Building Regulations and Urban Policies as Incentives for Application of District Cooling Systems in Singapore

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ABSTRACT

Existing district cooling projects display the potential to increase energy efficiency and reduce energy costs for cooling applications. The application of district cooling systems both is affected by and affects urban zoning, urban and architectural design and economic parameters. This paper analyses the status quo of planning and building regulation and urban policies as direct and indirect incentives for the application of district cooling systems (DCS). The paper aims at proposing strategies to facilitate the connection of more users to DCS in Singapore. We collect the planning and building regulations related to DCS in Singapore. Additionally, we retrieve more information from the video recordings of a discussion by experts on DCS in Singapore and China for first-hand experiences of the practice side. As a result, we will provide an assessment of the status quo of planning and building regulations and relevant urban policies concerning DCS in Singapore and suggest changes that may improve the efficiency of DCS and incentivize developers and proprietors to consider such system.

Keywords: *district cooling, policy and regulation, building codes*

1. INTRODUCTION

The global trend calls for serious and responsible actions on carbon emission reduction. Singapore has pledged to reduce CO_2 emissions by 36% in 2030 at COP21 (Ho 2015). The growing population and a potential increase in energy consumption also challenge this determination. District cooling systems (DCS) offer a solution for better energy performances as well as resilience-related, economic and environmental benefits (UNEP 2014). Research and application demonstrate multiple benefits of DCS with respect to architectural design, urban design and occupant comfort. These benefits include space saving, noise reduction and building program with complimentary temporal occupancy patterns.

Space savings in DCS refers to the space freed up by removing cooling facilities from the building rooftops and basements. It improves aesthetic and efficiency of the building and the city. Cooling towers on the rooftop can be replaced by sky gardens or terraces; chillers in the basement can be replaced by interconnected underground pedestrian tunnels. For example, the ship-like infinity pool floating over the three towers of Marina Bay Sands would not be realized without the district cooling systems. In addition, the removal of cooling facilities takes away the noises and the heat rejection into the urban environment especially street canyons.

DCS desires a stable consumption of the cold produced. Offices, for example, consume mainly in the daytime while residential buildings consume mainly at night. Thus, to maintain a stable and constant consumption pattern throughout the day, a mixed-use of various building programs with various types of occupancy, usage, time-of-the-day and weather conditions is beneficial (Tey 2010; Fonseca & Schlueter 2016).

Two of the main DCS providers in Singapore are Keppel DHCS and Singapore District Cooling (SDC). Keppel DHCS started operations in June 2000. Currently, it operates four cooling plants located at Changi Business Park, Biopolis One North, Woodlands Water Fab Park, and Mediapolis One North in Singapore. SDC, a subsidiary of the local electricity-utility started operations in May 2006 (Tey 2010). Currently, SDC operates two plants at the Marina Bay Business District. As part of a special urban policy for the development of the Marina Bay Business District, most buildings in the area are mandatorily required to connect to DCS (Zhuang 2016).

2. DIRECT AND INDIRECT INCENTIVES FOR DCS

A series of incentives have been adopted globally to promote energy efficiency in buildings and reduce their carbon emissions. Olubunmi, Xia & Skitmore (2016) categorized the incentives as internal incentives and external incentives. The internal incentives are human well-being related incentives, market demand-related incentives, gratifying incentives, altruistic incentives, and persuasion and inspirational incentives (Olubunmi, Xia & Skitmore 2016). These incentives highly rely on the developer's internal willingness to care about the human well-being and the green benefits. The external incentives include financial incentives and non-financial incentives. Financial and fiscal incentives are usually immediate financial remissions, like tax returns or fee waivers (Brilhante & Skinner 2015). Non-financial incentives include promotion and awareness incentives and economic incentives. Promotion and awareness incentives are services and assistances offered by the government as well as some pilot projects. Economic incentives concern peak pricing policies (Brilhante & Skinner 2015) and additional Gross Floor Area (GFA) (Shapiro 2011).

This paper focuses on the external incentives granted to the developers during the design and construction of buildings for connections to DCS. In Singapore, besides the incentives directly applied to the developers for the connections to DCS, there are also "hidden" benefits triggered by doing so. For example, DCS frees up the rooftop space, which can be used as public spaces or rooftop green. In Singapore, a green rooftop cannot only add economic and aesthetic values to the project but also raise the building height limit enforced by the Urban Redevelopment Authority (URA). We categorize the former as direct incentives and the latter as indirect incentives.

