APEC Workshop on District Cooling and/or Heating Systems

EWG 08 2019S

HKGBC 香港綠色建築議會 ARUP

Two Decades of DCS Implementation in Hong Kong

Dr Vincent Cheng,

Director of Hong Kong Green Building Council

Director of Sustainability of Arup

DISTRICT COOLING SYSTEM

1

Background

2

DCS Implementation

3

Engineering Challenge

Commitment

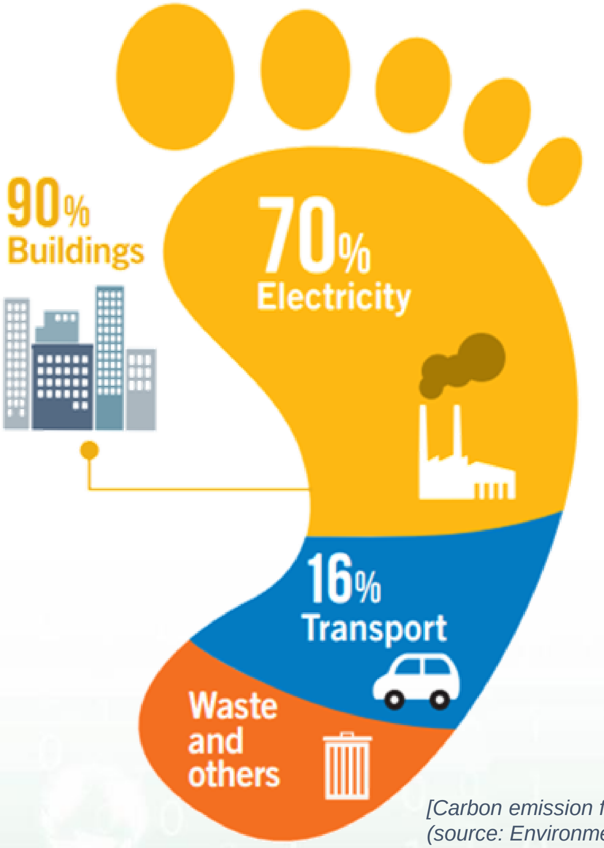
[www.international-climate-initiative.com]

[https://www.climateready.gov.hk]

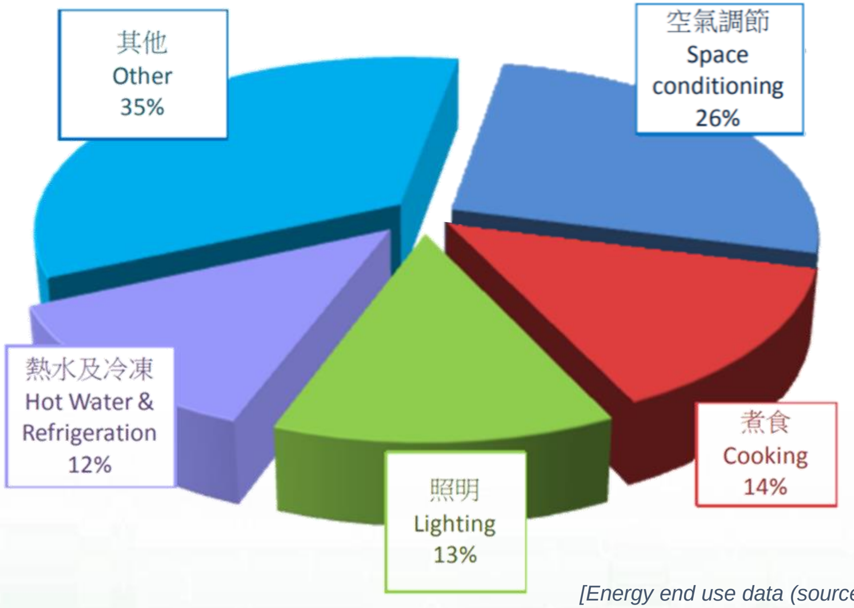
"targeted to reduce carbon intensity by ***65% to 70%*** *using 2005 as the base"*

Background
In Hong Kong

- **70%** of carbon emission footprint comes from Electricity
- **90%** of them are contributed from buildings
- **26%** of the energy consumption are from space conditioning



[Carbon emission footprint of Hong Kong (source: Environmental Bureau, HKSAR)]



