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GUANGMING DISTRICT, SHENZHEN, CHINA

Ice Storage Air Conditioning Procurement for Green Building

03

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Shenzhen Guangming District in Southern China will procure an unconventional air conditioning system using ice-storage technology for a public utility in 2019, yielding up to 48% electricity bill cut and 14% carbon emission reduction by balancing energy demand between peak and off peak hours, and using an air conditioning system with higher coefficient of performance (COP).

Introduction

Recognized as the "Green Valley" of Shenzhen Municipality, Guangming District, a former agrarian community, has transformed into a green growth model fueled by high-tech innovations in a decade's time.

In 2008, the Chinese central government designated Guangming as one of the country's first green building demonstration zones. Following this, Guangming issued a comprehensive set of local construction regulations, standards and guidelines in achieving the target of 100% green building coverage rate by 2020. In 2017 alone, investment in green building amounted to roughly 20% of GDP in the district, entailing a great number of construction work, goods, and services acquisition. Among this, space cooling equipment draws particular attention, given that air conditioning (AC) accounts for the vast majority of energy consumption in building

Facts & Figures[1]

Shenzhen Guangming District

Country	People's Republic of China
Land Area	~156 km²
Population	596,800 (2017)
GDP	RMB¥85 Billion (2017) ≈ US$12.6 Billion[2]
GDP per capita	RMB¥146,900 (2017) ≈ US$21,757.20
Green Building Investment	RMB¥16.6 Billion (2017) ≈ US$2.5 Billion
Pillar Industries	IT, AI, New Materials & Energy, Bio-industry, Environment, Culture

1. Economic data provided by the Shenzhen Guangming District Development & Construction Bureau of Science City.
2. This report adopts a yearly average currency exchange rate for US Dollar to Renminbi, 6.75, provided by the China National Bureau of Statistics in 2017.

10YFP on SPP WG1A Project "GPP Tender Implementation and Impact Monitoring"

Initiated by the UN Environment, the 10 Year Framework of Programmes on Sustainable Consumption and Production (10YFP on SPP) was adopted at the Rio+20 UN Conference on Sustainable Development in 2012 as a global framework that boosts international cooperation in transitioning towards sustainable consumption and production.

The 10YPF on SPP is one of the six programmes under the 10YFP that contributes explicitly to SDG target 12.7 — promote public procurement practices that are sustainable in accordance with national policies and priorities. It is a global multi-stakeholder platform, led by UN Environment, and co-led by ICLEI and the Korea Environmental Industry & Technology Institute (KEITI) to support the mainstreaming of SPP/GPP via capacity building, technical and financial assistance.

The 10YFP on SPP Working Group 1A Project, implemented by ICLEI, supported two Chinese and one Korean local governments in procuring green and innovative products and forged a regional partnership on GPP from 2016 to 2018.

operation phase. The subtropical climate with humid, long and hot summers in Guangming adds to significant cooling demands, increasing electricity bills and carbon emissions. In quest for more environmentally friendly AC systems to realize green building, Guangming joined the 10YFP SPP Working Group 1A Project "GPP Tender Implementation and Impact Monitoring" in August 2017 to apply new tender models with the support of ICLEI—Local Governments for Sustainability.

Procurement Approach

Following the 10YFP pledge made by the Guangming District Government, a GPP baseline assessment survey was conducted by ICLEI in late 2017. The AC procurement of the Guangming Cultural and Arts Center was selected to apply greener tender criteria. Aimed at opening by 2020, the Center is expected to become a landmark public building which meets the highest environmental and energy standards at national level.

Guangming set the bid control price as 22.67 million RMB (3.37 million USD) for acquiring an AC system turnkey solution in the second quarter of 2019, covering design, installation, debugging, training, and warranty. A particular type of technology —ice storage— is required considering its life cycle economic savings and energy efficiency. The ice storage AC system is commercially proven in North America but much less known in China due to market immaturity. The principle of this technology is simple: instead of using conventional air compressors that

Table 1: 10YFP Environmental Criteria for Ice Storage Air Conditioning in Guangming