2.1 Direct incentives

The incentives directly applied for the adoption of district cooling systems are called direct incentives. Direct incentives usually come in the form of cash or tax rebate, discounted application fees, or additional allowance of gross floor area. Both Building Construction Authority (BCA) and URA have initiated several schemes of such direct incentives over the past decade to improve the energy performance and appearance of buildings in Singapore. These incentive schemes include the Green Mark Incentive Scheme by the BCA with cash incentives (BCA 2009) and the LUSH program 2.0 by the URA with extra gross floor area allowances (URA 2014). None of the existing incentive schemes in Singapore is focused on the adoption of district cooling systems.

2.2 Indirect incentives

Indirect incentives benefits are the result of the DCS's influence on various aspects of the building projects. Though there are no direct incentives, several building regulations and urban policies function as indirect incentives for the developers to decide to connect to the district cooling plants in Singapore.

Rooftop: As presented in Section 1, DCS's free up rooftop space in buildings can be used as public space or for rooftop greenery. In Singapore, a green rooftop can not only add economic and aesthetic values to the project but also lower the height restrictions enforced by URA. Roofscape is considered as one of the key urban design element (URA 2016a). URA grants bonus Gross Floor Area (GFA) for outdoor refreshment areas on landscaped rooftops of both new and existing commercial and mixed-use developments within the Orchard, the Downtown Core planning areas as well as parts of Singapore River (URA 2014). URA grants GFA exemption for rooftop pavilions when they are integrated into the rooftop landscape design occupying at least half of the rooftop space (URA 2014). For non-landed residential developments, rooftop landscapes meeting the criteria can be counted to meet the overall greenery provision and relieve the needs of spaces for on-ground greenery (URA 2016b).

Underground: When meeting certain criteria, URA grants GFA exemption for underground pedestrian links to rapid transit system stations (URA 2016c). Additionally, URA grants extra GFA allowances for activity-generating uses within the underground pedestrian links from Rapid Transit Systems (RTS) stations to existing development beyond the GFA allowed by the Master Plan. However, this additional GFA is not transferable and cannot be used to form future redevelopment of the site (URA 2001). The activity-generating uses include commercial uses like retail and eating outlet (URA 2016c).

Energy efficiency and noise control: DCS's have been proved in practice to increase the energy efficiency of buildings significantly (Tey 2010). Energy efficiency accounts for the majority of the points in the BCA Green Mark rating system (BCA 2013). The BCA Green Mark Scheme is a benchmarking scheme that evaluates environmental performance of building projects (BCA 2016). Additionally, points are also awarded for the performance of noise level (BCA 2013). Projects meeting the Green Mark criteria can be granted cash incentives and GFA incentives by BCA and URA (BCA 2009; URA 2009).

2.3 Voices from practices

This section outlines positions and experiences of developers and operators of district cooling systems in Singapore and China (Happle 2016). Participants include academic researchers and DCS providers.

Except for the mandatory cases, the main drivers for building owners/ developers to connect to a DCS are the increased freedom of building design and improved energy efficiency which allows to better meet the requirement of Green Mark ratings (Happle 2016). These aspects are both related to the building regulations and the urban policies discussed as indirect incentives in the previous section.

Residential building excluded from the mandatory connection: Although most of the building projects are mandatorily connected to DCS, residential buildings are exempted from this obligation. Unlike offices where cooling is needed on a daily basis, the occupancy pattern of residential buildings is more versatile. Personal living habits such as a short trip away from home can alter the cooling need. Also, the in-taking stations in the building take up GFA and the additional piping systems to distribute cold in the building generate costs. Additionally, the district cooling systems remove the air-conditioner ledge of the split-units, which doesn't count as GFA but is sellable. These are some of the reasons that undermine the economic profits potentially brought by the connections to district cooling systems.

Electricity tariff: To maintain a stable cooling need, various buildings with different occupancy pattern are needed. In Singapore, the electricity tariff defined by the Energy Market Authority fluctuates over the day. A cooling provider would thus rather generate and store cold during low tariffs and sell it out during peak time than generating all in the peak time as needed. Residential buildings have higher cooling demand during the night when there is the low tariff. This is another reason that the residential buildings are not preferred.

