Cooling-as-a-service overview

Commercial models in Singapore and core benefits of DCS

8th May 2023 – UNEP delegates to KI@Changi

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Agenda

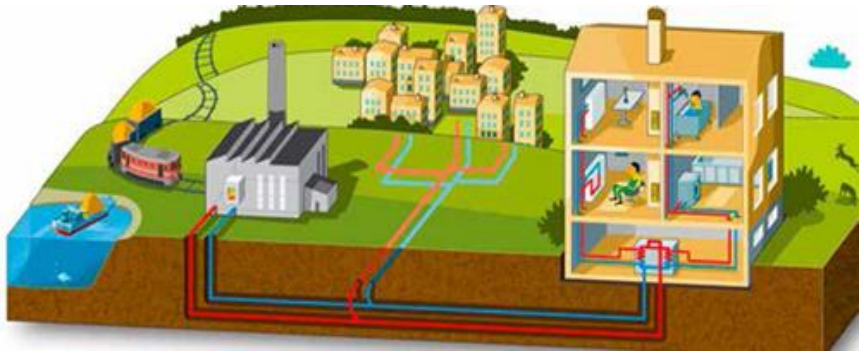
- Overview of District Cooling System (DCS)
- Key Benefits of DCS
  - Thermal Energy Storage (TES)
    - Load shifting
    - Types of TES tanks
    - Phase Change Material (PCM) TES
  - Urban Heat Island (UHI) Effect Mitigation
  - Enhanced Reliability

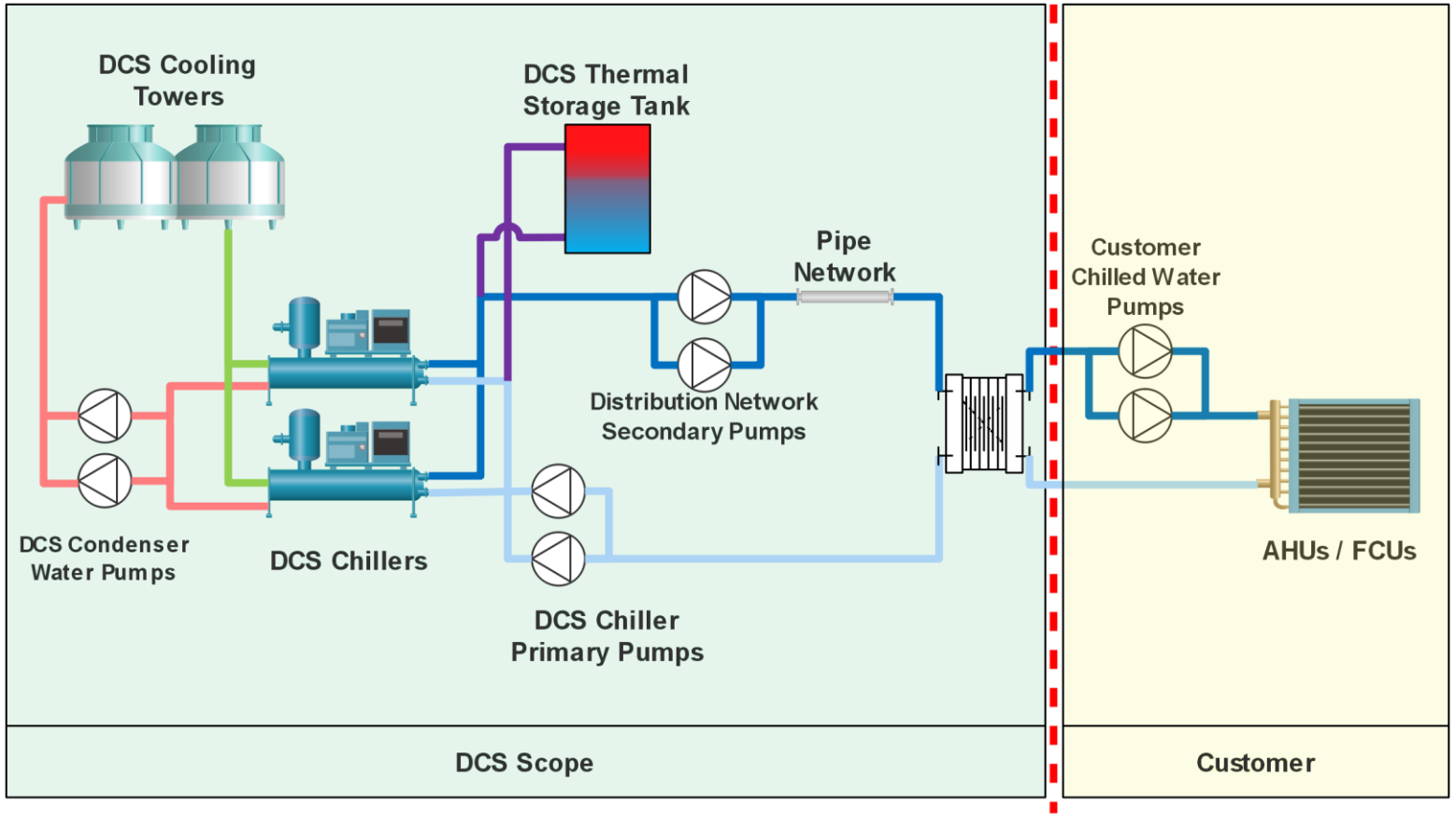
Overview of District Cooling System (DCS)

