


PLANNING AND GOVERNANCE

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Keeping Cities Cool as The World Heats Up

Conventional air conditioning may not be the most efficient.
Image: Chromatograph / Unsplash

As global temperatures rise because of climate change, demand for cooling is expected to increase. Some cities have implemented district cooling systems as an energy-efficient solution. Faizal Zulkefli and Livia Tan from the Centre for Liveable Cities explore some such projects.

> A district cooling system is more resource-efficient and offers space and energy savings, as well as improved reliability.

Cities, because of their high density and the Urban Heat Island effect, are particularly vulnerable to extreme heat due to climate change. With temperatures reaching unprecedented highs and greenhouse gas emissions still rising, cities face ever-greater demand for cooling and pressures to decarbonise. Adopting more efficient forms of active cooling has become paramount for cities' sustainable development.

Conventionally, cooling in buildings is carried out by stand-alone systems, either through individual air conditioning units (for a room or floor), or a centralised chiller plant (for the entire building). Such cooling systems are inefficient as they are designed for peak loads, which only happen about 5% of the time.

A district cooling system (DCS), on the other hand, provides cooling across several buildings through a network of pipes linking them to one or more centralised chiller plants. Being part of a network allows for DCSs to be more resource-efficient than stand-alone systems, creating space and energy savings as well as improved reliability.

Innovation in business models can help to encourage the uptake of high capital expenditure projects like DCSs.

A good example of this is the Tampines Eco Town DCS project, featured in a 2021 white paper jointly published by Singapore's national utility SP Group and sovereign wealth fund Temasek. Connecting the chillers of 14 existing commercial properties in Tampines Eco Town—thereby forming a type of DCS—will result in a 17% reduction in energy consumption and 18% reduction in carbon emissions, the paper said. Additionally, it projected that S$130 million in economic value will be generated over the next 30 years through cost savings and potential earnings from leasing out freed-up chiller space.

