Challenges in Realizing Green Building Concepts in Trade and Industry Tower

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ABSTRACT

The newly established Kai Tak Development Area (KTDA) marks a new era of sustainable urban development in Hong Kong featured by its first-ever District Cooling System for air-conditioning of buildings in the district. The Trade and Industry Tower (TI Tower) is the first office building in this new exemplary district of sustainable urban planning and design. With its strategic location at the gateway to the KTDA, the design of the building is set for demonstration purpose using sustainability as the theme to showcase sustainable building design.

The office building is designed not only to meet the building occupants' needs in respect of comfort, security, safety and operational efficiency, but also to achieve an eco-friendly building following the assessment guidelines set out in the BEAM Plus for New Buildings and LEED for New Construction. The project was bestowed a Grand Award of Green Building Award 2014 by the Hong Kong Green Building Council and is certified to Platinum level under LEED® and provisional Platinum level under BEAM Plus.

This paper introduces the exemplary green building designs of the TI Tower, including extensive greening, passive architectural design and active energy efficient features for maximizing building energy performance, automatic refuse collection system, intelligent building control and monitoring systems, educational provisions for promoting sustainable building design to the public. Property management measures are put in place after completion to ensure that the building is managed, operated and maintained to meet the objectives of its green building designs.

In the course of realizing the green building concepts, the project met various challenges in terms of site constraints, technical feasibility as well as time and budgetary constraints. This paper attempts to sum up the invaluable experiences gained by overcoming the relevant challenges through the collaborative effort of all stakeholders involved in the project.

Keywords: *green building, green building management, green construction technology*

1. INTRODUCTION

The project is organized into a 20-storey Office Tower, in which all the government offices are located and a separate Community Hall, which accommodates the multi-purpose hall and ancillary facilities.

A conscious target is laid down at the outset to make the project "green" in both aesthetic and performance terms. In the design, soft landscaping is seen to meander from one corner of the site to the opposite, covering the roof of the Community Hall, spreading over to all four elevations of the Office Tower, reaching its roof to form a lush roof garden. The distinctive "Green Ribbon" forms the signature of the building and is clearly discernible from all directions. The aesthetic interest is enhanced by introducing an organic, aerodynamic form – the "White Ribbon" of the Community Hall to contrast the efficient and functional image of the Office Tower. The "Ribbons" combine to conjure up a concept of a "gift" of services from the government to the local community the building serves.

The completed building provides daily service and leisure to the general public, and therefore is an excellent showcase for various green features.

2. GREEN BUILDING CONCEPTS

2.1 Extensive greening

In keeping with the "Green City" concept in Kai Tak Development Area, emphasis of the project has been placed on greening.

An exemplary 42% greening ratio is achieved and over 120 trees are planted with over 40 of them on the office tower roof. Greening wraps around all surfaces of the development in the form of a "Green Ribbon", which symbolically and visually links and unifies spaces at all levels. The visual integration of landscape and greening with adjoining streetscapes is achieved by integrating bounding planting which compliment the selection and character of roadside planting outside the site boundary. A rich variety of open spaces, including at-grade spaces which are visually and physically connected to the ground level streetscapes, spaces at footbridge level with connecting staircase to ground level and break-out spaces on the roof of the office tower, provide a variety of passive recreation opportunities for visitors and users.

2.2 Sustainable building design

Sustainability is identified as one of the main themes of the project. Passive consideration of sustainability begins with the site planning and building layout and extends to the application of various features listed below:

2.2.1 Passive devices

- High performance facade material is selected with a Solar Coefficient (SC) value of 0.26. The glazing material is selected to maximize the amount of natural daylight provided to the building whilst reducing the solar heat gain.
- Solar shading is provided to all facades, providing shading from solar energy and from glare to the facade in the east and west under low angle sun conditions. Optimal application of solar shading also contributes to reduction of OTTV.
- Solar chimneys use solar energy to heat the air inside the 2 nos. of chimneys serving the Community Hall and basement car park, leading the air to become buoyant and driving an upward stack, entraining air in the low zones into the chimney to be extracted from the space. This allows the reduction in the amount of air conditioning and ventilation required to the Community Hall and car park respectively.

