A Study on District Cooling System in APEC: Japan and Malaysia Cases

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Elvira Torres Gelindon, Senior Researcher

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1. Background of the study

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Motivation/Objective

- District cooling systems (DCS) are increasingly significant in a number of APEC economies; the space cooling data flow has not been clearly accounted for in energy statistics or energy balances.
- Question raised in APEC EGEDA workshop, how district cooling data can be reported.
- To assess DCS in selected APEC economies, and learn how the consumption in DCS are reported.

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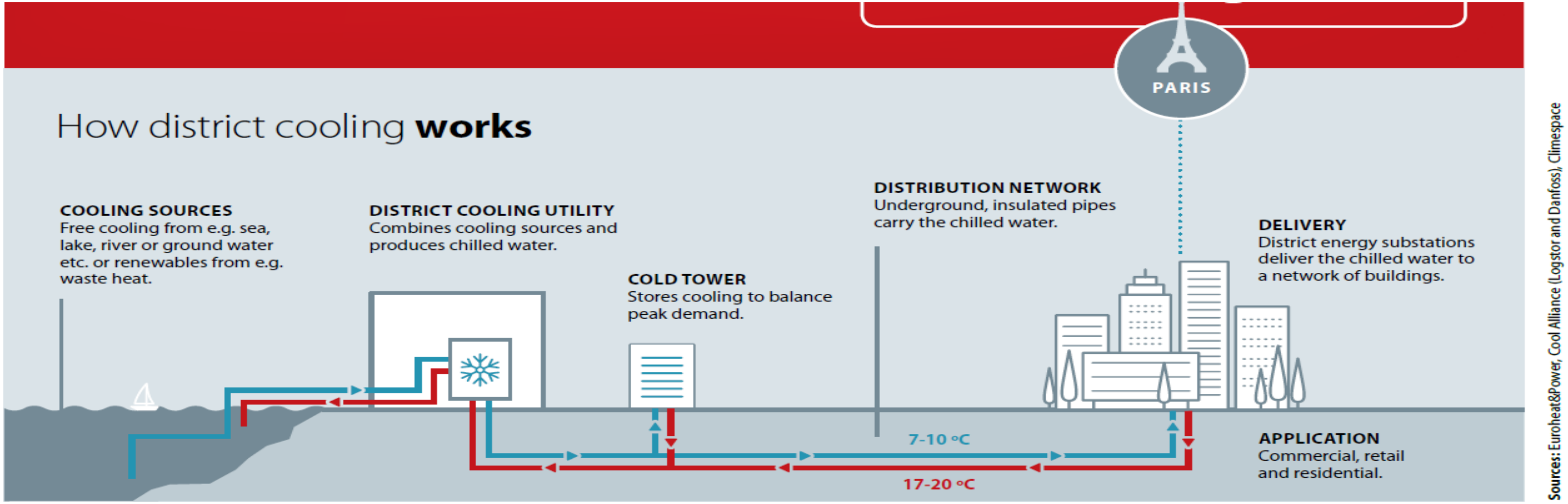
What is district cooling?