Park/District Level

District Cooling

since 2000





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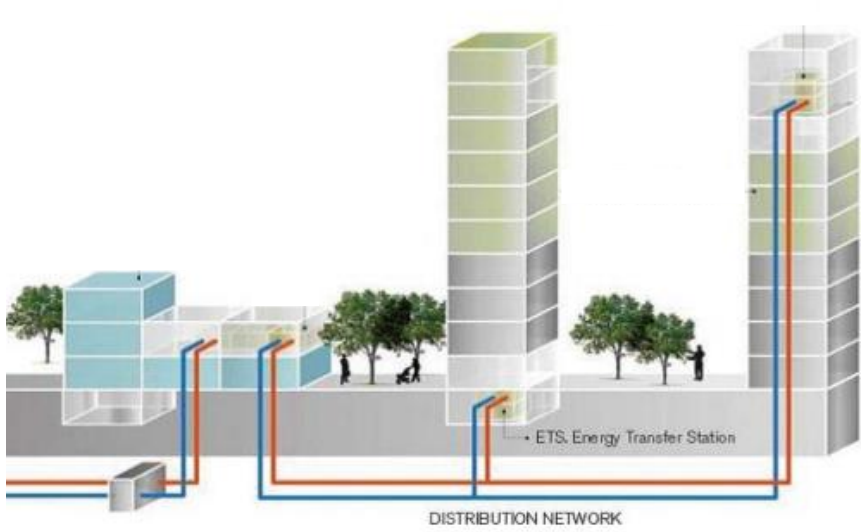
Key Benefits of DCS

Highly Efficient DCS Plant
Optimal Utilization of chiller system

Thermal Energy Storage (TES)
Demand Side Management

Highly Reliable
Multi-layered redundancies

Up to 40% energy savings compared to a conventional in-building chilled water system