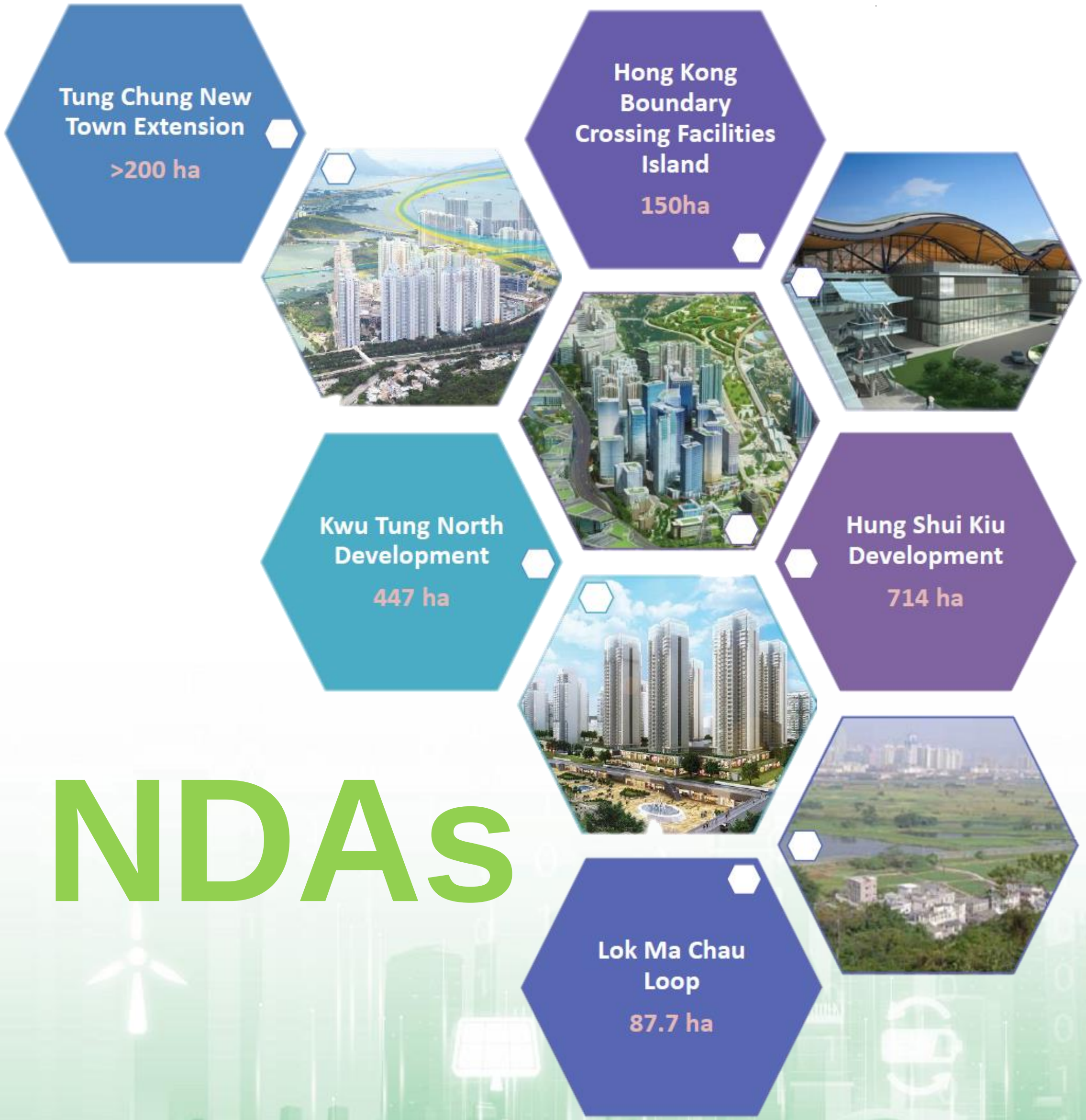
[Energy end use data (source: EMSD, HKSAR)]

Policy Address

"The phased implementation of the District Cooling System (DCS) at the Kai Tak Development is progressing smoothly.

Upon its full completion in 2025, the maximum annual saving in electricity consumption is estimated to be 85 million kilowatt-hour. In line with the Government's commitment to low-carbon development, we will also ***explore the feasibility of providing DCSs in other New Development Areas*** *such as Tung Chung and Kwu Tung North."*

Policy Address 2018



What is DCS?

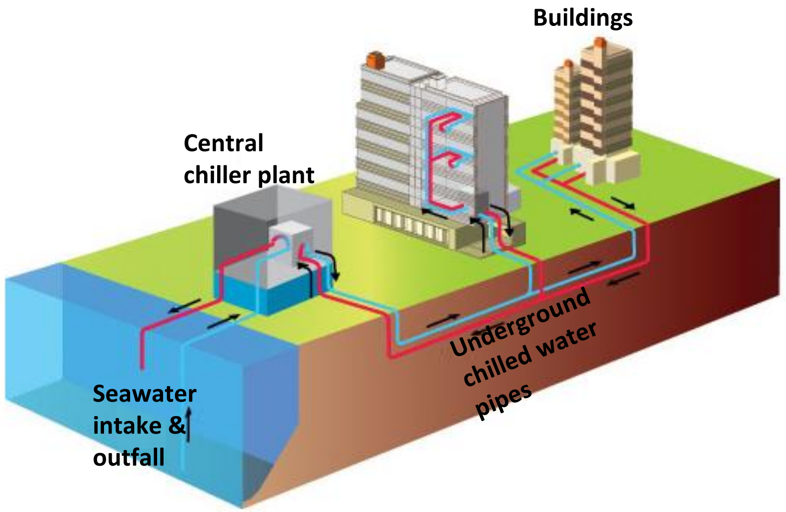
- "concept of providing and **distributing**, from a **central plant**, cooling to a surrounding area (district) of **tenants or clients** (residences, commercial businesses, or institutional sites)"