Category	Criteria
Environmental Management	• Supplier with GB/T24001 or ISO14001 environmental management system certification • Supplier with no record of environmental violations in the past 3 years • Supplier with clean production process audited by third party
Reporting	• Supplier having reported corporate social responsibility in compliance with credible standards
Design	• AC system designed with a seasonal coefficient of performance (SCOP) ≥ 3.5 • AC system designed with minimum refrigerating capacity and optimized with off-peak electricity tariffs
Raw Materials	• Components of AC system in compliance with the Restriction of Hazardous Substances Directive (RoHS) standards. *Maximum Concentration Values of the RoHS restricted substances are: i. Lead 0.1% by weight, ii. Cadmium 0.01% by weight, iii. Mercury 0.1% by weight, iv. Hexavalent chromium 0.1% by weight, v. PBBs 0.1% by weight, vi. PBDEs 0.1% by weight*
Packaging and Transport	• AC system packaged with minimum recyclable and eco-friendly materials • AC system delivered by Clean Energy Vehicles
End-of-life Treatment	• AC system with guaranteed end of life collection and disposal services • Supplier in compliance with the Waste Electrical and Electronic Equipment Directive (WEEE)

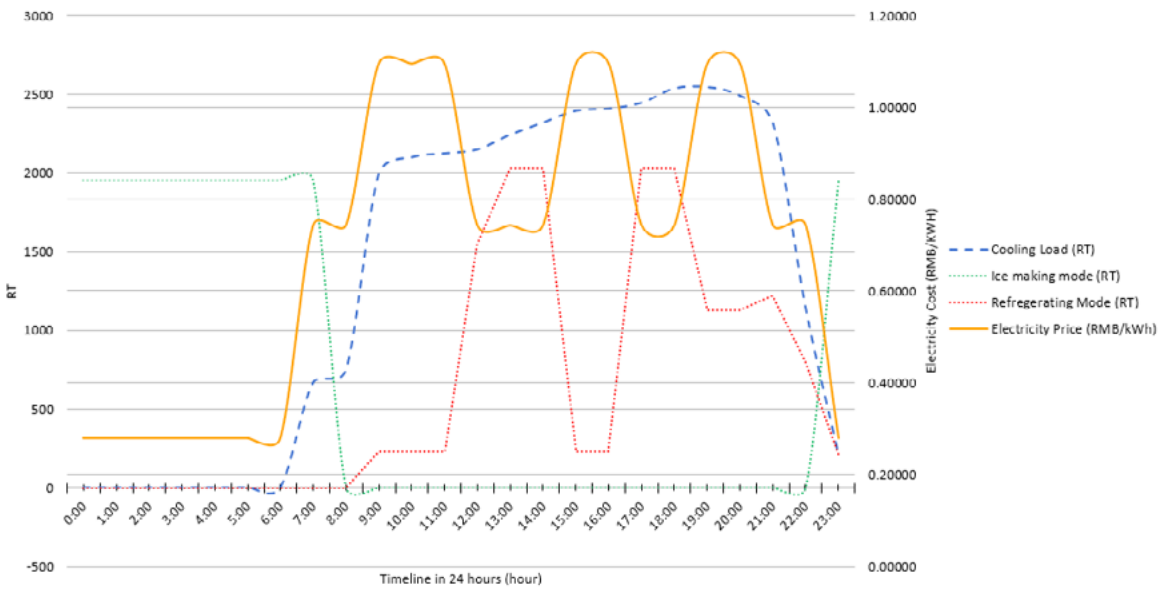
are potentially more energy intensive, the system forms ice during the night for storage, and melts ice to provide cooling during the day when energy demand is higher.

Neither national nor industrial environmental standard has been established for ice storage AC systems in China, and the only environmental aspect considered in bidding processes of such systems was the environmental management system (EMS) certification. Through the 10YFP on SPP project, ICLEI and the procuring entity developed an environmental criteria for ice storage AC in the Guangming Culture and Arts Center construction project (Table 1).

Estimated Results

The actual bidding process with the new green criteria is scheduled to take place in May 2019. Individual supplier with the highest capacity to fulfill *quality* and *environmental performance* evaluations will be selected. The procurement criteria are expected to bring along advantages, such as lower utility bills, GHGs reduction, toxic substances removal, and improved resource efficiency. Due to the limitation of project scope and data availability, only two aspects of the advantages are evaluated in this project phase.

Figure 1: Expected Daily Load Distribution of Ice Storage Air Conditioning in Guangming



*Refrigeration ton (RT) is the rate of heat transfer resulting from freezing 1 ton of ice at 0°C in 24 hours. 1RT = 3.517 Kilowatt (kW)

- **Lower Electricity Bill.** The intended ice storage AC system is equipped with a dual-chiller system, which runs in ice-making mode during the night to produce ice and store energy, and melts ice during the day to cool the building, with excess cooling demand supplemented by regular refrigerating mode (air compressors) in the peak hours. By taking the advantage of the peak-valley tariff dispersion of local power grid, utility bills could be significantly reduced.