Renewable Sources
Solar

Land Intensification
Fully underground DCS plant

CAPEX and OPEX Savings
Sharing of resources and lower production cost

Free up GFA and roof-top space

Better Aesthetics
Reduced heat, vibration and noise pollution

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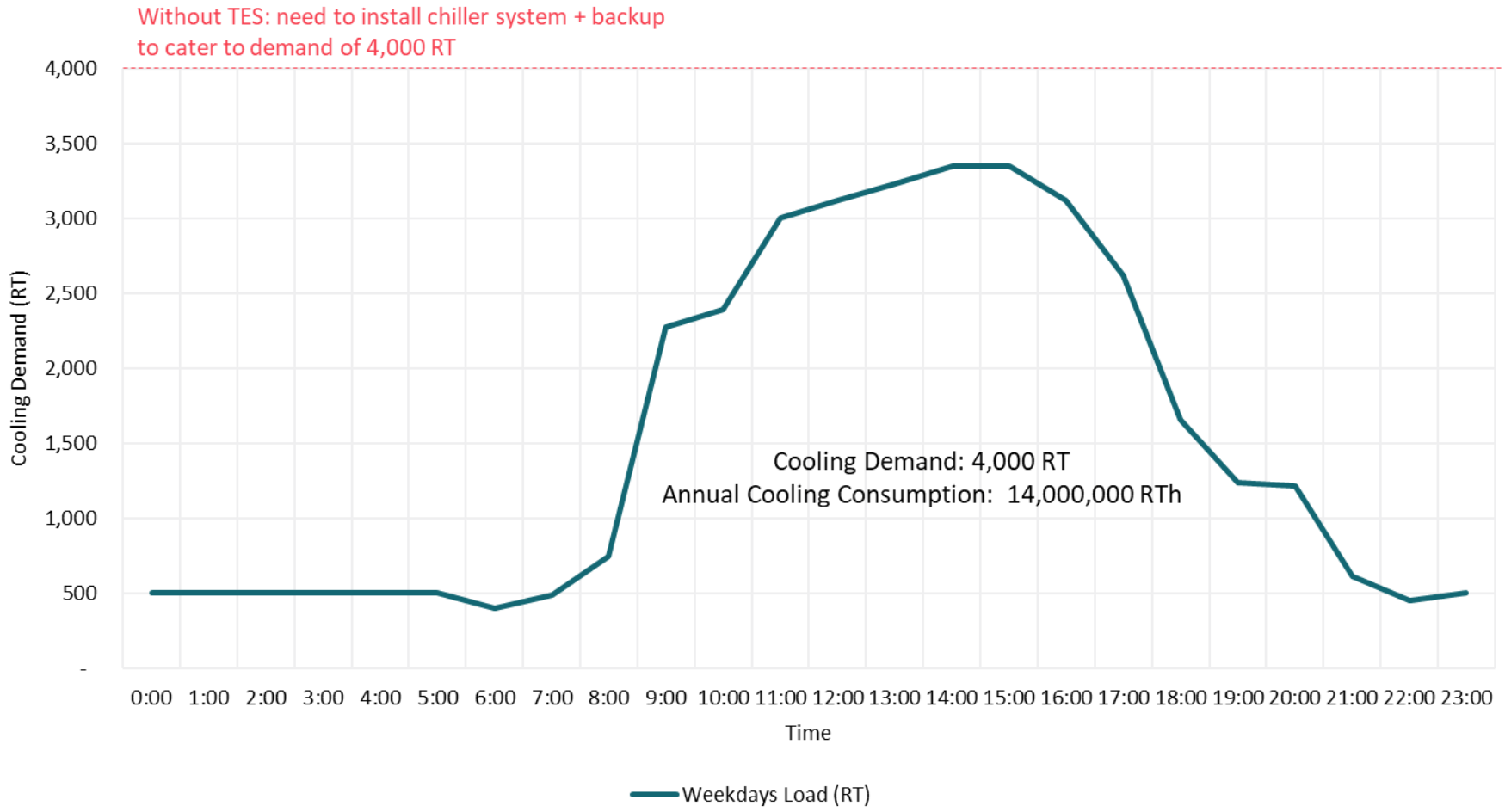
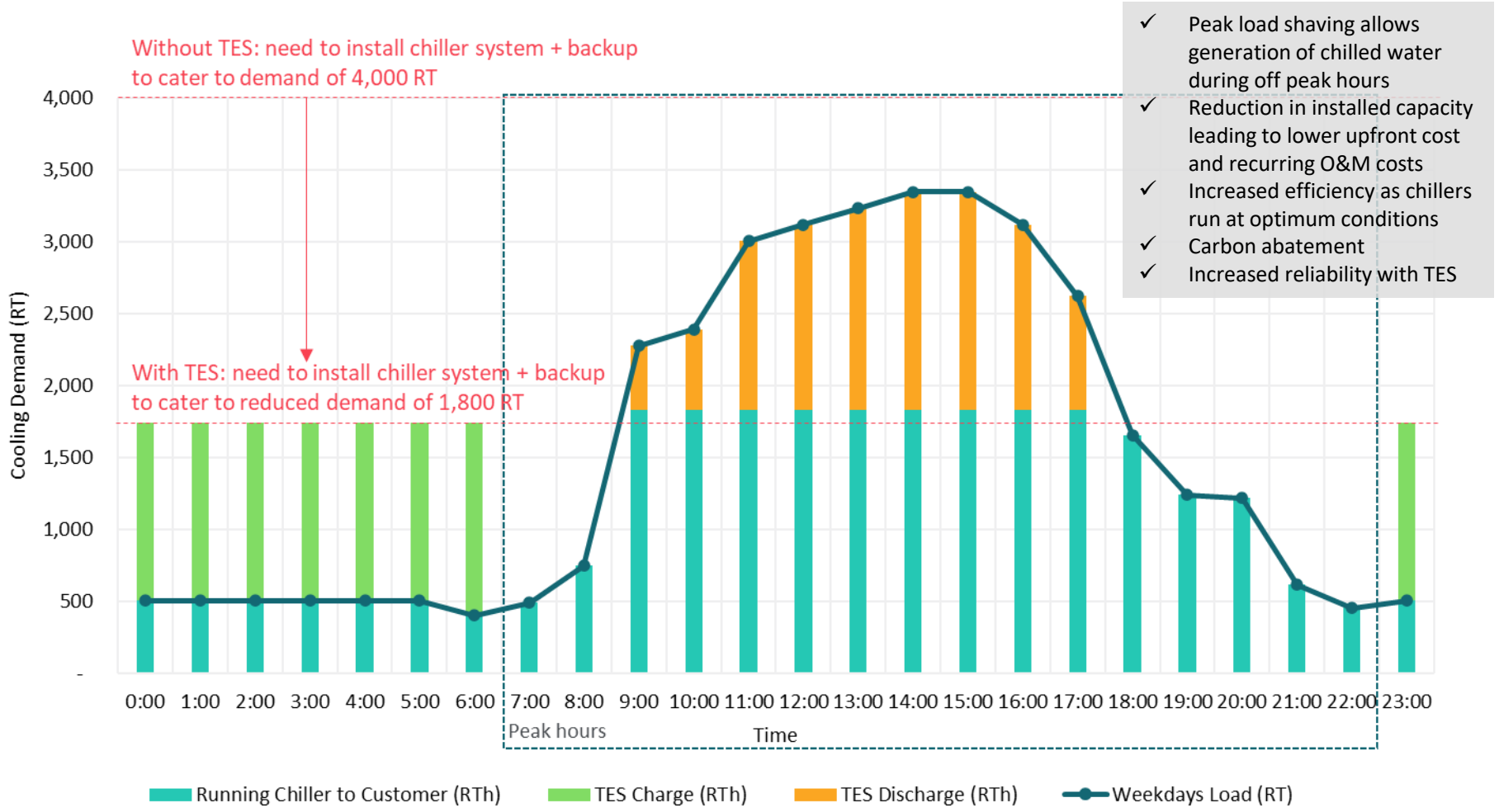
Load Profile of a Building

