Implementing district cooling to cool down the cities

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2023.09.13 Tokyo, Japan

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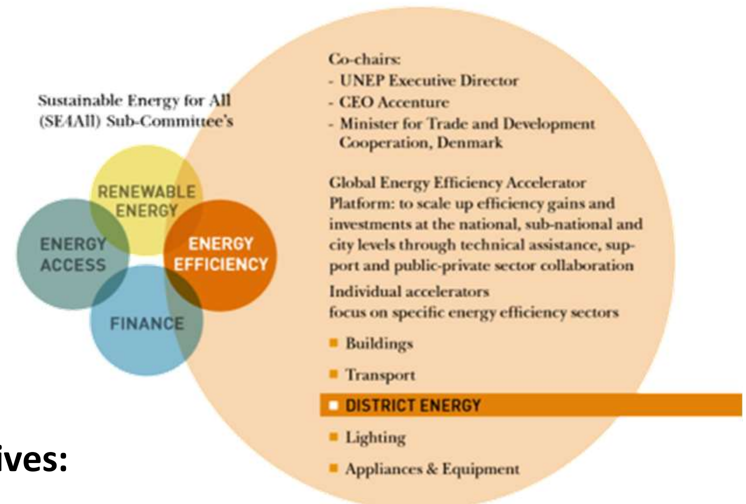
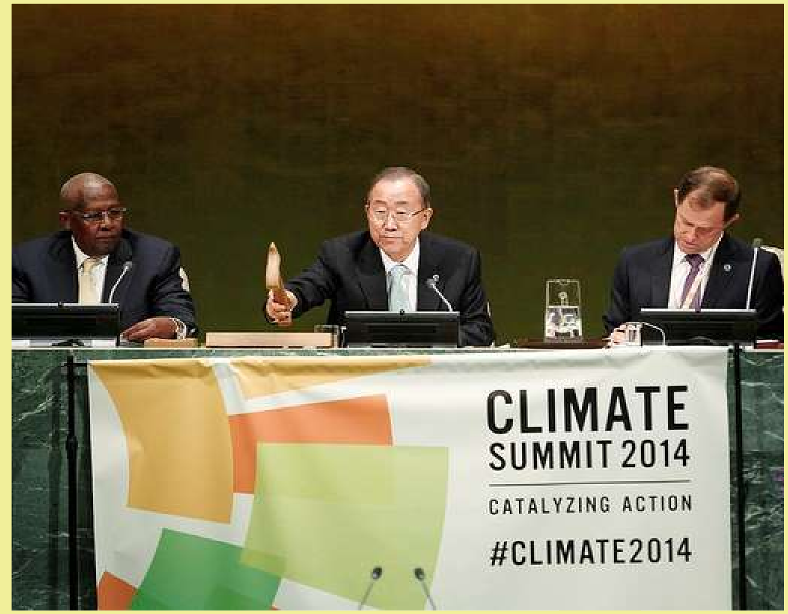
Introduction: why district energy?

SUSTAINABLE ENERGY FOR ALL





Agenda 2030

Execution initiatives:

DISTRICT ENERGY IN CITIES INITIATIVE

Cool Coalition

BEAT THE HEAT
COOL CITIES AND COUNTRIES PAVE THE WAY TO CLIMATE ACTION

Global Alliance for Buildings and Construction

Funding partners:

Federal Ministry for Economic Affairs and Climate Action | IKI INTERNATIONAL CLIMATE INITIATIVE

Clean Cooling COLLABORATIVE

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gef GLOBAL ENVIRONMENT FACILITY INVESTING IN OUR PLANET

Ministry of Foreign Affairs of Denmark
DANIDA | INTERNATIONAL DEVELOPMENT COOPERATION

GREEN CLIMATE FUND

IFC International Finance Corporation WORLD BANK GROUP
Creating Markets, Creating Opportunities

Introduction: Why district cooling?

ENSURING *universal access* TO MODERN ENERGY SERVICES.

DOUBLING THE GLOBAL RATE OF IMPROVEMENT IN *energy efficiency.*

DOUBLING THE SHARE OF *renewable energy* IN THE GLOBAL ENERGY MIX.

Sustainable cities & communities

Affordable & Clean Energy

Global Alliance for Buildings and Construction

SUSTAINABLE ENERGY FOR ALL

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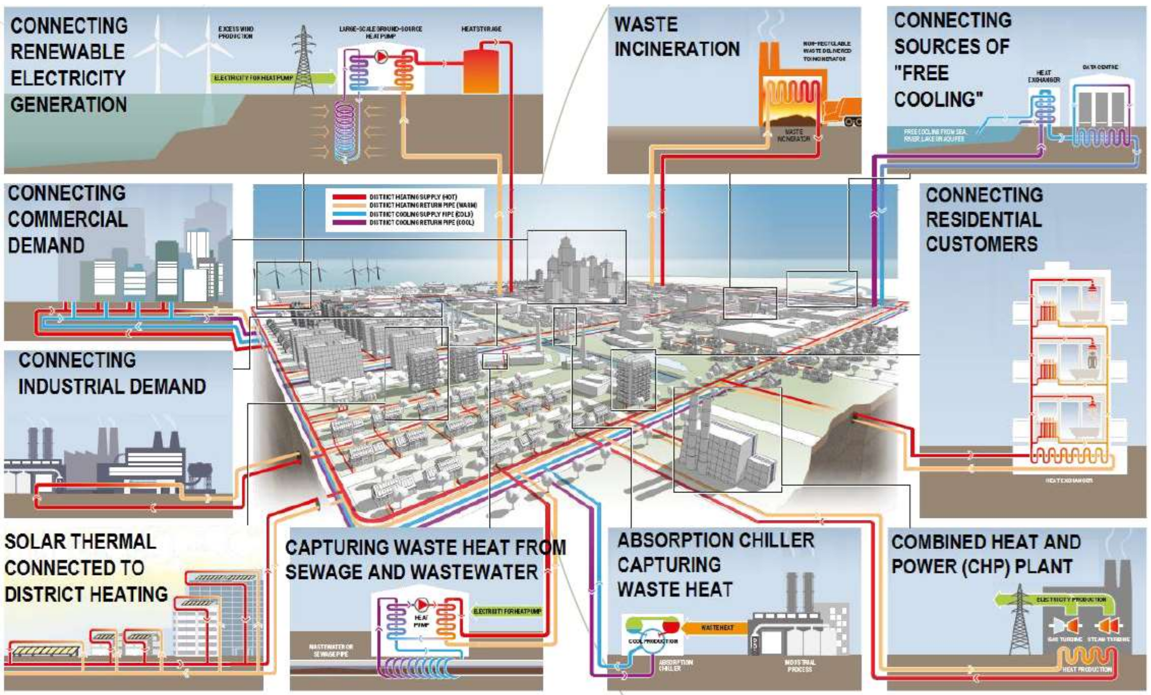
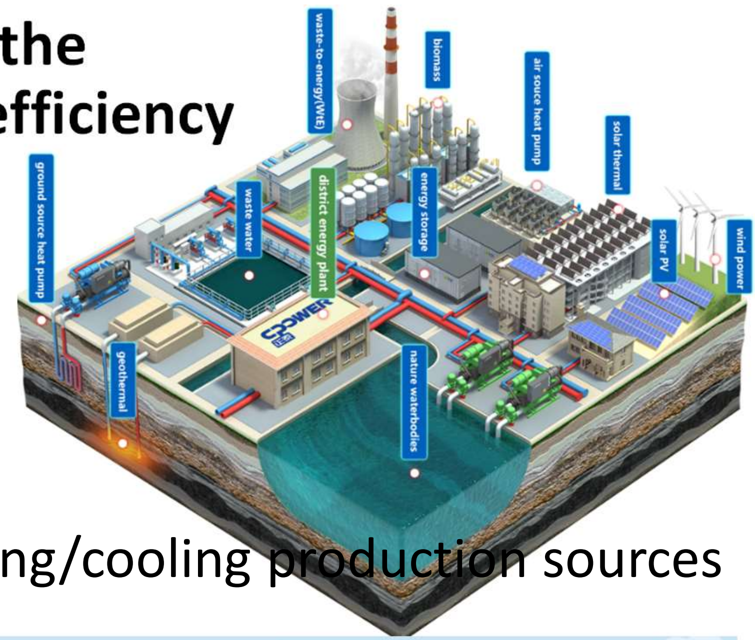
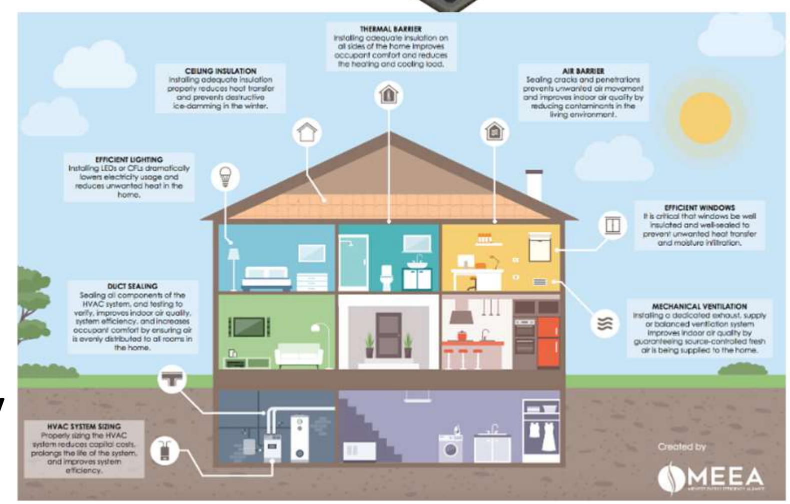
District energy: Key for smart cities to increase the share of renewable energy and overall energy efficiency