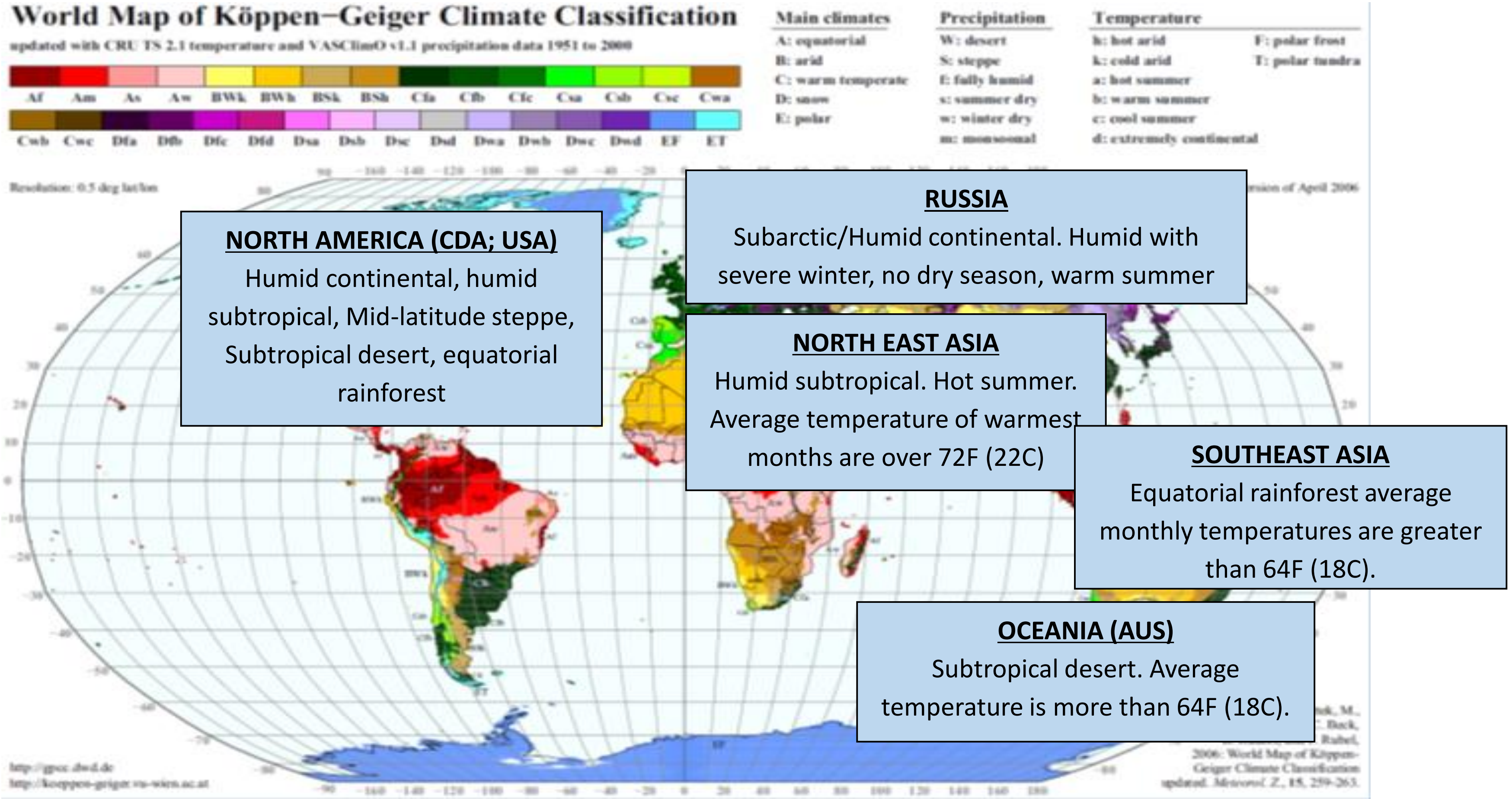
District cooling system works the same as district heating



Source: Danfoss. (2016). *How District Cooling Works.* © Copyright Danfoss | Pravda.dk.

- *Production and distribution of chilled water from a central source to facilitate air conditioning; done by producing chilled water at a central plant and then piping the water to customers through an underground insulated pipes network.*
- *Data on energy inputs and output are measurable.*
- *Deliveries to customers are also measurable.*

Climate in APEC



Source: Köppen-Geiger climate classification. (Kottek, Grieser, Beck, Rudolf, & Rubel, 2006)

- ***DCS is not only popular in tropics but also in other APEC economies during warmer season***

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Possible DCS installations in APEC

- ❑Australia: 4 known installations
- ❑China: more than 300 installations in the south of the economy
- ❑Hong Kong, China: developing 2 large DCS projects in the old airport area with cooling capacity of 284 MW
- ❑Korea: 27 installations supplying 1151 buildings
- ❑Malaysia: 27 plants
- ❑New Zealand: DCS serving residential and commercial buildings
- ❑Philippines: 2 known large installations
- ❑Chinese Taipei: 2 companies operating DCS supplying large hospitals and buildings
- ❑Thailand: 6 big installations
- ❑There are known installations in Canada, Singapore and the USA.