- From the sample load profile below, there is a need to install chiller system + back up to cater to demand of 4,000 RT



Load Shifting with Thermal Energy Storage (TES) Tank

With a 10,000 RTh TES tank, the chiller system will only have **to cater to a reduced demand** of 1,800 RT now



- ✓ Peak load shaving allows generation of chilled water during off peak hours
- ✓ Reduction in installed capacity leading to lower upfront cost and recurring O&M costs
- ✓ Increased efficiency as chillers run at optimum conditions
- ✓ Carbon abatement
- ✓ Increased reliability with TES

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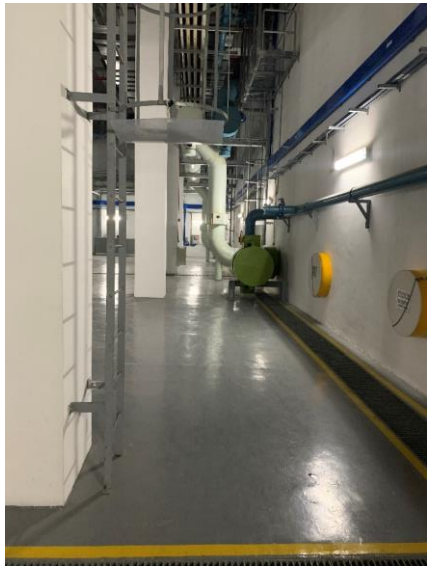
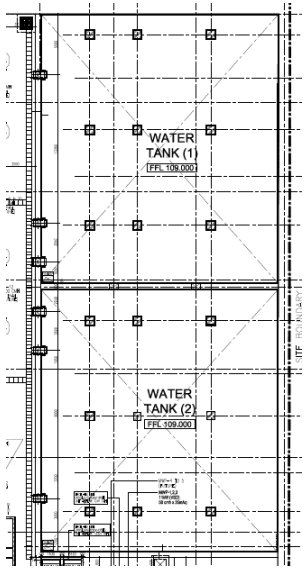
External Circular TES Tanks