District energy systems for heating & cooling



Heating/cooling production sources



Building energy system

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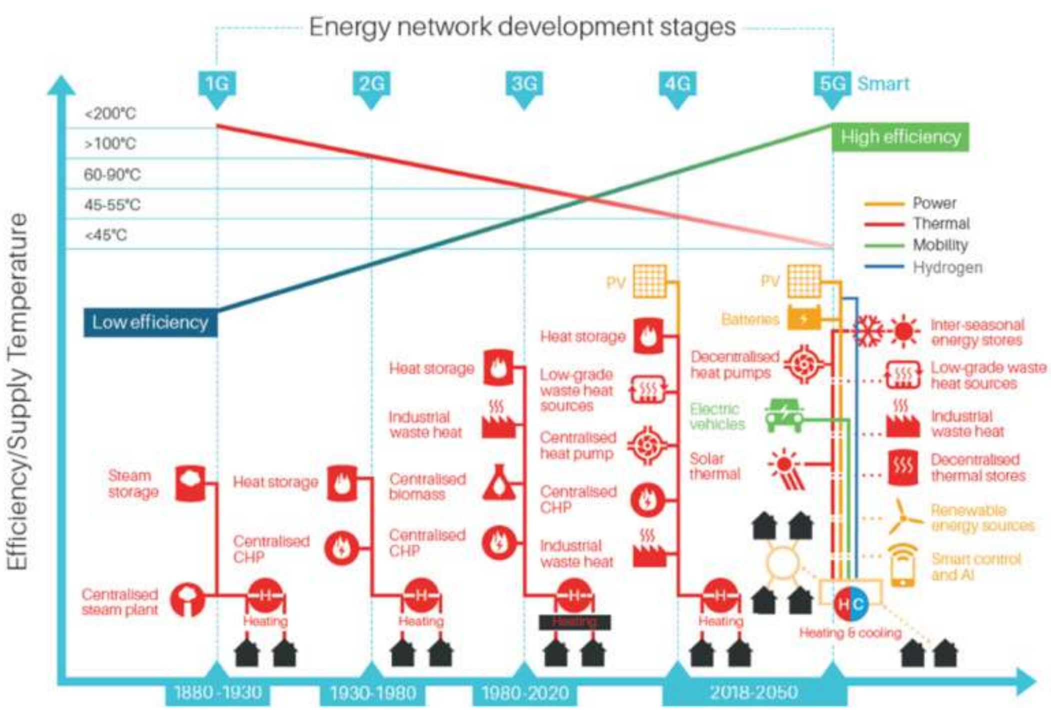
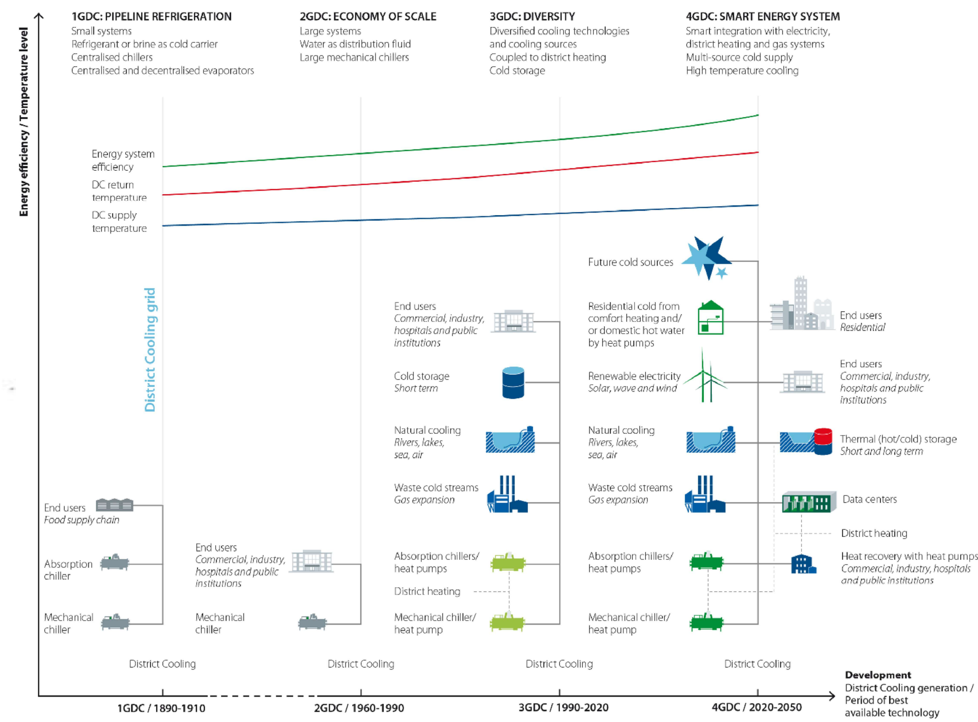
Development of district heating & district cooling





5th Generation of District Heating (5G DH)

4th Generation of District Cooling (4G DC)

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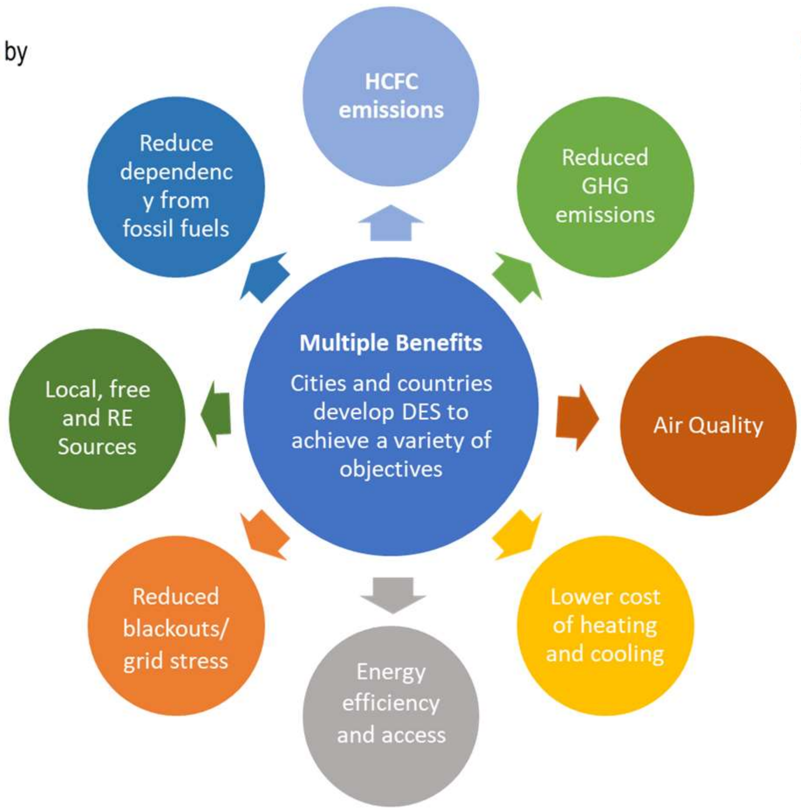
Source: Journal papers from Aalborg University etc.