  ASHRAE District Cooling Guide, 2nd Edition

- "means a system in which chilled water is supplied from one or more **central chiller plants to user buildings** within the area served by the system **through a network of pipes** for air-conditioning in the buildings"

  Cap. 624 District Cooling Services Ordinance, HK

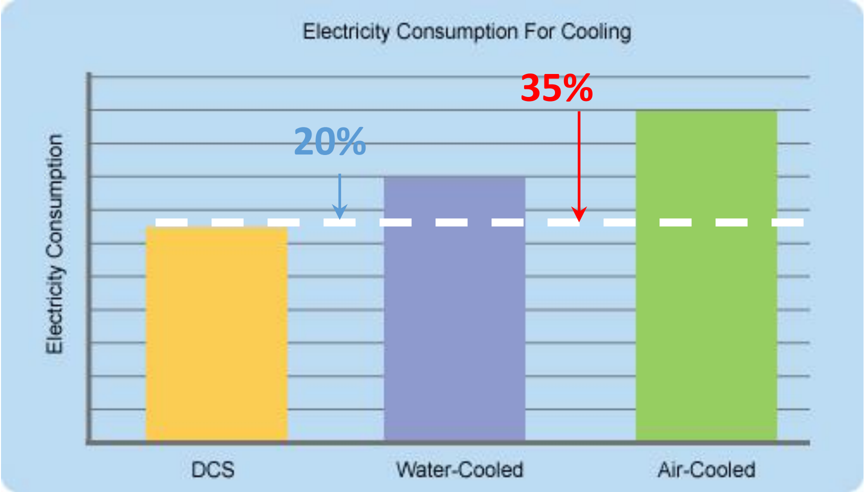
- Suitable for developments with **varied operational diversity and clusters of buildings**



DCS in Hong Kong

- **Electrical & Mechanical Services Department, HKSAR**

  Consume **20%** and **35%** less electricity as compared with air-cooled air-conditioning systems and fresh water-cooled air-conditioning systems respectively



Source: EMSD's website

- **Hong Kong Jockey Club**

  "We saw over **35%** improvement in energy efficiency, and in some instances **43%**"

PROPERTY News

香港賽馬會 The Hong Kong Jockey Club

The Property Management Newsletter of the HKJC | Issue. 03 | OCTOBER 2012

A green start to the season

In this edition. Tunnelling under Happy Valley. Easy riding on JCHQ lifts. And chilling out just about everywhere else.

IT'S COOL TO BE GREEN

It was a 'green' start to the racing season last month. Or at least it was for fans arriving through Sha Tin's gate one, who came face to face with Grandstand II's giant 'green wall' of plants and vegetation.

But Sha Tin's real green dividend lies behind this new facade.

For this is the location of the New Energy Centre, a purpose built facility housing energy efficient chillers that will keep racegoers cool, drive energy costs down, and help reduce the Club's carbon footprint.

'Of course it's early days', says Eric Lau, Technical Services Manager.

'But by our estimates the first racemeeting saw a 40% saving in air-conditioning energy consumption.'

Why the difference?

'The new air-conditioning system is water rather than an air-cooled. For obvious reasons it's much easier to use water to extract heat, rather than trying to cool air directly like your home air-conditioner.'

But the real difference has been the creation of a centralised energy centre.

'In the past we had numerous air-cooled units scattered across both grandstands', says Thomas Hui, who project managed the construction of the new centre.

'Now we've concentrated almost all the plant in a new building, which makes on-going monitoring and maintenance much more efficient.'

Installing all of the capacity in one go also saved on procurement costs.

A Clubwide programme

The New Energy Centre is just the latest of a rolling programme to install water-cooled chillers across the Club.

'It goes back to 2006 and the start of the Club wide energy audits' says Graham Tier, Executive Manager, Property Facilities Management.

'This led us to identify air-conditioning as a prime opportunity to reduce energy consumption.'

Taking advantage of the Government's support for the introduction of water-cooled chillers, the Club was one of the first companies to install the technology, with Happy Valley Clubhouse being one of the earliest pilot schemes in Hong Kong.

'The benefits were almost immediate' says Graham.

'We saw over 35% improvement in energy efficiency, and in some instances 43%.'

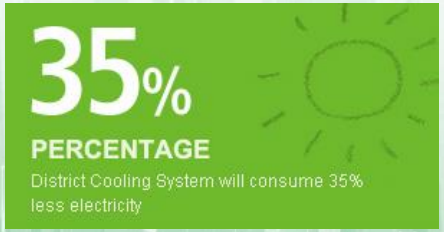
With the technology now proven, Property embarked on a large scale conversion project to install water-cooled chillers, including in the Headquarters building and at both racecourses, where installation is being synchronised with the master development plan.