3. DISCUSSION

Interdependencies on different levels: When introducing a comparatively new technology to a new context, technical feasibility is usually the first issue to be tested and solved upon application. However, to keep the system operating in a much more complicated context, it requires many other issues to think about, like business, policy-making urban planning, urban design, building design, and operations. For example, since the mid-1990s, URA, Singapore Power and Dalkia have conducted feasibility studies to identify district cooling as an urban utility and its commercial viability for the Marina Bay Business District (Tey 2010). Afterward, in the urban planning process, the application of district cooling system requires establishing a link between the urban and energy aspects, e.g. density arrangements corresponding energy strategies (Cajot et al. 2016). In the building design process, it needs back-and-forth negotiations between the district cooling engineers and the architects for the building's connection to the network. However, beyond all these, an operational business model with a reasonable charging strategy is the one that keeps the system running. This model should give considerations to the benefits of all the related stakeholders, like the cooling provider, the customers, etc.

Policy matters: Building projects like Marina Bay Sands connect to DCS to free up the rooftop space from cooling towers for architectural design freedom, e.g., the rooftop infinity pool. More importantly, one of the reasons that the developers voluntarily choose to connect to district cooling plant is to meet the requirement of a higher Green Mark certification (Happle 2016). Policy matters. However, it is admitted that since there was no information from the developers' side, it is not sure that the other indirect incentives are effective. Except for cases with mandatory connection requirement, for the developers or the customers, decisions to connect to the district cooling plant are usually profit-driven. Thus, there are three directions that building regulations and urban policies could be adapted to incentivize more projects to join. One is to strategically introduce direct incentives of GFA or cash rebate. Another one is to increase the indirect incentives to make such "hidden incentives" more attractive and "visible". And finally, one is to tighten up the requirement of energy efficiency, noise control, green rooftop, and underground pedestrian networks to "force" the projects within the service radius to join.

Residential or not? As discussed in the introduction, it requires buildings with various occupancies, usage, and time-of-the-day to maintain a stable cooling demand pattern to the system. So far, all the district cooling plants in Singapore are located in business districts mainly with office buildings. Office buildings have high cooling demand mainly in the daytime of weekdays while residential buildings usually have intensive cooling demand at night and weekends. Thus, the cooling need of residential buildings can be considered complementary to that of office buildings. However, in Singapore, residential buildings are currently either excluded from the mandatory requirement of connection to DCS or not "embraced" by district cooling providers. Multiple economic reasons including the electricity tariff and the increased investment together with the versatile occupancy pattern mainly lead to this situation. Though economic issues are highly important in practices, mixed-use developments also offer urban qualities. Based on challenges like "eyes-on-the-street" of Jane Jacobs in the 1960s (Jacobs 1961) and experiences generated from projects like La Defense in Paris, business districts worldwide benefit from being mixed-use and all-day vibrant. To achieve such goal, residential buildings are indispensable. So, in the process of urban design within the service radius of a district cooling plant, residential buildings should not be excluded merely for the sake of the reasons discussed above. However, whether a residential building should be connected to the plant can be optional and on a case-by-case basis. Possible strategies of regulations and policies include bonus GFA or cash rebate and tariff discount to developers and DCS providers of residential buildings. In this way, the additional investment on the facilities for DCS connection can be fully or partially compensated by the bonus GFA

4. CONCLUSION AND OUTLOOK

This paper reviews the status quo of DCS applications and relevant building regulations and urban policies as direct and indirect incentives in Singapore. Experiences and voices from the practice side are valued and addressed. It is once more underlined that the application of district cooling system is multifaceted and more than merely a technical, a commercial or a policy issue. Exemplified for residential buildings, the interactions between aspects of energy systems and urban qualities become apparent. When introducing a comparatively new technology like district cooling system we can observe its influences on other aspects such as urban design issues of density deployment, building programs, etc. Urban design and district cooling systems should, therefore, work in synergy to increase the energy efficiency and urban quality. Last but not the least, policy matters. Building regulations and urban policies can work as direct or indirect incentives to promote voluntary connections. However, any adaptations of such regulations and policies should be carefully evaluated before coming into force.

Future studies on district cooling systems will include ideas, and experiences from all the stakeholders involved in the lifespan of a building project. This includes cooling providers, policy-makers, developers and district cooling customers.

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