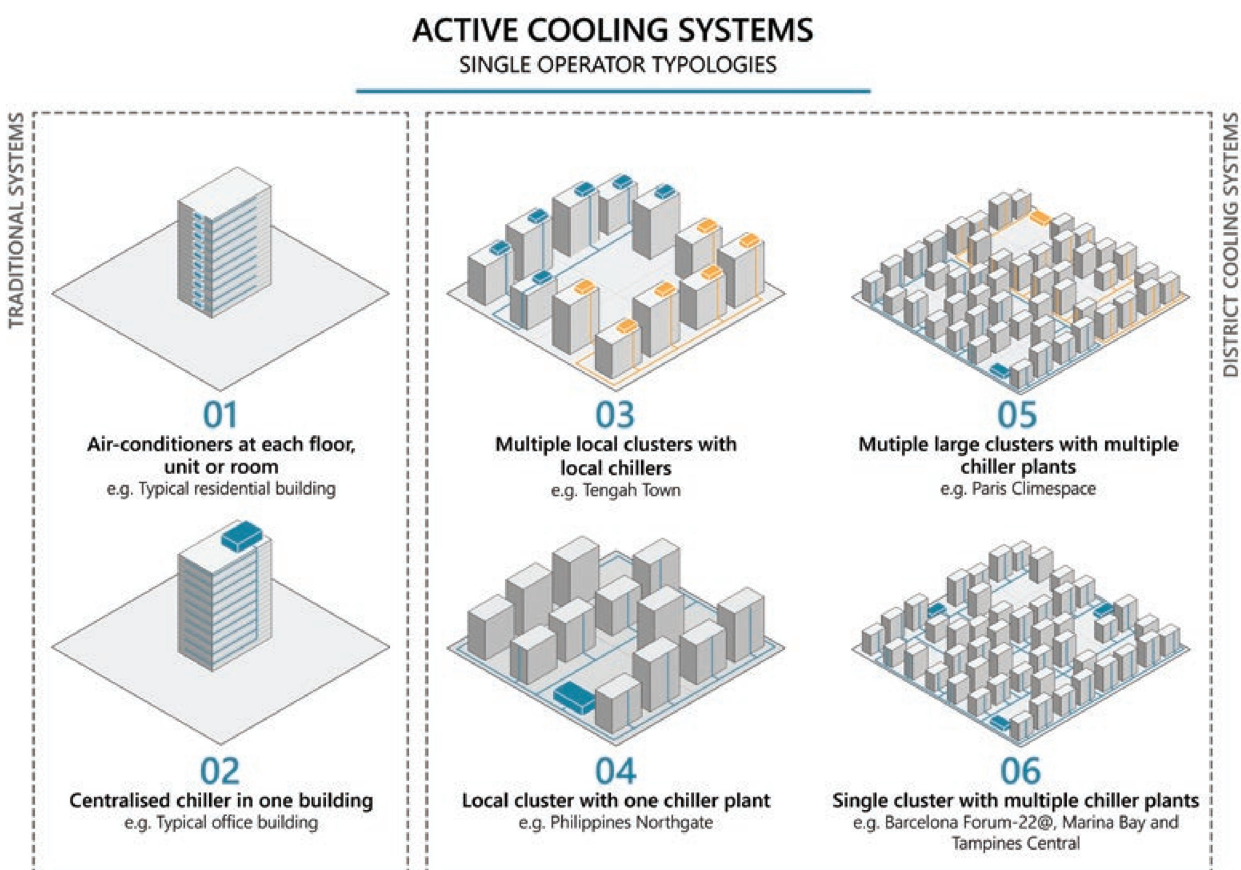


Figure 1. Typologies of active cooling systems.
Image: Centre for Liveable Cities

Examples of district cooling in cities

	PROJECT AND CITY	DESCRIPTION
LOCAL	**Marina Bay, Singapore**	Marina Bay was envisioned as a new business district with state-of-the-art infrastructure. Spanning 360 ha (3.6 km²), the Marina Bay DCS started operations in 2006 under SP Group and has been in operation since.
	Tengah Town, Singapore	The 700 ha (7 km²) Tengah Town was conceptualised as Singapore's first smart and sustainable town and will be the first Housing & Development Board (HDB) estate to implement district cooling when completed.
	Tampines Central, Singapore	A feasibility study of 14 existing buildings in Tampines Central was completed in 2021 to support the transformation of Tampines into an eco-town by 2025. This will be the first local project that will implement district cooling through brownfield retrofits.
GLOBAL	**Forum-22@, Barcelona**	The District Heating and Cooling (DHC) system at Forum-22@ was introduced in 2002 as part of the renewal of the Forum area to become the city's technological and innovation district. The DHC system has been operated by Engie and has expanded to an area of about 1,000 ha (10 km²).
	Climespace, City of Paris	The Climespace DCS system in the City of Paris was the first and largest in Europe. It began operations in 1991 under Engie and has been serving a 11 km radius at the heart of Paris.
	Northgate, Alabang, Philippines	In 2017, Filinvest partnered with Engie to implement a DCS in the 18.7 ha (0.19 km²) Northgate district, as part of its efforts to transform the existing industrial park into a green district.

Lowering Barriers to Deployment

Innovation in business models can help to encourage the uptake of high capital expenditure projects like DCSs by transferring the risks from the consumer to the solution provider (the DCS operator in this case), while ensuring financial viability for the latter. This can be seen in an upcoming residential estate in Singapore, Tengah Town, which deployed a form of DCS called the Centralised Cooling System (CCS).

The provision of a CCS for the residential blocks is a key sustainability feature in Tengah and will be implemented in collaboration between the Housing & Development Board (HDB), the public housing authority, and SP Group. The role of SP Group consists of financing, designing, building and operating the CCS, while the HDB designed the building infrastructure to support the CCS, such as provisions for the projected electrical load, structural strengthening and space for CCS plants and pipes. This model allows the HDB and SP Group to each focus on the work that is within their core competencies, thereby reducing risks for both.