6,250 RTh per tank

Reference photos: KDHCS Woodlands

Concrete building-integrated TES Tanks





Each tank's dimensions:

Parameters	Units	Values
Capacity	RTh	10,000
Length	m	24
Width	m	22
Height	m	13

Internal Circular TES Tanks

Biopolis: Total of 16,000RTh of storage

Tank Dimensions

Parameters	Units	Values
Capacity	RTh	10,000
Height	m	22.8
Diameter	m	16.8

Excluding space required for piping, pumps and clearance, etc.

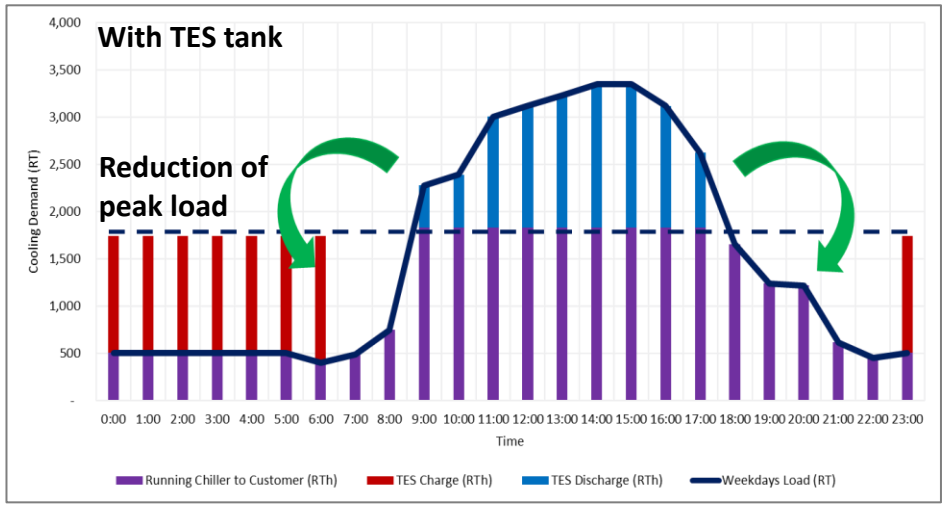
Reference photos: KDHCS Biopolis

Our proprietary technology in TES PCM has resulted in greater efficiency and better energy management

Overview of Keppel's proprietary PCM TES

✓ PCM-TES has a higher thermal charging temperature of around 8°C as compared with < 0°C for conventional ice storage technology. This allows operating the chillers at **better efficiencies** compared to Brine Chiller operating efficiency.

Thermal Energy Storage (TES) tank loading shift



Leverages on the peak/off-peak tariffs to charge up the tank during off-peak hours and discharge chilled water during peak hours

Coupled with KDHCS' optimization program, chillers can run at their **optimal load**

Patented TES technology which uses a novel **Phase Change Material (PCM) to boost energy efficiency of DCS**

Case study

Changi Business Park (CBP) DCS plant

Process

1. The TES tank incorporates PCM within the existing chiller systems
2. PCM releases cold energy by changing from solid to liquid when demand is needed
3. The cold energy is distributed via chilled water to buildings at CBP

