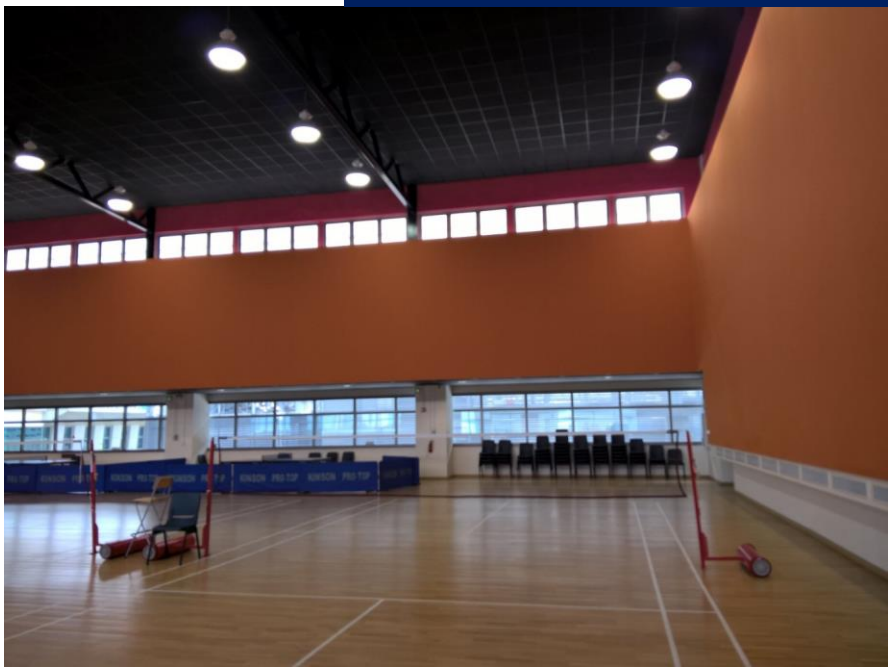
The Library

56 Classrooms

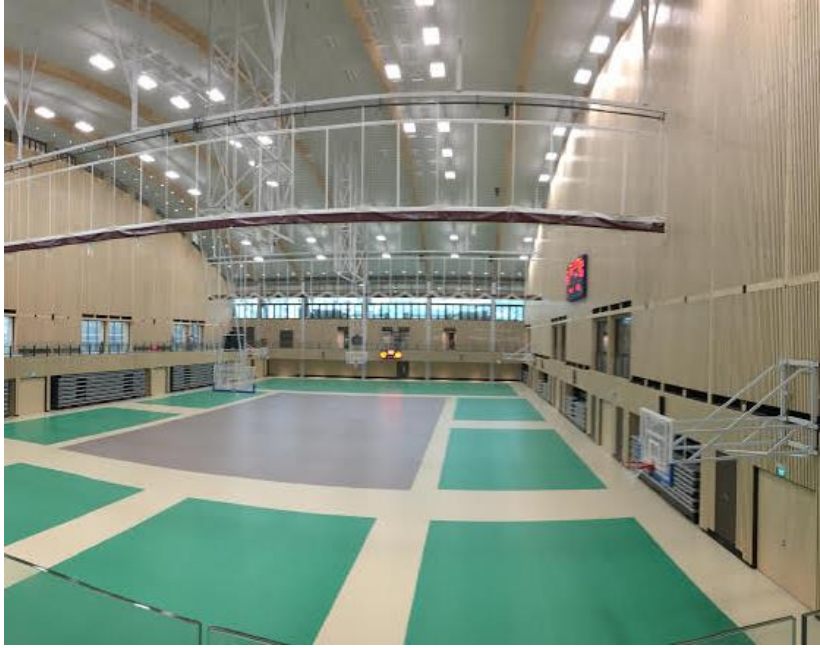
The Shugart

Gymnasium

Multiple Purpose Hall



The Wave @NTU



The Wave @ NTU

Stress test

More than 1,000 students attended an event over 4 hours

Achieved design conditions

24° ± 1°C

< 65% RH

Total AC system efficiency

water side : 0.6 kW/RT

air side : 0.0 kW/RT

The Wave
Nanyang Technological University

Smoke-illustrated air flow during T&C

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