Conghua Thoroughbred Training Centre will also utilise the technology.

'This is not just a conversion project but a rationalisation of the whole air-conditioning infrastructure' explains Graham.

'In Sha Tin we used to have 54 air-conditioning plants spread across the racecourse. By the time this project is finished we will have just four.'

1



DCS in Hong Kong

Government
Non-Government

DISTRICT COOLING SYSTEM

1

Background

2

DCS Implementation

3

Engineering Challenge

HKGBC 香港綠色建築議會

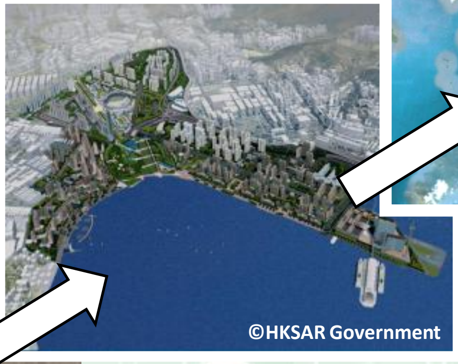
ARUP

DCS at Kai Tak District

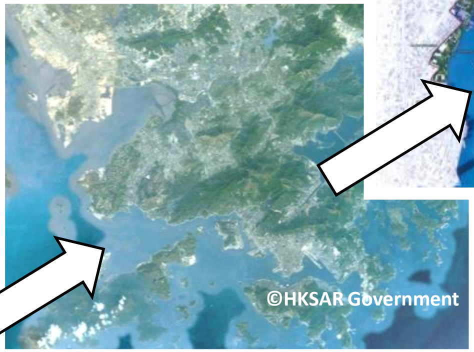
1997
EMSD commissioned a study on territory-wide water-cooled A/C study. DCS is recommended

©HKSAR

2000
EMSD commissioned a study of the viability of DCS at SEKD (Now KTD). Basic design was conducted

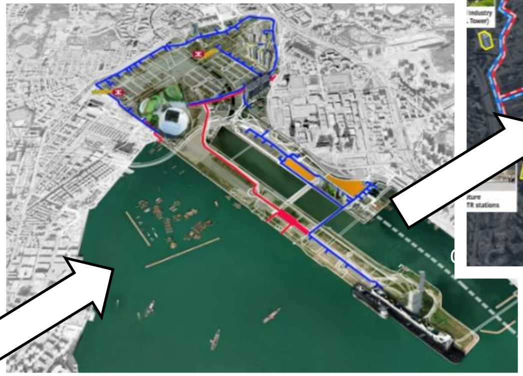


2003
EMSD commissioned a study on territory-wide DCS applications



2009
DBO of Kai Tak was tendered and commissioned

2014
EMSD commissioned the remaining system design of the entire DCS



2017
EMSD commissioned the Third Plant design and construction

HKGBC 香港綠色建築議會

ARUP

Asia-Pacific Economic Cooperation

環境局 Environment Bureau

機電工程署 EMSD

DCS at Kai Tak District

IMPLEMENTATION ROADMAP

1999	Planning Study for DCS at Kai Tak
2000	Feasibility Study on Cost, Regulations, Contract strategies and Environmental
2002	Engineering design commenced
2003	EIA approved
2004	Tariff study and charging mechanism
2005	DCS Ordinance passed at LegCo
2008	Policy Address
2009	DBO contract for Phase 1 & 2
2012	First user, Cruise Terminal connected
2015	Phase 3 commenced
2017	Third Plant design commenced

Environmental Issues
Water Quality

✓ **Temperature**

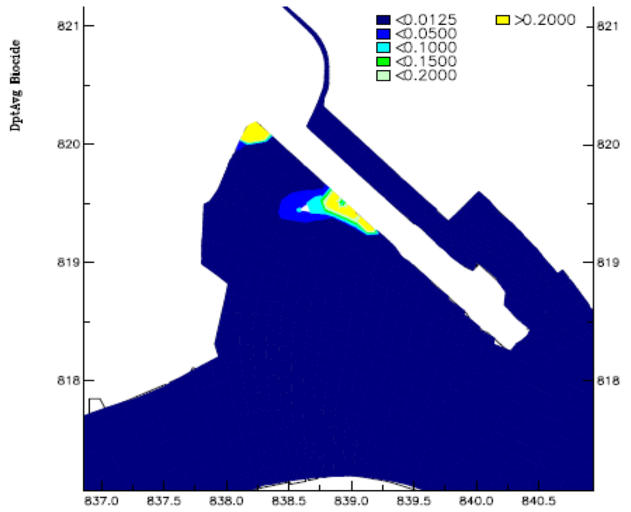
- maximum daily depth-averaged temperature elevation shall be **less than 2^{o}C** to comply with the WQOs and will not cause any insurmountable adverse impacts