In return for their initial investment and provision of services, SP Group will earn revenue from the residents of Tengah through: (i) hardware and installation costs of the CCS indoor units in the apartments; (ii) servicing and providing warranty for the indoor units; and (iii) sale of cooling services, for which residents will be billed monthly based on their consumption. As profits are obtained through the sale of cooling, SP Group will be incentivised to upgrade the equipment and continue innovating to optimise the performance of the CCS. Accordingly, the CCS was designed with modular systems that can be easily upgraded as technology advances to achieve better performance.

> **Despite challenges, district cooling in brownfield sites should still be explored as there are compelling environmental and economic reasons for doing so.**

Complementary Users

By serving a diverse mix of use types with different temporal usage patterns, the DCS would be able to distribute peak cooling demand across different times of the day and different days of the week. In an ideal situation, the DCS will serve complementary users who have different cooling demands. For example, non-residential and mixed-use areas would have cooling demands that typically peak during the day and on weekdays, while residential uses would have cooling demands that peak at night and on weekends.

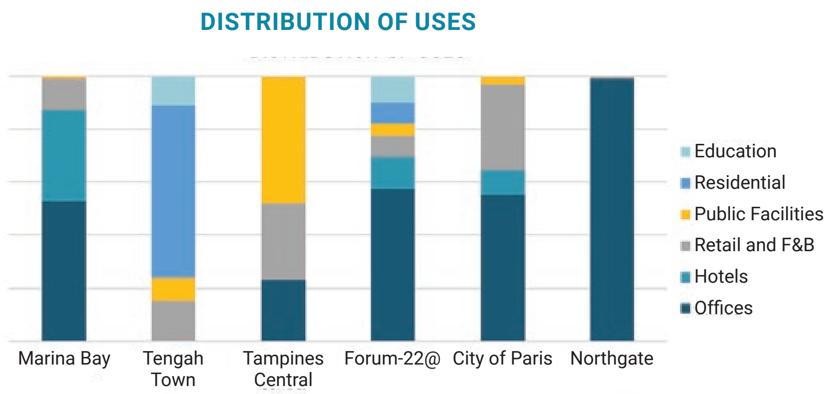


Figure 2: Distribution of uses served by the DCS.
Image: Centre for Liveable Cities, based on aggregated data.