2.2.2 Active energy efficient features

- Connection to Kai Tak District Cooling System (DCS) provides the centralized air-conditioning system with a reliable supply of chilled water for building heat rejection. The DCS is over 20% more energy-efficient than a conventional air conditioning system using cooling towers. The connection with the DCS eliminates the building space required for accommodating the conventional heat rejection equipment such as cooling towers, thereby sparing more roof space for photovoltaic panel installation and roof garden. The elimination of evaporative cooling towers is also conducive to the saving of cooling tower make-up water, which is used for compensating for the evaporative water loss and regular water bleed-off. The DCS also eliminates the need of installing chillers in the office building, thereby reducing the total electricity demand as well as the space for accommodating power supply transformers.
- Free Cooling Design is adopted for the entire air-conditioning system so that the conditioned space is served by 100% untreated fresh air when the outside air meets the prescribed air intake conditions. During the free cooling mode of operation, the fresh air supply from PAU is shut off whilst the chilled water supply to the AHU cooling coils is also shut off for the sake of saving energy.
- Improved Specific Fan Powers for all Air Handling Units (AHUs) by reducing the external static pressure by paying careful attention to the pressure drop of ductwork.
- Condensate Recovery System is adopted for collecting the cooling coil condensate water from drip trays of CRAC units and AHUs of each floor to a thermally insulated condensate storage tank via a vertical riser. Condensate water is then pumped to a separate cooling coil of a designated PAU for reducing the DCS chilled water demand of the same PAU.

- Heat Recovery Wheels are adopted for all 6 No. of PAUs. Each PAU is equipped with a heat recovery thermal wheel between the supply and return air streams for reclaiming the waste energy from exhaust air and pre-cooling or pre-heating the incoming fresh air.
- Demand Control of PAUs Based on the Indoor CO_2 Concentration Levels and Temperatures facilitate energy saving of the fresh air supply system, especially for indoor spaces with significant variations in the number of occupants. The PAU is equipped with a variable-speed drive for coping with the fluctuations in fresh air demand at different times.
- Active Harmonic Filters of the Electrical Distribution System minimize the electrical energy losses arising from harmonic currents that originate from electronic equipment or components (power switching devices, IT equipment etc.). The Active Harmonic Filters eliminate the undesirable harmonics by using power electronics, reducing the thermal stress induced by harmonic currents and enhancing the efficiency of electrical power distribution.
- Active Power Factor Correction Units of the Electrical Distribution System improve the overall system power factor by counteracting the undesirable effects of electric loads that create a power factor that is less than 1. Power factor improvement is achieved by reducing the reactive component of the supply current by adding capacitors in parallel with the connected inductive load circuits. The inductive effects of an electrical load are cancelled out by the current generated by the capacitors. The power factor improvement enhances the energy performance of electrical distribution system, including the improvement of cables' current-carrying capacities, reduction in electrical power losses as well as increase in the portion of useful electrical energy produced from the electrical energy sources.
- Heat Pump System is used to absorb heat from the return chilled water and pre-heat the hot water tank. This serves as a secondary heat source to the Solar Hot Water Supply System when the installed solar collectors cannot provide the required heat energy for pre-heating the incoming water of the water mains, therefore enhancing the overall energy performance of the Solar Hot Water System. At the same time, the chilled water demand of the air-conditioning system is also reduced.
- Service-on-demand Mode of Operation is adopted for the four escalators at G/F and M/F, whereby passenger proximity sensors are installed at the entrance of each escalator for controlling the ON/ OFF operation of the escalator, thereby contributing to a substantial saving of escalator running energy during the period when there is no passenger traffic.
- Demand Control of Mechanical Ventilation for Basement Carpark based on Indoor CO_2 Level and Temperature is an effective means of minimizing energy consumption of variable-speed exhaust air fans whilst keeping concentrations of indoor pollutants like CO and NO_2 below the ceiling levels by use of gas monitoring devices throughout the carpark.
- LED and T5 Fluorescent Lamps are adopted for the lighting system. Tubular LED lamps are installed at selected part of the office areas whilst LED downlights are provided for lift lobbies, lavatories, pantries and outdoor areas. High efficiency T5 fluorescent lamps are installed in office areas, corridors and plant rooms.
- Energy-efficient Fan and Pump Motors are selected to enhance the energy performance of mechanical, electrical and plumbing systems.
- Variables Speed Drives (VSD) are adopted for all chilled water pumps, AHU and PAU fan motors, lift motors, escalator motors and automatic refuse collection system. The extensive use of VSD boosts the energy performance of electric motors running under part-load conditions.
- Occupancy Sensor Control of VAV Boxes reduces the VAV air flow rate to a preset minimum level so as to minimize wastage of cooling energy when the air-conditioned space is unoccupied.
- Lift Regenerative Power Converters are installed to all of the 18 lifts serving the building. The regenerative energy can be reclaimed under light-load lift ascending and heavy-load lift descending operation modes. When a lift car moves down with a heavy car load or moves up with a light car load, the lift traction motor is driven by the lift car load or the lift system counterweight and, motor braking is necessary to prevent free fall of lift car. The energy generated under the motor braking mode is called the regenerative energy. To harvest such regenerative energy, the lift system is provided with a regenerative energy converter for diverting the regenerative energy to the building's electrical distribution system for use by other electrical loads.