Multiple benefits of district cooling for cities

DH can help **reduce gas imports** by switching to readily available sources: heat pumps, surpluss energy, biomass, solar….

Denmark, has achieved a 20% reduction in CO2 through district energy that integrates renewables



Cities like **Toronto** or **Paris** use free cooling from rivers and lakes for cooling supply

Improving cities air quality and reducing PM2.5 emissions is the main driver for district energy in **Chile**

Dubai, UAE shifts peak electricity demand with cold storage lowering power transmission investment

Qatar, to produce 1 TR hour DC consumes 55% less electricity than individual window units and 47% less than air-cooled chillers (source: Kahramaa)

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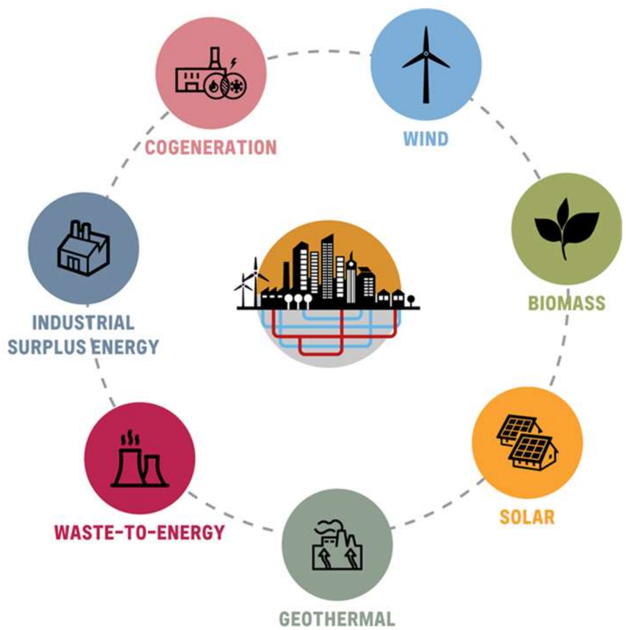
Multiple benefits of district cooling for cities

District energy systems are an important part of heating and cooling sector decarbonisation, as they allow for the integration of flexible and clean energy sources into the energy mix, which could be challenging at the individual building level in urban dense areas.

Toronto Deep Lake District Cooling(Canada)



Waste Heat recovery from Facebook Data Center in Odensee (Denmark)

Waste to energy Issy les Moulineaux(France)

Geothermal DH plant Gentilly(France)

What are the challenges for district cooling?

Lack of local capacity

Lack of data

Design marketable or investable or bankable projects

Bridging the gap between the regulatory level and ground level

Long-term support to local authorities

Communication and awareness raising

Standardisation and transferability

What are the financial barriers in new markets?

District energy systems can make returns from 6 to 20 per cent, with a break-even point from 6 to 10 years depending on the market and the project. But to really take advantage, we need to address upstream barriers and make it easier for the private sector to invest.

Main financial barriers:

1) lack of low-cost capital with cities and utilities
2) lack of upfront finance to cover project development and tendering costs
3) lack of capacity in national and subnational governments to create the enabling environment to unlock investment
4) lack of political will to improve heat tariff regulation and utility structuring;

Examples of solutions implemented in some markets:

- ✓ In India, UNEP supported IFC and Tabreed to establish a $400 million investment platform for district cooling
- ✓ UK has established a Heat Networks Investment Programme to help municipalities overcome financial barriers and scale-up the market. The District Energy in Cities Initiative is trying to replicate this model in new markets
- ✓ Subsidies, tax incentives

District cooling VS. other cooling technologies

- Higher energy efficiency than conventional cooling technologies

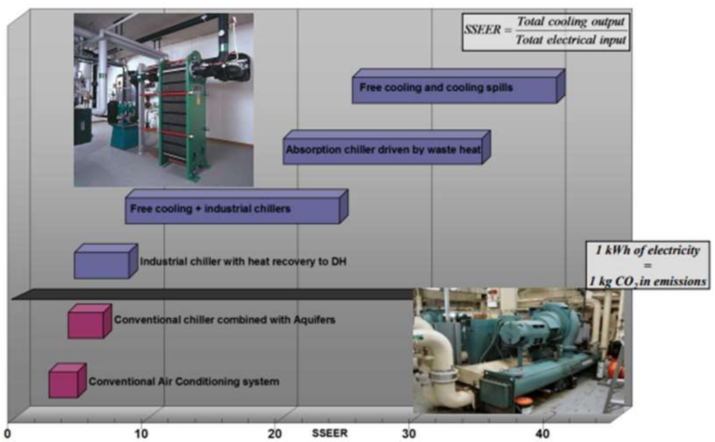


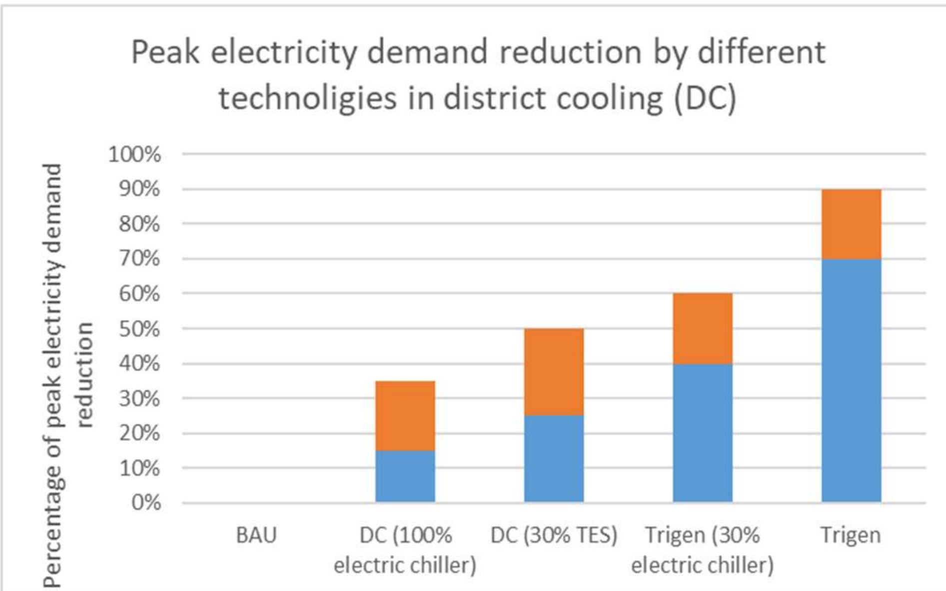
Figure: Comparison in COP for various production systems