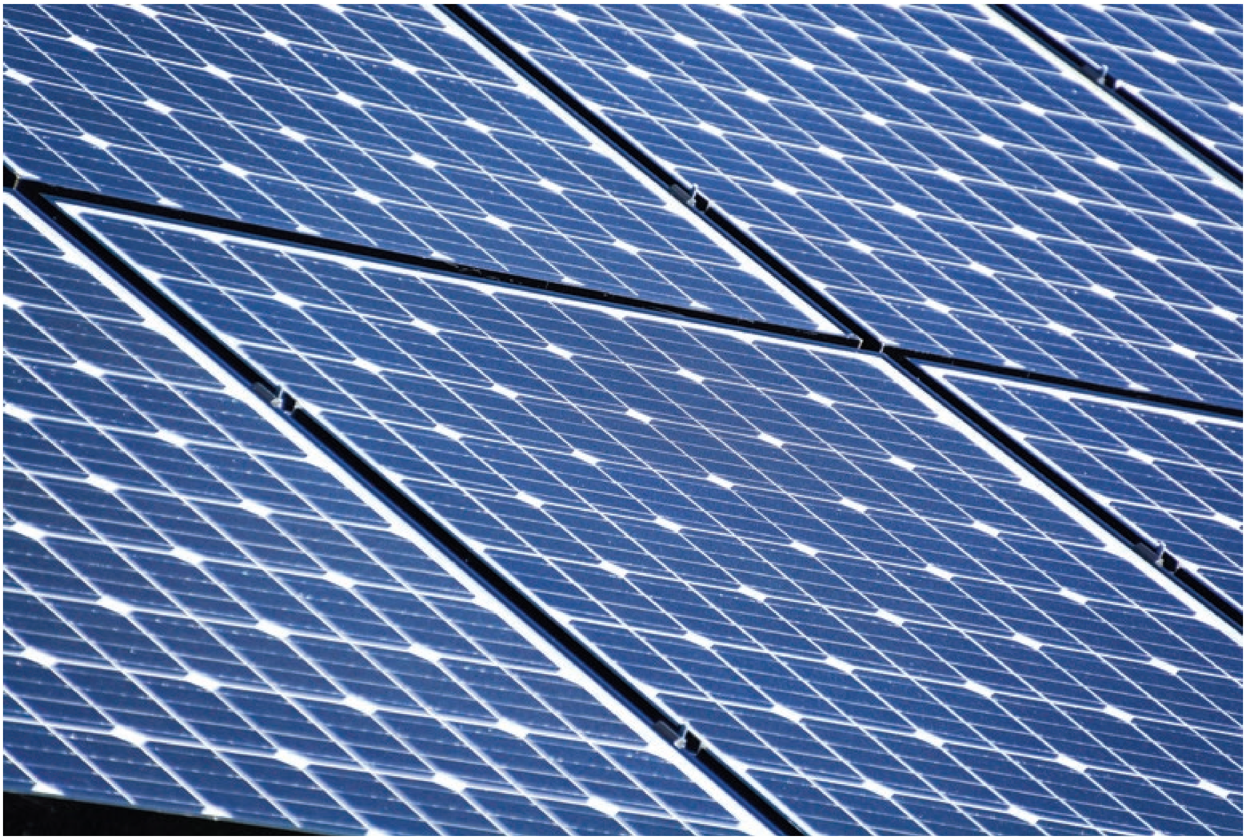
This can be seen in Climespace, in Paris, which is connected to a wide variety of uses, from commercial uses and public buildings to healthcare and residential uses. Through aggregating the peak demands of diverse uses, it has been able to maximise the capacities of fewer chiller plants to serve a larger number of clients. As a result, it was able to sell 431 MW of cooling power, despite only being designed with a 269 MW capacity.

Greenfield vs Brownfield Considerations

It is typically less complicated for DCSs to be established in greenfield sites, as they could be planned for alongside and integrated with new developments. Such facilities could hence be designed for maximum resource efficiency—crucial for cities with land or space constraints. For example, the DCS chiller plant in Marina Bay Sands was 25 m below ground, which minimised land take in the premier Marina Bay District and kept the machinery out of sight.

There are additional challenges when implementing the DCS for brownfield sites, however. Chiller plants will have to be planned around existing buildings and assets, which may not result in efficient design. Planners will also have to manage various existing stakeholders, who may not be equally invested in having a DCS. This is particularly so for stakeholders with differing building and land tenures, as they will also have different considerations in terms of return on investment.

Despite the additional challenges, district cooling in brownfield sites should still be explored as a possible solution to meet cooling demand. As the white paper by the SP Group and Temasek illustrated, there can be compelling environmental and economic reasons for doing so. In highly built-up cities like Singapore, implementing the DCS for brownfield sites will be an important sustainability strategy.



Thermal energy storage can be used to address solar intermittency.
Image: Jeremy Bezanger / Unsplash

Opportunities for Innovation

The DCS offers opportunities for extending innovative cooling methods to areas beyond the buildings within its network. One area that can be further explored is the use of the returning chilled water, which in a DCS still has sufficient capacity for further cooling, for outdoor spot cooling. The returning chilled water can be further used to cool down open air areas such as walkways and other public amenities. Another area to explore is thermal energy storage: storing energy in the form of ice or chilled water to be used later. This can be used in conjunction with solar photovoltaic systems to address issues such as solar intermittency and balancing energy demand and supply.

Conclusion

The DCSs are an opportunity for cities to meet their cooling demand, while boasting several advantages not offered by conventional stand-alone in-building chiller plants. These include environmental sustainability through energy savings and emission reductions, greater optionality and reliability for end-users, and less infrastructure and space required for cooling. City planners should take into consideration the various factors discussed above to ensure that resource efficiency and value capture is maximised in their implementation of the DCS.

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