✓ **Residual Chlorine**

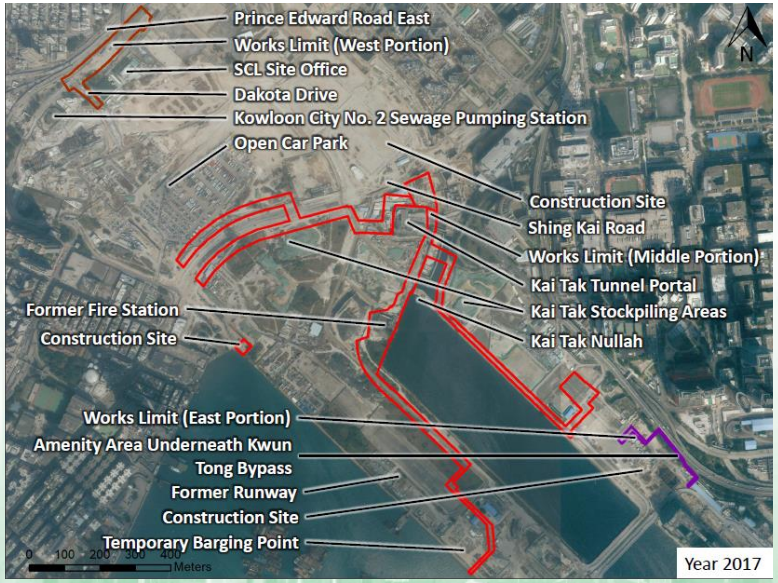
- the **maximum depth-averaged chlorine** at the water sensitive receivers (WSRs) where the chlorine criteria are applicable are simulated

✓ **Residual Biocide**

- the **maximum depth-averaged biocide** at the water sensitive receivers (WSRs) where the biocide criteria are applicable are simulated



Kai Tak DCS
Depth Averaged Biocide, Wet, 1hr after discharge



Institutional and Regulatory Issues

Land

- Land allotment for plantroom and distribution network;
- Connection to DCS in all nondomestic projects

Development Programme

- Master development programme and project phasing

Design and Technology

- Energy efficient DCS and distribution system design and operation

Operation Arrangement

- Abundant experience in managing the operation and maintenance on large scale chiller plant

Contract Strategies

- Most appropriate contract strategy to suit the business case

Charging Mechanism

- Tariff adjustment mechanism to allow variation of tariff;
- Regular Tariff review;
- Transparent to DCS customers

Options of DCS Implementation

Regulated Public Utility

- regulate the operation of DCS as a business and protect the benefits of consumers

Key Characteristics of Public Private Partnership (PPP)

- sharing of risk and responsibility between the public and private sectors in services delivery
- involving a contract between Government and the private sector over a medium to long term timescale
- involving arrangements which take advantage of private sector management skills incentivized by having private finance at risk

Options of DCS Implementation

❑ O&M Arrangement

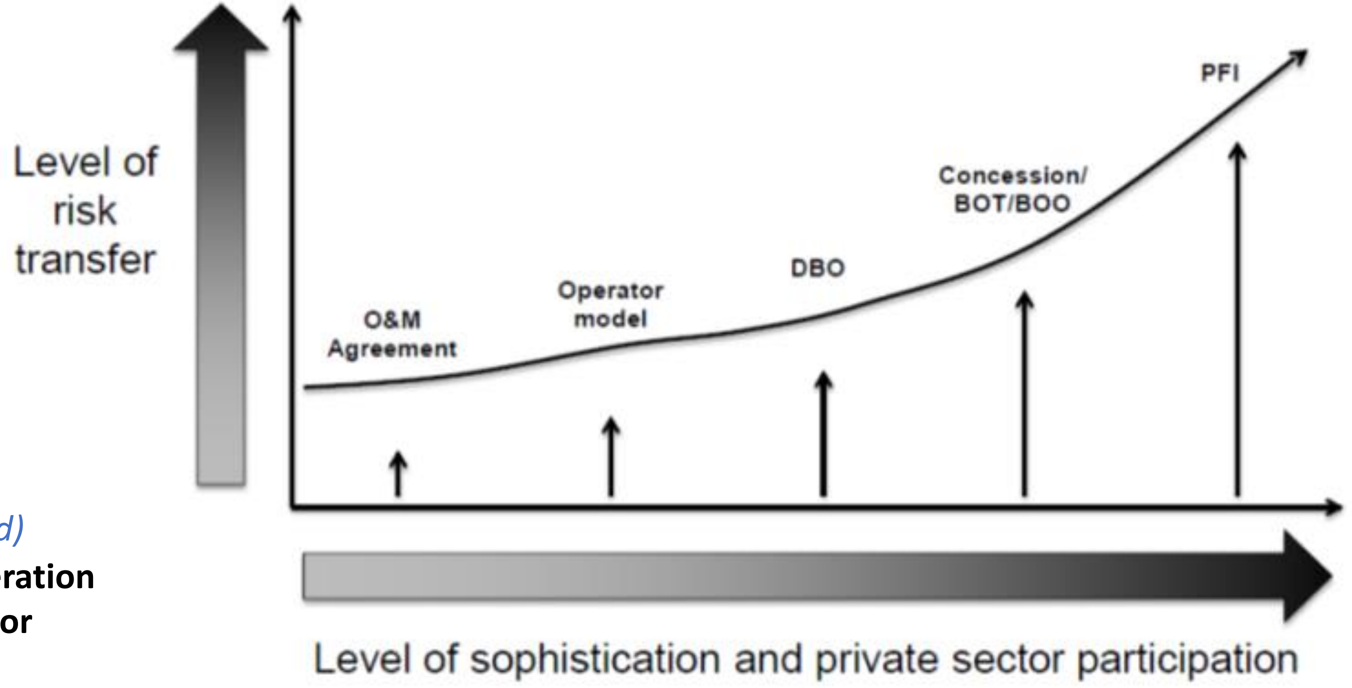
- Owner responsible for funding and construction; Operated by contracted party; Tariff set by owner