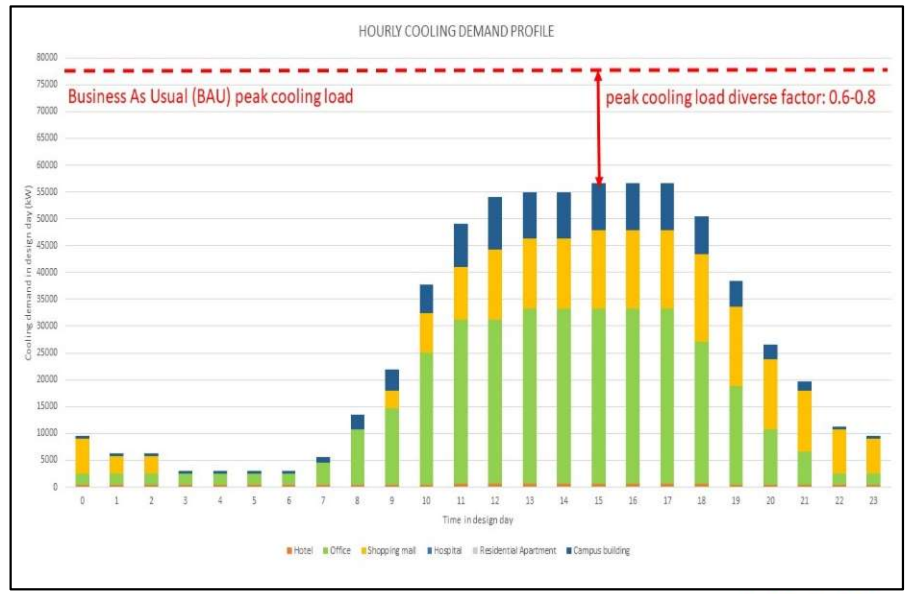
Cooling system type	Primary Energy Efficiency	Peak load shifting factor-Electricity
Split AC, VRF/VRV	25%-30%	0
Conventional Central (water-cooled elec. chiller+ FC/AHU)	20%-30%	10%-15%
Conventional Central (air-cooled elec. chiller+ FC/AHU)	15%-30%	10%-15%
District cooling (all elec. chiller)	25%-30%	15%-25%
District cooling (free cooling+elec. chiller)	30%-60%	30%-50%
Tri generation (electricity, district heating, district cooling, domestic hot water)	60%-80%	30%-50%
Tri generation (30%TES)	55%-75%	40%-60%

*Assumption: Grid electricity PEF=35%, cooling factor=0.15, heating factor=0.2, electricity=0.5, all equipment reaches A-level under Energy Star or ASHRAE/ASME

District cooling VS. other cooling technologies

- Peak electricity load shifting
- Cooling load reduction to save total investment in the district





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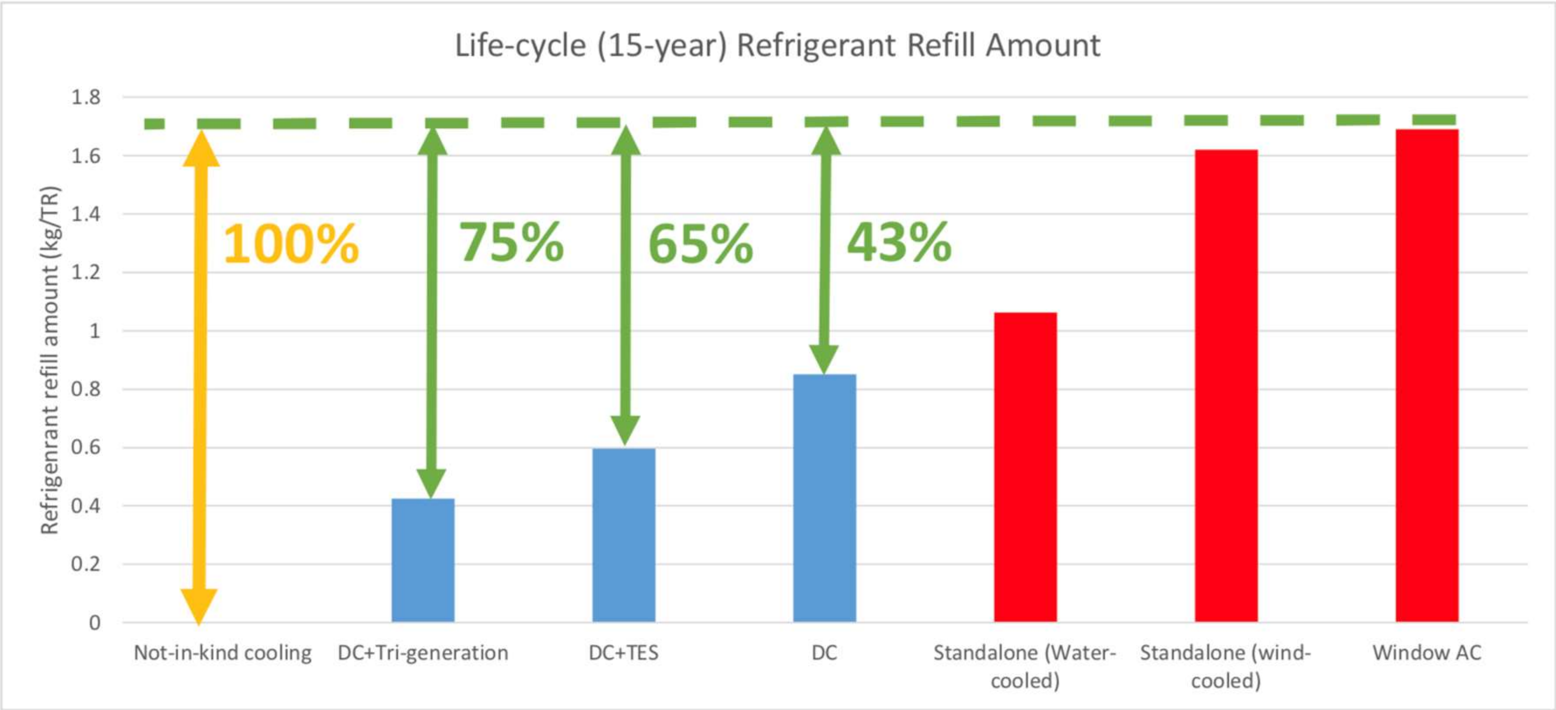
District cooling VS. other cooling technologies

- Refrigeration phasing out



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District cooling VS. other cooling technologies

- Better indoor environment and air quality

		DC+Central End (FC, AHU)	Conventional Central (FC, AHU)	Split AC	VRF/VRV
Indoor Environment Parameters	Temperatur e				
	Humidity			Not humidify, but dehumidify	
	Wind speed				
	Fresh Air ratio				
Indoor Air Quality (IAQ)	VOC (CO, CO2)				
	PM10, PM2.5				

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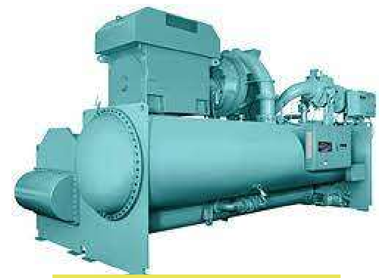
System components: district cooling

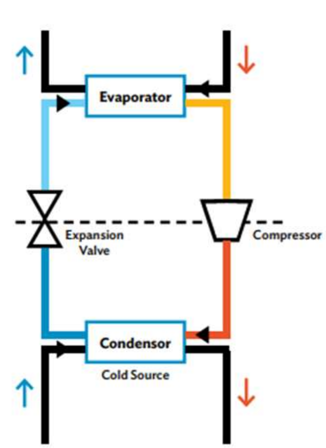
Cooling/heating generation plant

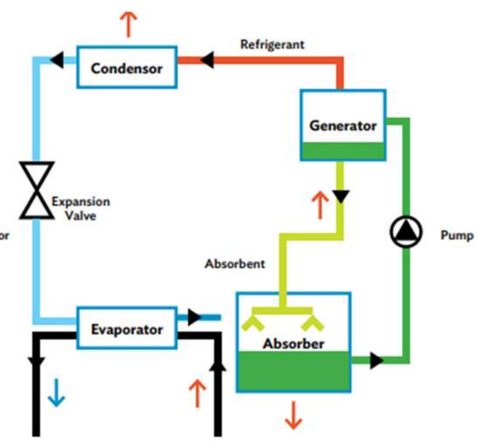
- Chillers: 10kV/6kV/380V electric chillers, absorptive chillers
- Circulation pumps: chilled/condensed water
- Electricity transformers
- Water supply and treatment systems