- *The largest district cooling capacity is in the United States, at 16 gigawatts-thermal (GWth), followed by the UAE (10 GWth) and Japan (4 GWth). In South Korea, district cooling more than tripled between 2009 and 2011 (Euroheat & Power, 2014).*

2. Why consider district cooling as energy?

Arguments (1)

- The production and delivery of service of district cooling and district heating are similar
  - Energy is used to produce both chilled water and heat, and district heating is considered a transformation process, why not district cooling?
- All DCS technologies need a large amount of energy input
  - *Electric chillers* requires electricity for cooling; *free cooling* (cold water from oceans, lakes, rivers or aquifers) uses natural gas; *absorption chillers* utilise surplus heat from waste incineration or industrial processes
- Building efficiencies are measured by energy use intensity (EUI) in kWh/m^2
  - Excluding chilled water will result in lower (EUI) and understate the actual energy consumption of the building

Arguments (2)

- Opens the possibility to be considered renewables
  - Huge potential for the use of free cooling in the production of chilled water; increasing the share of RE in the energy mix;
  - Will also encourage many economies to use free cooling resulting in lower carbon energy supply
- Environmental impacts are normally reduced
  - Higher efficiency of district cooling compared to individual building cooling systems;
  - Refrigerants and other chemicals can be monitored and controlled;
  - Free cooling reduces energy requirement for chilled water production
- If properly allocated in the energy balance table, energy intensity improvement can be huge.

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3. Case studies

Japan and Malaysia

Benefits of DCS

- Both economies identified the following benefits
  - Reduced capital cost in buildings in terms of avoided cost of chiller and other air-conditioning equipment
  - Reduced electricity usage and maintenance cost
  - Space savings due to avoided space requirement for chiller and air-conditioning installations

Case study (1)- Japan (a)

Illustration in energy balance table, (2014, TJ)

Sector	Gas	Oil	Coal	Electricity	Others	Cold Energy	Heat Energy	Hot Water	Total
Transformation									
CHP	-14 885	-159	0	-3 627	-2 970	12 311	9 020	280	-30
Final Consumption									
Residential						1 477	1 082	34	2,593
Commercial						9 849	7 216	224	17,289

Source: Japan Heat Supply Association

- *The total heating and cooling energy reported were lumped together, i.e. heat reported by Japan includes both heating and cooling energy.*
- *Energy efficiency due heat was overestimated;*

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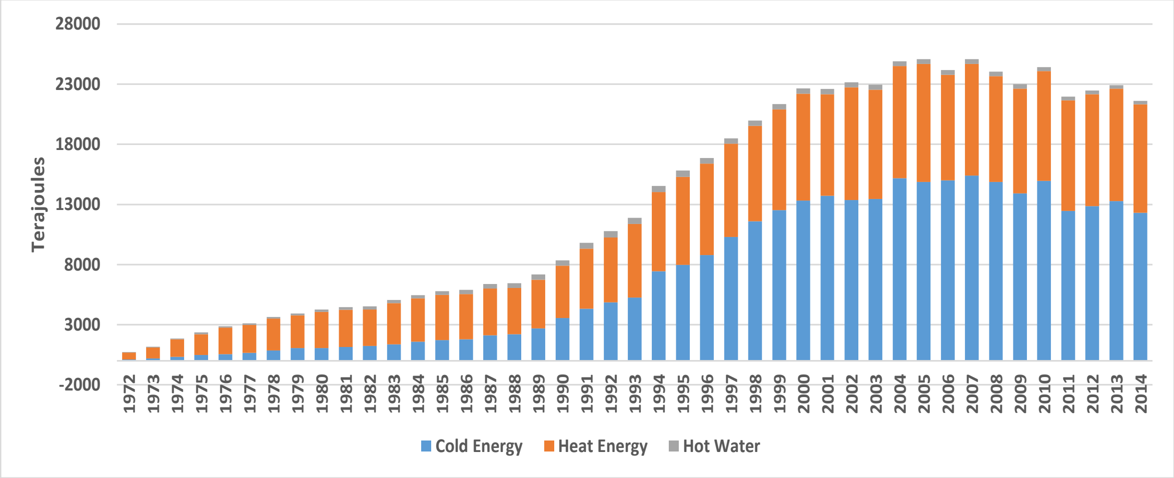
Case study (1)- Japan (b)