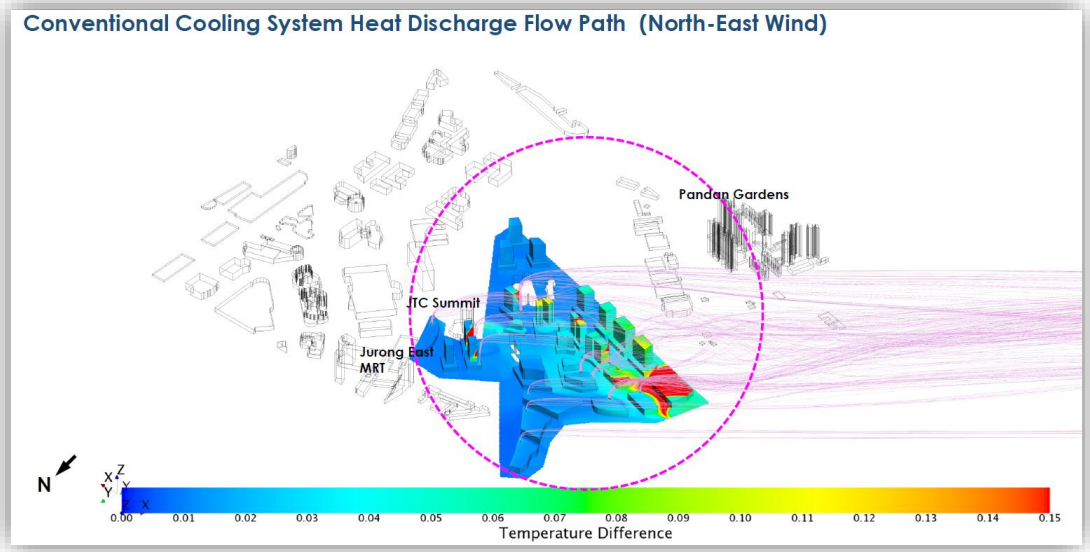
PCM key figures

3x more energy carrying capacity than water, resulting in greater efficiency and space savings

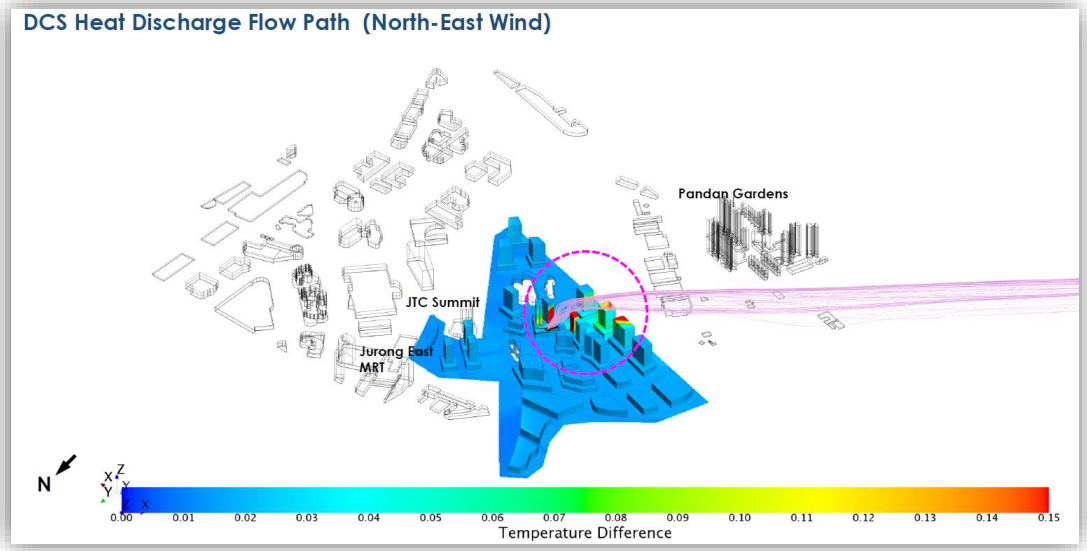
>10% annual cost savings achieved during trial at Changi Business Park DCS plant

Urban Heat Island (UHI) Effect Mitigation

Conventional Cooling System Heat Discharge Flow Path (North-East Wind)