Electric chillers

Absorptive chillers





District cooling plant at Business Bay - Empower

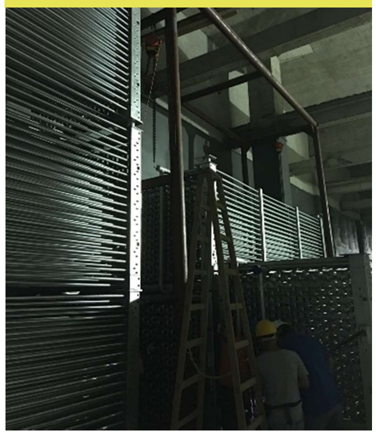
System components: district cooling

Cooling/heating generation plant

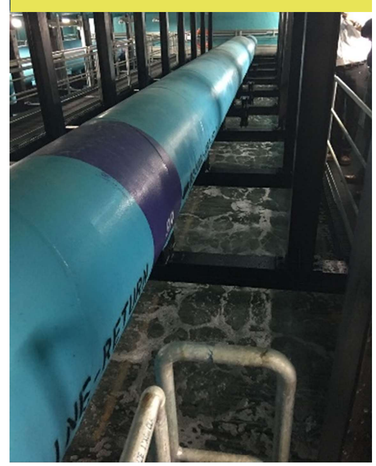
- Cooling towers
- Thermal storage systems: ice/chilled water storage
- Central control systems

Dynamic ice storage in DC of Chengdu (In operation)

Ice storage coils in DC of Shenzhen (Construction stage)



Ice storage in DC of Marine Bay, Singapore (In operation)



Cooling tower cluster of DC in Macau University (27000TR)

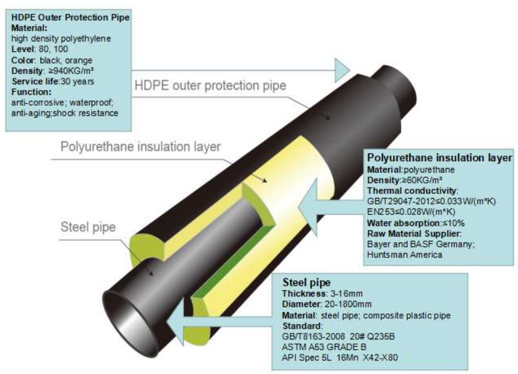
Central control system for multi cooling sources in DC system of Marine Bay, Singapore

System components: district cooling

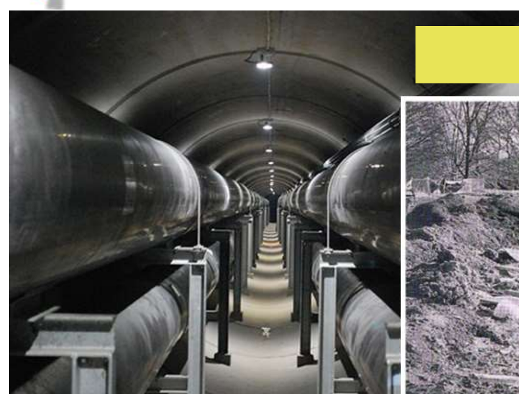
Distribution system

- Pre insulated pipes
- Direct buried network VS. corridor
- Controlled heat loss in pipeline network
- Leakage detective sensors and alarming system

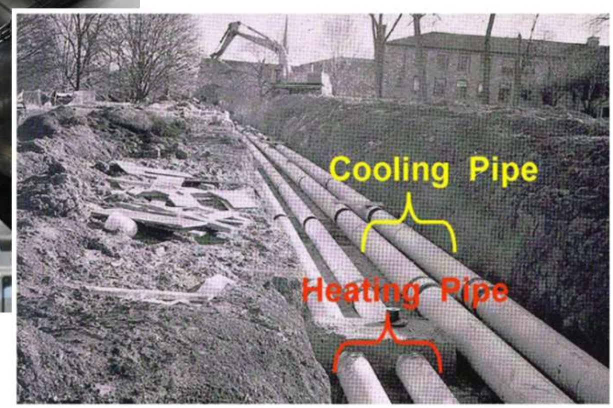
Pre insulated chilled water pipe



Leakage sensors & alarming system in Shenzhen DC



External DC pipe network



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System components: district cooling

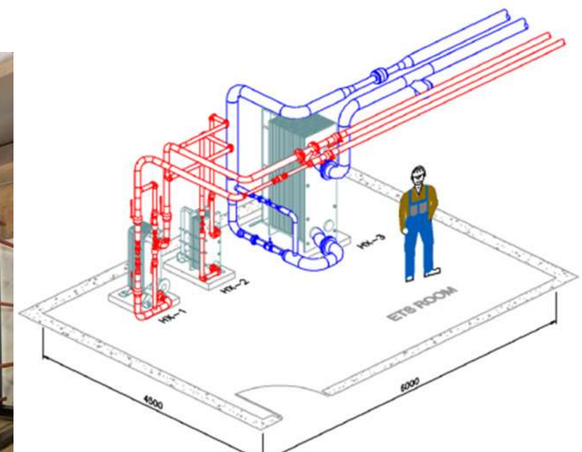
Energy transfer stations (ETS) in standalone buildings

A typical ETS room has:

- Pipe connections or rough-in with knockout panels on exterior wall
- Heat exchangers for space conditioning
- Controls and meters

Normally it is regulated on design and installation as well as maintained by district cooling suppliers

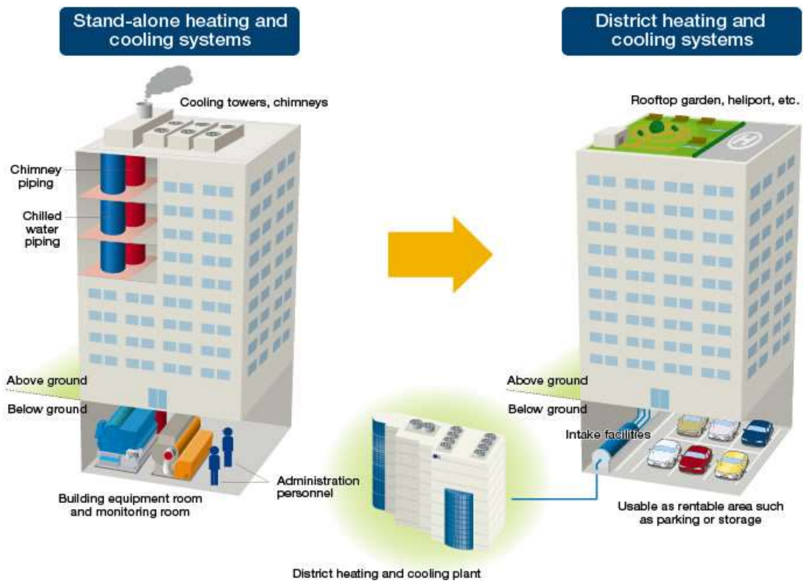
ETS room design and installation



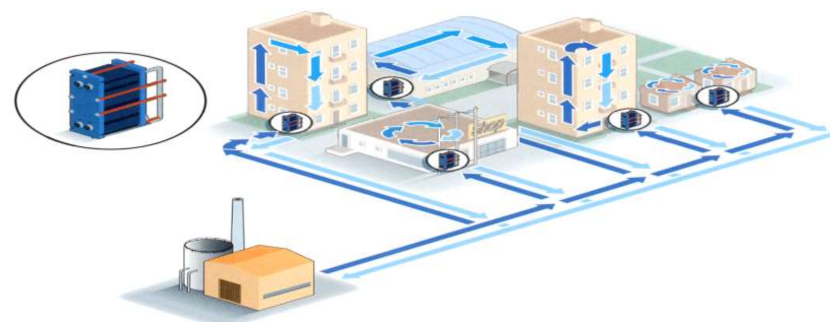
Source: DESIGN GUIDELINE FOR DISTRICT ENERGY, City of Toronto, 2016

System components: district cooling

What does a district cooling system change?