  Figure 1 visualizes how total cooling load of the Center could be met by balancing two operation modes to generate most savings. The system runs in ice–making mode from 23:00 to 7:00 of the next

day on a lower electricity tariff of 0.28 RMB/kWh (0.04 USD/kWh), and minimizes energy use during the daytime when the price of electricity is four times higher.

The economic saving calculation is based on the comparison of the ice storage dual system with a seasonal coefficient of performance (SCOP) of 3.5 against conventional air compressors with a market average SCOP of 3.0, operating a load distribution as demonstrated in Figure 1.

Under this scenario, it is expected to cost the Center 35,105 RMB (5,200 USD) per day to meet the daily cooling load with a conventional AC system, in contrast to 18,328 RMB (2,715 USD) per day with ice storage systems, which is equivalent to a 48% reduction of the electricity cost. With the installed AC system expected to operate 210 days per year (April to November), it is expected that the Center could save 3,523,176 RMB (521,952 USD) annually. Considering the planned upfront investment (bid-price control) and annual savings, the investment payback time is anticipated to be no more than 6.5 years.

- **Reduced Carbon Emission.** AC systems with higher refrigerating efficiency require less energy to meet cooling demand, contributing to lower carbon emissions in operation. Using the same scenario, the report compares emissions between the ice storage AC with a SCOP of 3.5 and the conventional system with a SCOP of 3.0.

  Electricity carbon intensity (ECI) of China Southern Power Grid in 2017 is calculated as 610.7 g/kWh, the carbon emissions of AC systems can be further derived by

$$Carbon\ Emission\ (g) = Cooling\ Load\ (RT) \times 3.517\ (kWh/RT) \div SCOP\ \times ECI\ (g/kWh)$$

  Table 2 shows comparison results on daily, monthly and yearly basis. The carbon reduction is forecasted to be 3.32 tons (14%) per day.

Table 2: CO_2 Reduction using Different Type of Air Conditiong

	1 Day	1 Month	1 Year
AC–SCOP 3.5 (ton)	19.93	598	4,185
Conventional SCOP 3.0 (ton)	23.25	698	4,883
Reduction (ton)	3.32	100	697

Lessons Learned

- **Ice storage AC system has great potential for monetary savings and emission reductions.** By consuming electricity in the off-peak hours at night, ice storage AC systems could not only reduce the property owner's expenses on electricity for cooling, but could also level the peak load of the domestic power grid during the peak hours — especially on hot summer days. On a broader perspective, a more balanced energy demand within the society could ultimately diminish the need for peaking power generation which is usually less efficient, and could lead to an overal improved energy efficiency.

  In addition to the reduction of electricity bills by using lower-priced nighttime power, the time

distribution of electricity generation sources should also be taken into considerations by local governments that are interested in this technology. With the same refrigerating efficiency, emission reduction effects of ice storage AC systems would be more pronounced when compared to that of conventional alternatives where electricity is generated with clean sources, such as hydro and wind, during the off-peak hours.

- **International cooperation pushes the boundary of GPP at local level in China.** Resulting from the current imperfect legal and institutional framework, construction work and its associated components are usually excluded from the common understanding of GPP in China. Through participating in the 10FYP on SPP project, Guangming was provided with accesses to capacity building, peer-learning and intensive knowledge sharing opportunities, and received technical tender advice from ICLEI experts and project partners, which allowed the district to move beyond the incomplete definition of GPP in the country.

Sources

- China Southern Power Grid. (2017). 2017 Corporate social responsibility report. Retrieved from http://www.csg.cn/shzr/lshb/201805/P020180509622809911015.pdf [In Chinese]
- Guangming District Government. (2018). Guangming New District 2018 Work Report. Retrieved from http://www.szgm.gov.cn/xxgk/xqgwhxxgkml/ghjh_116525/gzbg/201803/t20180306_10896288.htm [In Chinese]
- Lazar, J. (2016). Teaching the "duck" to fly, second edition. Montpelier, VT: The Regulatory Assistance Project. Available at http://www.raponline.org/document/download/id/7956
- Li, X., Chalvatzis, K.J., & Pappas, D. (2017). China's electricity emission intensity in 2020-an analysis at provincial level. Energy Procedia, 5(4), 181-188.
- Wendling, Z. A., Emerson, J. W., Esty, D. C., Levy, M. A., de Sherbinin, A., et al. (2018). 2018 Environmental Performance Index. New Haven, CT: Yale Center for Environmental Law & Policy. https://epi.yale.edu/
- Yan, L. & Yonghui, L. (2018, December 20). Ecological civilization system reform guarding "Green Guangming". Southern Daily, p. A1. Retrieved from http://epaper.southcn.com/nfdaily/html/2018-12/20/content_7771213.htm [In Chinese]

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