❑ Operator Model

- Owner responsible for funding and construction; Operated by operator; Tariff set by owner and operator can charge to the users

❑ Design-Build-Operate (DBO) *(Government fund)*

- DBO contractor responsible for construction and operation with funding provided by owner; Tariff set by owner or negotiated between owner and the contractor



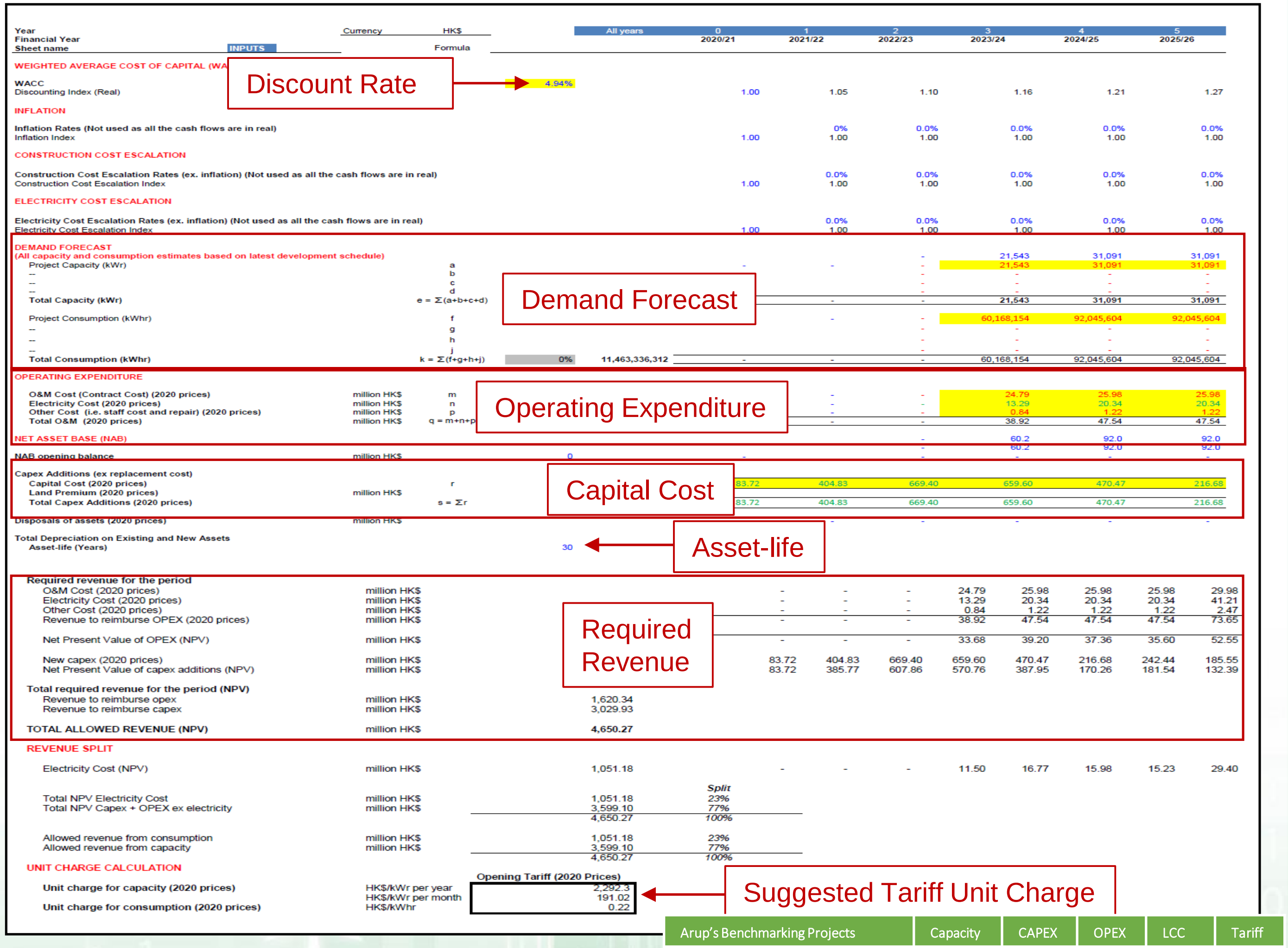
☑ Concession / Build-Operate-Own / Transfer (BOO/BOT) *(for investor)*