Standalone building level



Regional level

System components: district cooling

What does district cooling change from standalone central cooling system in buildings? 1) Cooling plant

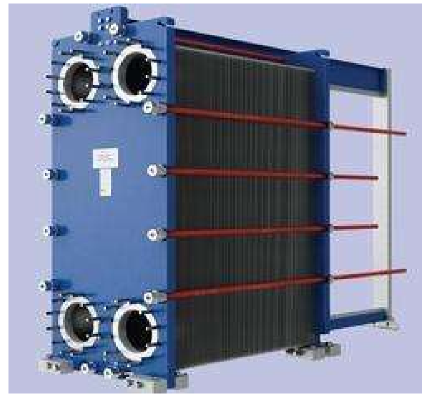
Chiller

Cooling tower & circulated pump

Electric transformer for cooling sources

Usual central cooling system in buildings

Change



Heat exchanger

Metering system

Connection station to district cooling system in buildings

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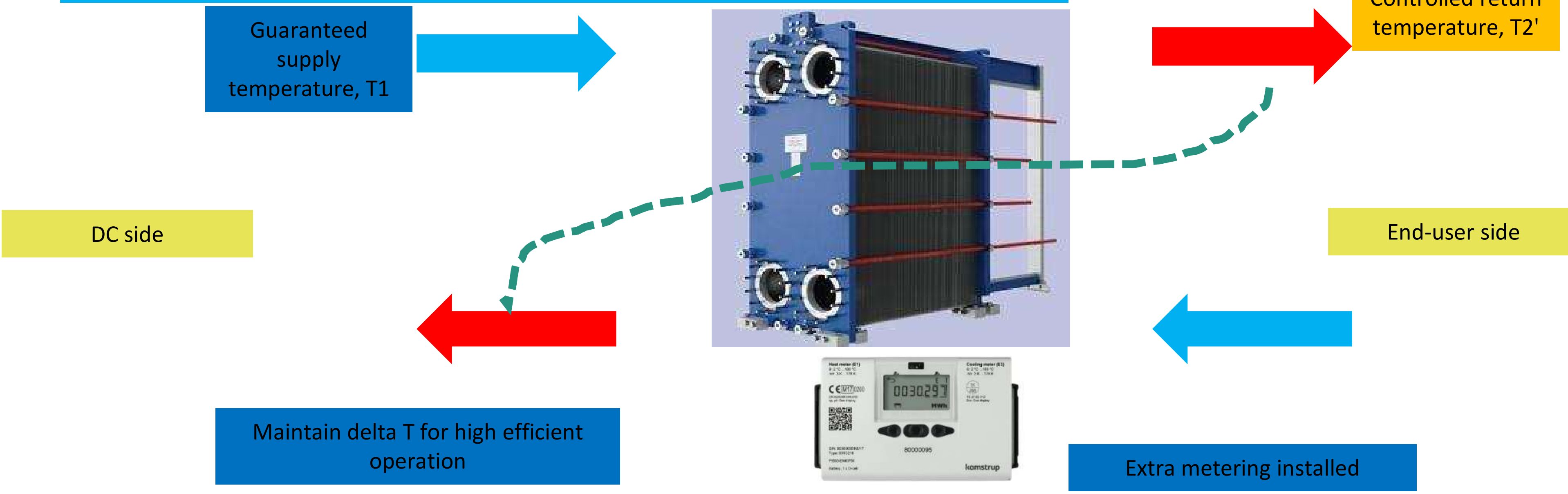
System components: district cooling

What does district cooling change from standalone central cooling system in buildings? 2) Control system

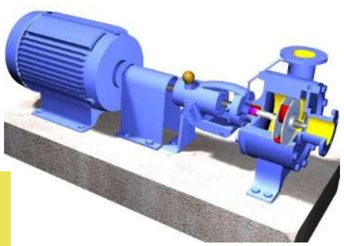


System components: district cooling

What does district cooling change from standalone central cooling system in buildings? 3) Internal AC (for existing buildings)

Existing system

Chilled water pump

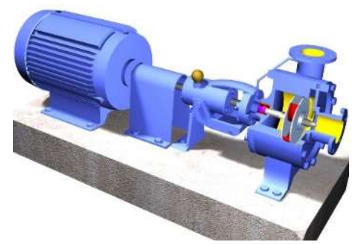


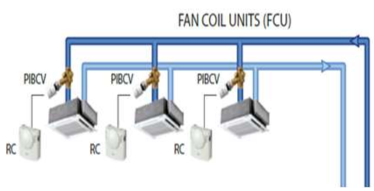
Calibrate with flow rate, head

Change or keep

After connecting to DC

Chilled water pump

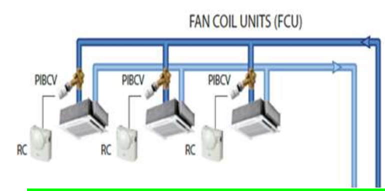




Room cooling

Calibrate with supply and return temperature

Should be the same in most conditions



Room cooling

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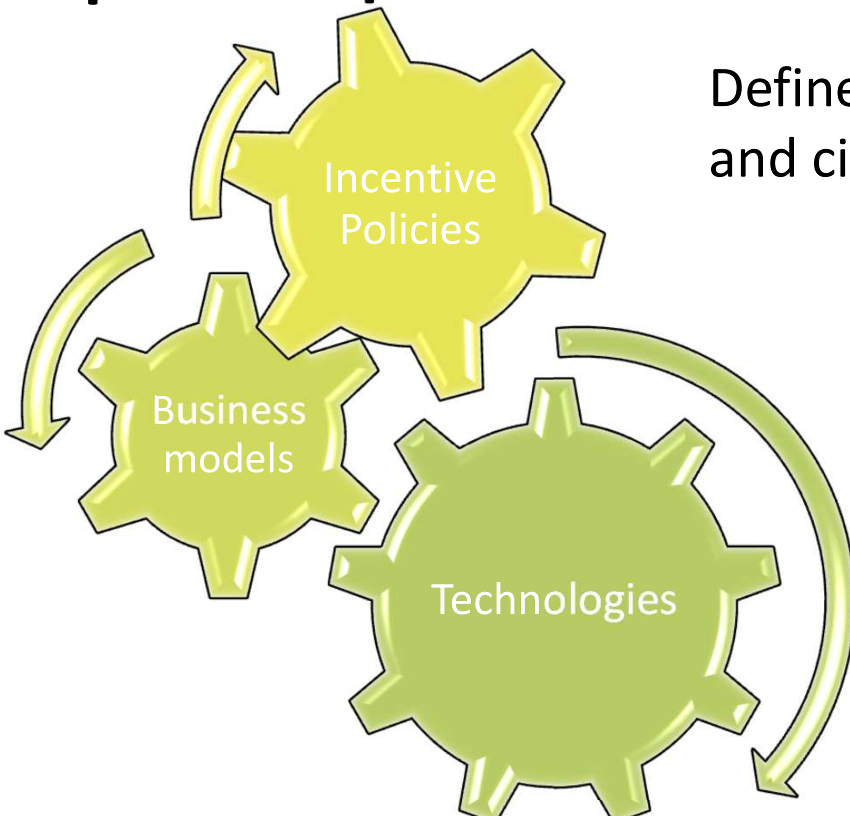
How to develop and implement district cooling projects?



Define the roles of municipalities and cities

Suitable business models to enable the investment environment

Cost-effective technologies to integrate multiple sectors for higher systemic efficiency

Combining suitable incentive policies, business models and cost-effective technologies can accelerate the implementation of carbon neutral communities and scale up after demonstration.