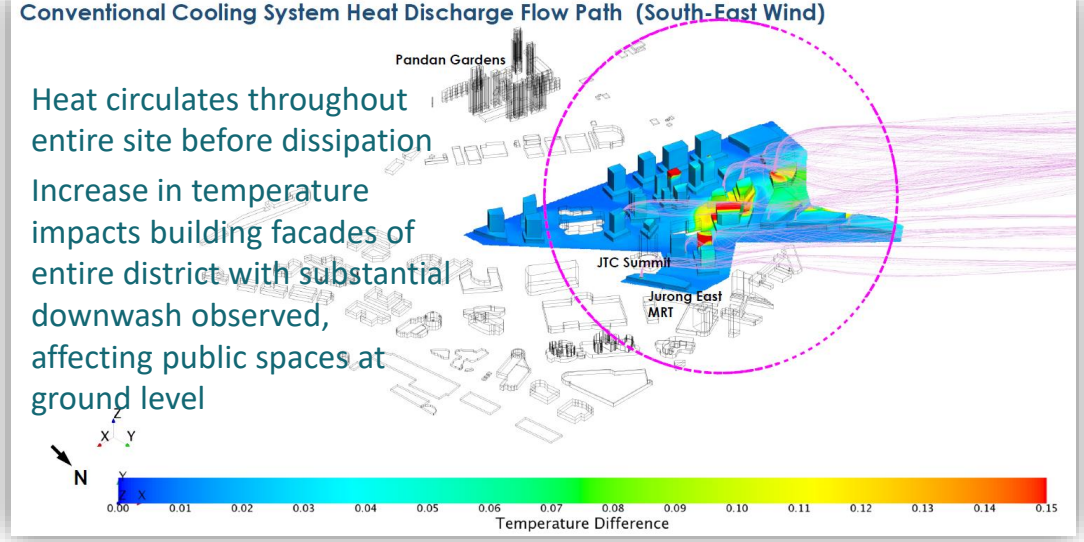
DCS Heat Discharge Flow Path (North-East Wind)



Conventional Cooling System Heat Discharge Flow Path (South-East Wind)

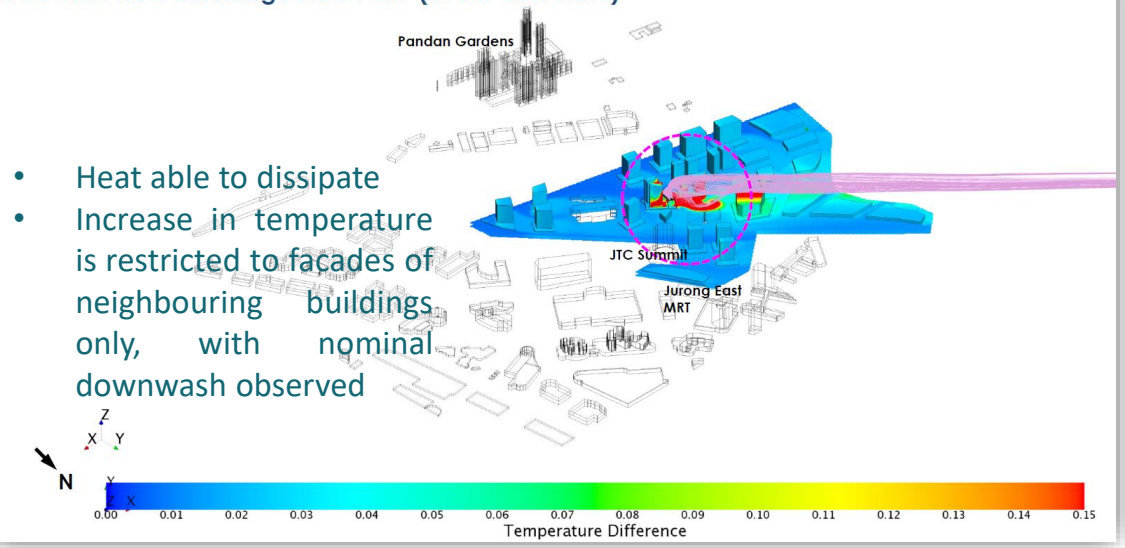
Heat circulates throughout entire site before dissipation

Increase in temperature impacts building facades of entire district with substantial downwash observed, affecting public spaces at ground level



DCS Units Heat Discharge Flow Path (South-East Wind)

- Heat able to dissipate
- Increase in temperature is restricted to facades of neighbouring buildings only, with nominal downwash observed



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DCS is a mature technology and provides enhances reliability

Reliability enhanced by….

Backup Diesel Generators

Thermal Energy Storage Tank

Proactively managing risks, to ensure…

Capability to control operations from Nerve Centre

High-grade insulated transmission pipelines

A high degree of reliability