- Contractor responsible for finance, construction and operation; Tariff is negotiated between owner and the contractor
- One of the most popular methods of privatizing government infrastructure work
- A private sector organization undertakes to finance, design, construct and operate an infrastructure facilities
- Concession will allow the company, to charge the public for use of the facility in order to repay loads and provide returns for investors

Options of DCS Implementation

Procurement method	Traditional construction with detailed design. Separate contract for operation and maintenance	Traditional construction with detailed design including term contract for operation and maintenance	Designs and builds; private sector operates (DBO) / Designs, Builds, owns and operates (BOO) / Designs, Operates and Transfers (BOT)
Risk	Medium	High	**Low**
Flexibility of tariff regulation by Government	Low	High	**Low**
Competition of DCS operation	No	No	**Yes**
Complicated tendering process	Less	Less	**Relatively complicated**
Land issues	No	Yes and easy	**Yes but complicated**
Financial incentive	Not necessary	Not necessary	**Necessary**

DCS Tariff



Cost Model

A financial model dedicated for District Cooling System (DCS) Project which allows the evaluation of financial performance, calculates a market price for the output of the DCS, and allows the key risks and sensitivities to be identified.

Approach

The model calculates:-

- the **Life Cycle Cost (LCC)** expenditure of implementing the DCS scheme,
- work out the **payback tariff**, and
- compares this cost with the **possible revenues** of the DCS operated under a range of demand scenarios, incorporating reduced customer up-take.

Individual AC and DCS Tariff Benchmarking

- Specialists performing detailed market research on commercial AC cost of similar building types and district nature to **check the viability**
- DCS experience could act as **benchmark reference** to ensure the project is commercially viable

Arup's Benchmarking Projects	Capacity	CAPEX	OPEX	LCC	Tariff
KTD DCS	284MW				
WKCD DCS	92MW				
KTD 3rd Plant	178MW				
Tung Chung (East) DCS	123MW				
KTN DCS	190MW				

DISTRICT COOLING SYSTEM

1

Background

2

DCS Implementation

3

Engineering Challenge

Engineering Challenges

Design

Cooling load profile

- More variety of building usages → lower DCS diversity factor
- Energy model to accurately estimate building cooling load

Heat rejection method

- Freshwater cooled / seawater cooled chiller system
- Feasibility of the use of rain-water recycling / treated sewage effluent (TSE) as heat rejection medium

DCS Plant

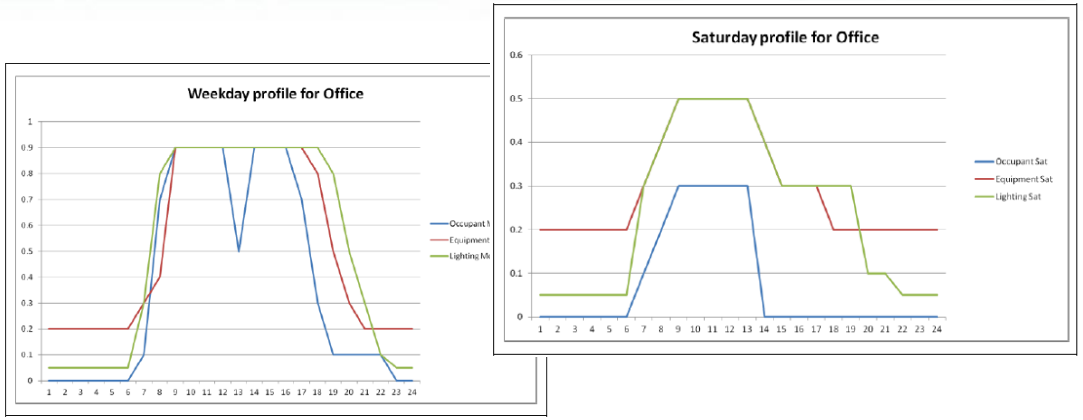
- Selection of high capacity chillers and water pumps
- Design and interface with the power utility (e.g. 132kV substation)

Substation

- The design of heat exchanger (Hx) and chilled water temperature to ensure DCS plant efficiency

Distribution network

- Three-pipe-system for chilled water pipe distribution network to enhance reliability
- Ring / Radial circuit with cost and feasibility consideration