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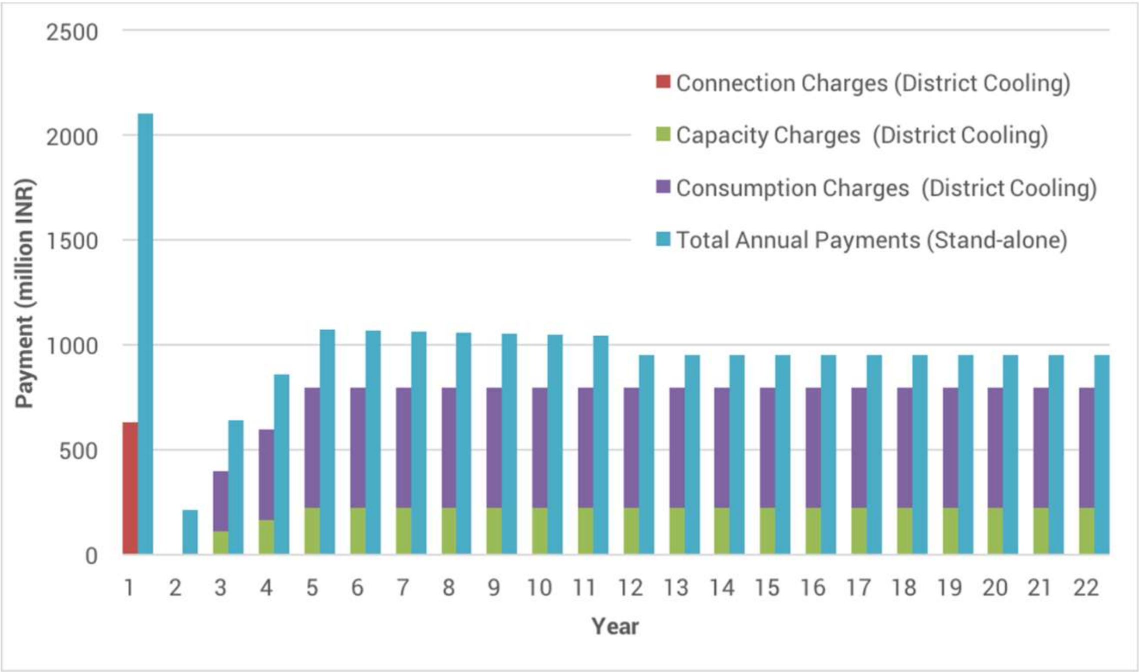
Recommendations: How we take actions in the APEC economies?

➢ Fill the data gaps

Benchmarking the cooling demand & cost in buildings: How cheap is cheap?

- Connecting to district cooling system can bring economic benefits to end-users compared to stand-alone solutions (blue pillar)
- The long-term cooling fee paid by end-users is comparatively less than self-built stand alone systems (blue pillar)



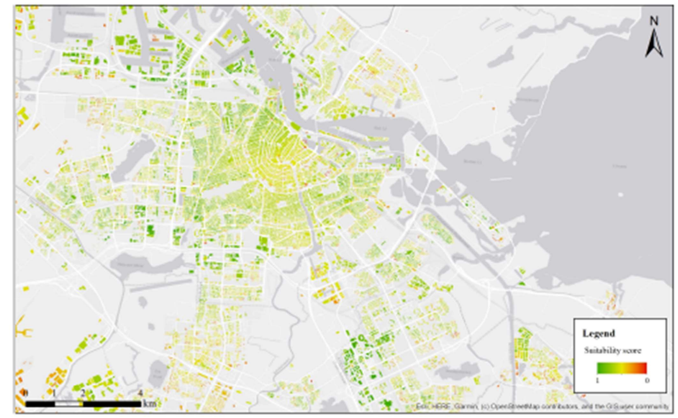
Recommendations: How we take actions in the APEC economies?

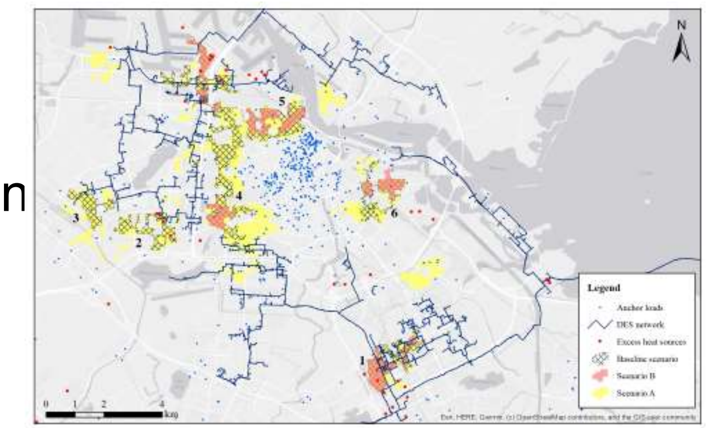
➢ Integrate cool mapping and planning into long-term urban planning

Use GIS data to

1) Assist urban planners in master planning
- Decide locations of DC plant
- Integrate land-use of DC to other utilities
- Phasing of DC
- Implementing pipeline routines

2) Expand or upgrade existing DC
3) Optimize DC and building energy systems operation through connection with smart city platforms
4) Facilitate feasibility studies, incentive policies and business plans in later stage





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Recommendations: How we take actions in the APEC economies?

- Integrate cool mapping and planning into long-term urban planning

New developments above 50,000m^2 must provide an "Energy Plan for Effective Utilization" in order to obtain a building permit. This energy plan requires:

(1) Setting targets for energy saving performance in newly constructed buildings;
(2) Study of introduction of unused energy and renewable energy;
(3) Study of introduction of district heating and cooling.

New developments that exceed 10,000m^2 (20,000m^2 residential) must do a technical assessment of district energy and demonstrate consultation with district energy suppliers.

Tokyo

London

- Integrated Energy and Land Use Plan

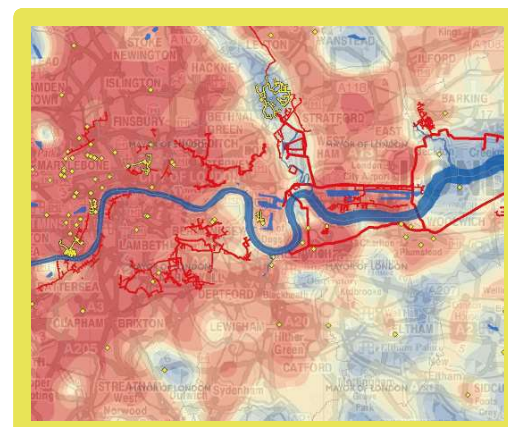
Large building developers must develop district heating if connection unavailable
London required its 32 boroughs to carry out energy master planning

- Encouraging Connection

Connect unless policy
Large new waste heat sources must accommodate connection to district energy

- Tariff Regulation and Customer Protection

Tariffs unregulated but city makes recommendations on methodology and contract length



Recommendations: How we take actions in the APEC economies?

- Innovative technologies for cooling

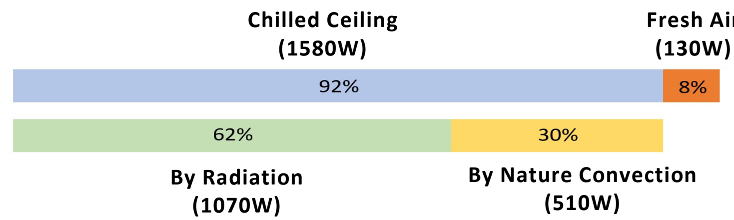
1) Passive cooling technologies in buildings

- Building envelope efficiency
- *Green building certification* (e.g. LEED, BREEAM)
- Cool roof, green roof
- *Nature ventilation*

2) Active cooling technologies

- *Free cooling* (e.g. deep sea water, direct condensation)
- Low-GWP refrigerant (e.g. R717)
- Thermal storage of ice and/chilled water
- Demand-side radiative cooling systems – chilled ceiling
- Multi-sector energy systems integration (e.g. waste heat from industry, IDC & super market)

Recommendations: How we take actions in the APEC economies?