Japan DHC balance (TJ)



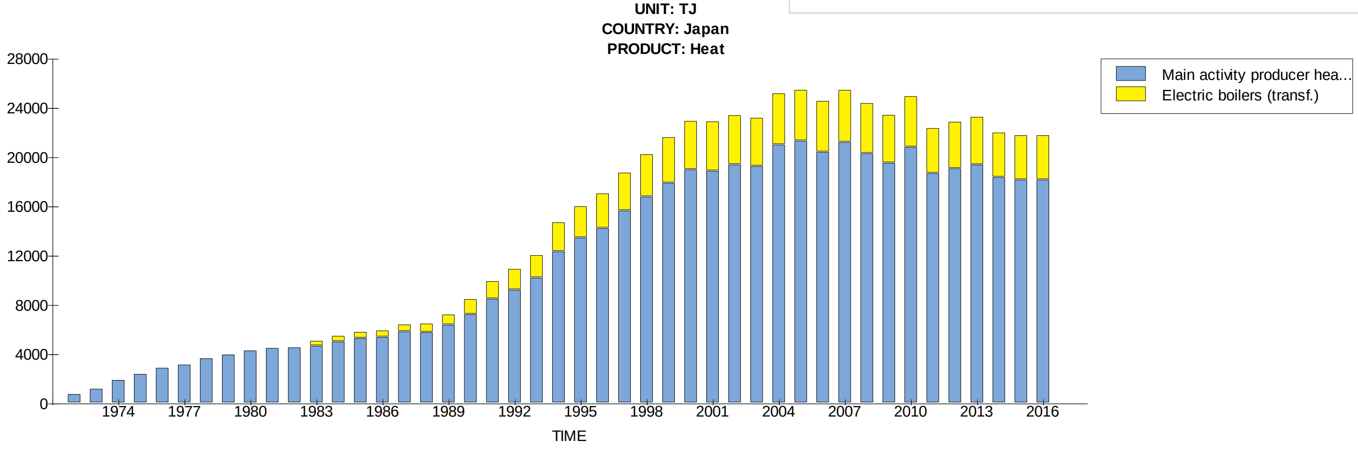


Table: wbal.ivt - World Energy Balances

Sources: Japan Heat Supply Association and IEA.

- ❑ ***Both IEA and JDHC reports looks the same, JDHC's however has more details***

Case study (1)- Japan (c)

- Expansion of DCS in highly **developed/congested cities** is difficult
  - Excavation for pipeline installation is nearly impossible as construction in roads are only allowed from late at night until just before sunrise
- Expansion of DCS would be possible for **new** building complex constructions

Case study (2)- Malaysia (a)

Illustration in energy balance table (MJ)

	Gas	Oil	Coal	Electricity	Others	Cold Energy	Heat Energy	Hot Water	Total
Transformation									
CHP	-165 632			-10 596		117 961			-58 267
Final Consumption									
Residential						0			0
Commercial						115 601			115 601

Might have been reported as commercial sector consumption

Not reported

Source: GDCP, 2016

- *Malaysia's report on DCS includes energy input (electricity and gas) and electricity as consumption (in KWhTR) ;*
- *The district cooling plant consumed more than 90% gas and the rest electricity.;*
- *Commercial consumption maybe over reported;*
- *Large amount of cooling consumption was not accounted for.*

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Case study (2)- Malaysia (b)

- The economy can report on chilled water delivered to customers;
- While data exists in district cooling facilities in Malaysia, the information is not yet captured in the economy's energy balance table.