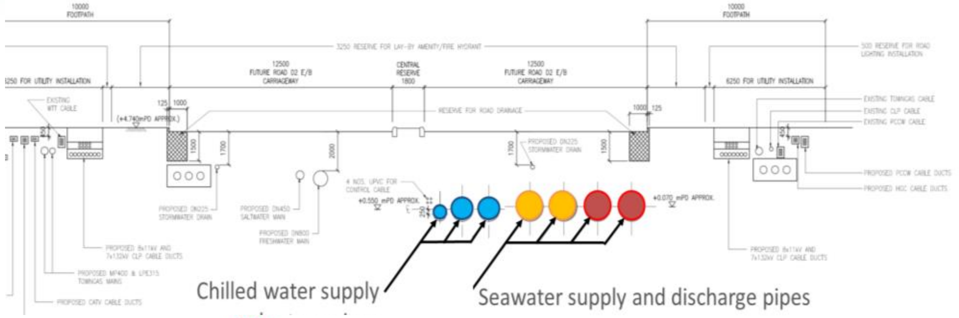


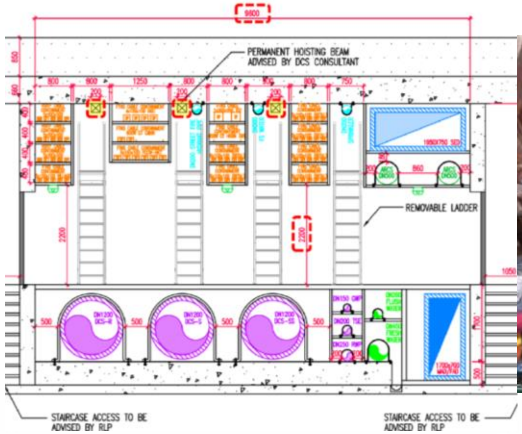
Engineering Challenges

Construction

Distribution network

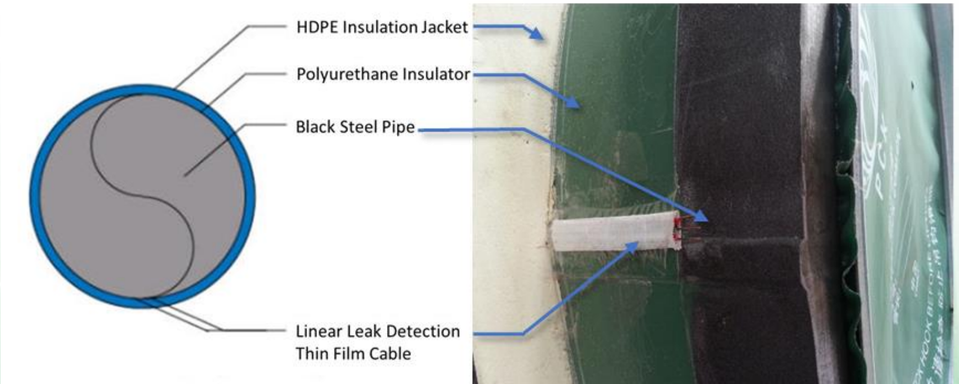
- **Extensive construction works** for DCS plants and pipeworks alignment
- **Interfacing issues with other utilities** is common and may happen in green field site
- **Integrated planning approach** for minimizing complication on construction and the potential escalation on cost
- Site constraints due to existing underground services, **tunnel boring machine (TBM)** is required for pipe laying





Pipe Insulation & Water Leakage Detection System

- Extensive piping network for DCS, heat gain from pipework has a significant impact to **energy efficiency** and **cost effectiveness** of the system
- provide an **addressable** system to monitor the DCS distribution network to check the pipework performance and allowed **early warning** if leakage occurs
- Ensure quality of **workmanship**
- Implementation of **Pre-insulated Pipe (PIP)** method



Pre-Insulated Pipe Configuration

Engineering Challenges

Operation

Testing & Commissioning

- Extensive T&C process to **ensure the system** will run as designed performance

Energy Management and Monitoring

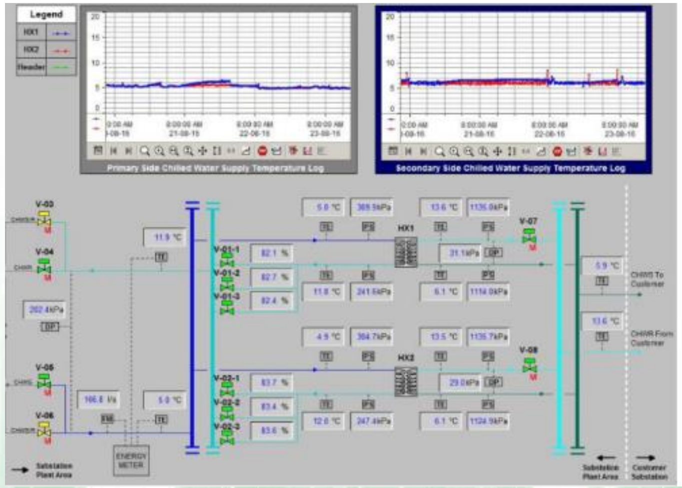
- **Smart automatic computerized system** to monitor and control the whole DCS centrally (DCICCS)

Operation & Maintenance

- Maintain **high reliability** of DCS system in order to provide stabilized AC to DCS users by chiller use / sequencing, leak testing, water quality, etc

Personnel

- People operating, maintaining, and supervising the performance shall be highly experienced, appropriately qualified, and dedicated.



THANK YOU

Vincent Cheng
Vincent.Cheng@arup.com