- ➢ Innovative technologies for cooling

2) Active cooling technologies

- Demand-side radiative cooling systems – chilled ceiling

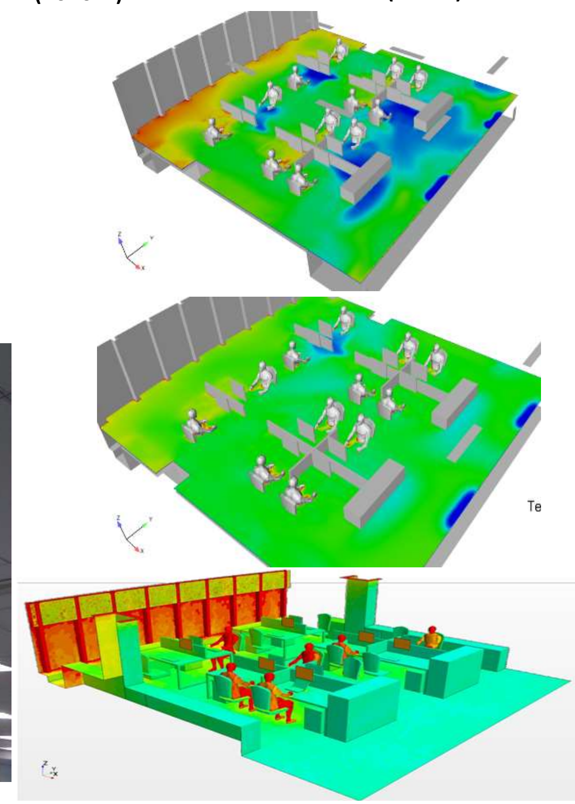
Benefits: a) raise the supply chilled water temperature to *12C and up*

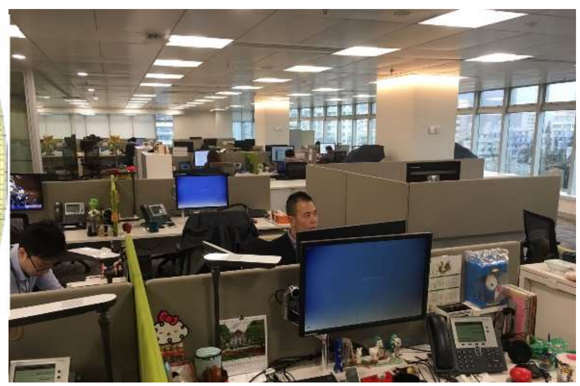
b) Raise energy efficiency of indoor cooling system at least 35%

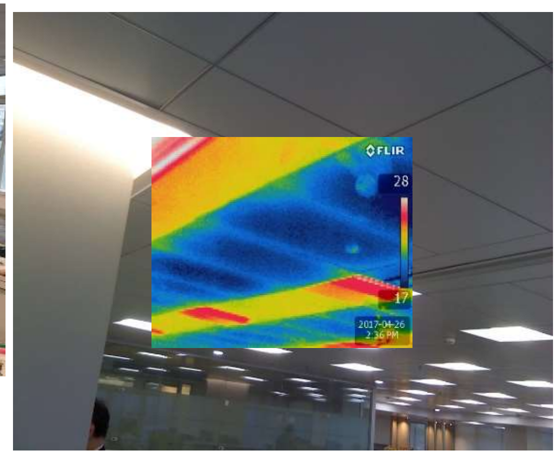
c) Almost no cold wind blowing, no noise from fan-coils

d) Save space in the ceiling so more height in the office space

Challenge: how to prevent condensed water on the ceiling surface







Recommendations: How we take actions in the APEC economies?

➢ Innovative technologies for cooling

3) BMS for building/district energy system monitor and control

- AI-aided control method
- Smart city
- Digitalization

Recommendations: How we take actions in the APEC economies?

➢ Innovative business models to bring long-term financial support

1) Business models for efficient cooling

- Service-targeted: Cooling as a Service (CaaS), Efficiency as a Service
- Performance-targeted: Energy Performance Contract (EPC)
- Turn-key & joint venture: Design-Build-Finance-Operation-Own/Transfer (DBFOO/DBFOT)
- Insurance-based: Energy Efficiency Insurance (EEI)

Recommendations: How we take actions in the APEC economies?

➢ Innovative business models to bring long-term financial support

2) City climate fund

- Start-up support from national/international financial resources
- Leverage private investments in a longer term or later stages

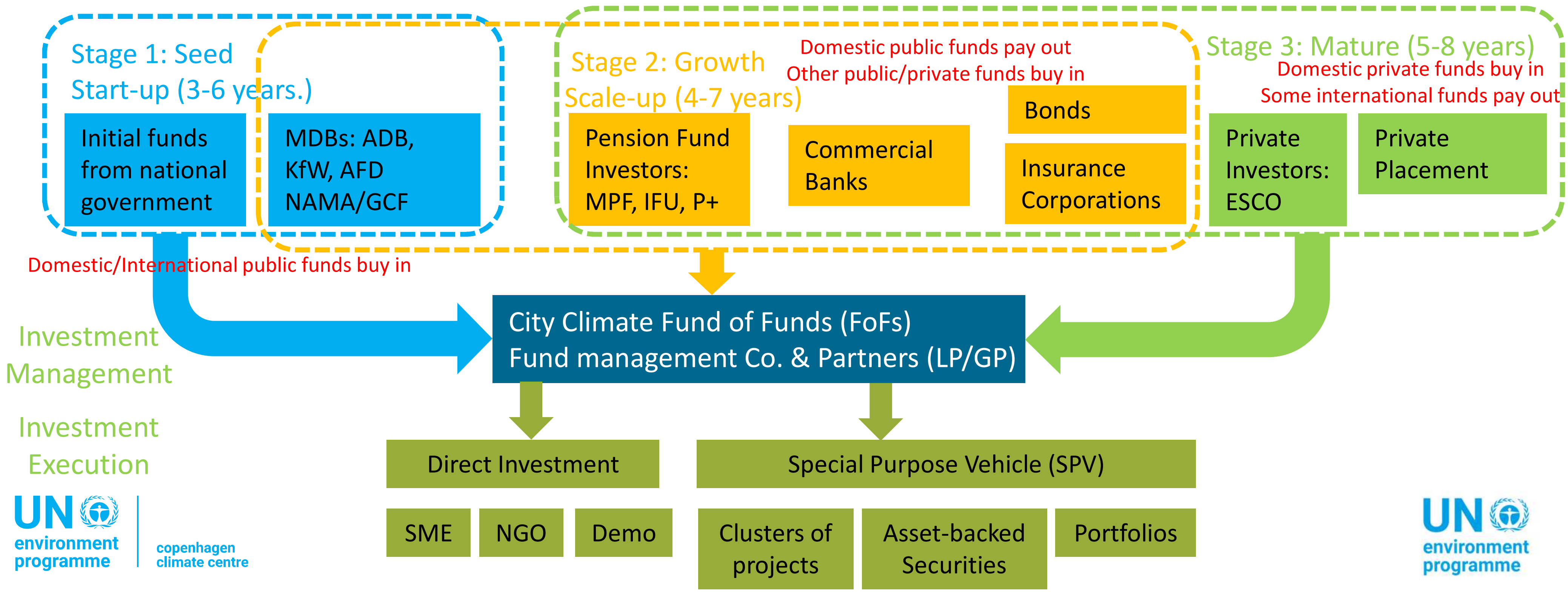
Examples:

- Climate Change & Environmental Protection Fund in Mauritius
- City Climate Funds in Xi'an, Qingdao & Shenzhen (China)
- City Environmental Protection Fund in New York State

Recommendations: How we take actions in the APEC economies?

- ➢ Innovative business models to bring long-term financial support

2) City climate fund



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Thank you very much!

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