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Proposed energy balance table

Supply

Transformation and Energy sector

Final Consumption

Year : 2014

Unit:KTOE

		1. Coal	2. Coal Products	3. Crude Oil & NGL	4. Petroleum Products	5. Gas	6. Hydro	7. Nuclear	8. Geothermal, Solar etc.	9. Others	10. Electricity	11. Heat	12. Total
1.	Indigenous Production	7,752		144,788		37,258	3,345	2,522	3,866	8,740			208,271
2.	Imports	4,760	334	386	29,950	23,622					183		59,235
3.	Exports	-2		-64,097	-9,955	-39					-228		-74,322
4.	International Marine Bunkers				-823								-823
13.1	International Aviation Bunkers				-3,245								-3,245
5.	Stock Changes	-191		-756	148	-335							-1,135
6.	Total Primary Energy Supply	12,318	334	80,321	16,075	60,506	3,345	2,522	3,866	8,740	-45		187,981
7.	Transfers			-6,612	7,820								1,208
8.	Total Transformation Sector	-10,349	1,119	-74,013	58,400	-31,388	-3,345	-2,522	-3,674	-1,769	25,929		-41,612
8.1	Main Activity Producer	-8,138			-7,083	-24,733	-3,280	-2,522	-3,282		22,210		-26,828
8.2	Autoproducers	-42	-121		-1,612	-7,175	-64		-392	-1,769	3,718		-7,457
8.3	District cooling												
8.4	Gas Processing				-792	520							-272
8.5	Refineries			-74,076	67,953								-6,122
8.6	Coal Transformation	-2,169	1,240										-929
8.7	Petrochemical Industry			63	-67								-4
8.8	Biofuel Processing												
8.9	Charcoal Processing												
8.10	Other Transformation												
9.	Loss & Own Use		-456		-5,940	-13,490					-4,930		-24,817
10.	Discrepancy	-356	0	304	-3,287	-1,901			0	0	738		-4,502
11.	Total Final Energy Consumptions	1,613	996		73,068	13,727			193	6,970	21,691		118,258
12.	Industry Sector	1,613	858		9,693	12,615			10	901	12,240		37,929
13.	Transport Sector				51,173	17					97		51,288
14.	Other Sector		139		12,201	1,095			183	6,069	9,354		29,041
14.1	Residential & Commercial				7,688	1,095			183	6,069	6,610		21,645
14.2	Agriculture				2,899						862		3,761
14.3	Fishing												
14.4	Others		139		1,614						1,882		3,634
15.	of which Non-Energy Use		139		5,556	644							6,338
16	Electricity Output in GWh	33,881			33,006	171,962	38,893	9,677	12,647	1,430			301,496
17	Heat Output in ktoe	0			0	0		0	0	0			0

- *Chilled water should form part of heat (energy products), and district cooling plants will be included in the transformation flow to balance.*

4. Situation and challenges in collecting district cooling data

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District cooling data situation

- In China and Korea, district cooling data are reported as part of "heat" like in Japan
- Data are not collected but maybe available:
  - Australia
  - Canada
  - China
  - Hong Kong, China
  - Malaysia
  - Philippines
  - Singapore
  - Chinese Taipei
  - Thailand
  - USA

- *Hope to collect data in Canada; Hong Kong, China; the Philippines, and US*

Challenges in collecting district cooling data

- District cooling is not yet a regulated industry in economies that just started this kind of business making data collection not as easy as in the regulated activities
  - Malaysia; Philippines; Singapore; Thailand
- APEC needs to prepare a document that would contain information on district cooling technology and methodology on related data that should be collected such as:
  - Fuel input
  - Use of free cooling, such as utilisation of water from deep sources, snow storage, etc.
  - Chilled water output
  - Chilled water delivered to customers
- Lastly, "should free cooling be considered renewable energy?"

Way forward

- Collect data in other APEC economies; i.e: Canada; Hong Kong, China; and USA;
- Identify major cities in APEC with potential to use free cooling;
- Estimating energy savings in the utilization of free cooling;
- Though cases maybe limited, complete the study by the end of the year;
- Continue sharing information with IEA, UNSD and other related fora.

Thank you for your kind attention.

https://aperc.ieej.or.jp/