2.2.3 Renewable energy

- Photovoltaic (PV) system comprises 189 opaque PV panels at the roof top, 48 see-through thin-film PV (TFPV) panels at main entrance canopy and 96 TFPV panels at 1/F elevated walkway. The entire PV system has an installed capacity of 42kW, helping to offset the amount of electricity provided to the building from the local power grid. The orientation of PV panels is optimized by means of sun path analysis so as to maximize the annual collection of solar energy.
- Solar hot water supply system is equipped with evacuated tube solar collectors, which serve to pre-heat the incoming water for a shower room. This type of solar collectors is compact in size and can maintain a high level of solar energy absorption without the need of separate solar tracking device. The solar heating design can reduce the total energy demand of electrical heating energy when compared with the traditional electric water heating system.

2.2.4 Features reducing reliance of artificial lighting

- 27 nos. of Fixed Light Pipes, 3 nos. of Anidolic Sun Pipes and 6 nos. of Sun-tracking Optic Fibre Sun Pipes are installed to reduce the artificial lighting energy consumption. The locations provided with Light Pipes are mainly interior zones of the office tower and the community hall such as basement carpark, multi-purpose hall, dressing rooms and top floor toilets. Sun Pipes make use of its highly reflective internal surfaces for transmitting sunlight from one end to the other. The Sun-tracking Optic Fibre Light Pipes are designed for maximizing the collection of available sunlight by use of automatic solar tracking devices. Sunlight is transmitted to indoor spaces via optical fibres, which can be routed virtually in any direction to the indoor spaces. The Sun Pipes are connected with photo sensors for facilitating automatic dimming of indoor artificial lighting whenever sunlight is available.
- Adoption of task lighting in office areas also helps to reduce the energy consumption of background lighting, the design illumination level of which is generally reduced from 500 lux to 300 lux, resulting in a Lighting Power Density (LPD) of 8.5 W/m^2, which outperforms the LPD requirements of 15 W/m^2 stipulated in the Building Energy Codes of Hong Kong (2012 Edition).
- Occupancy sensors are used extensively for both inner zones and perimeter zones and daylight sensors for perimeter zones throughout all open plan offices and cellular offices contributes to the effective saving of lighting energy that is otherwise wasted in un-occupied office spaces and in those perimeter zones with adequate daylight above 300 lux.
- Light colour scheme is adopted for indoor furniture and architectural finishes (e.g. partition walls, carpets etc.) so as to improve the indoor light reflectance and indoor illumination level and hence, reducing the lighting energy consumption.
- Computerized Lighting Control System is utilized to control the On/ Off of the lightings according to the pre-determined time zones at working days, Sunday or holidays.

2.2.5 Automatic refuse collection system

The Automatic Refuse Collection System (ARCS) is designed to facilitate effective waste management for the building. In the refuse room on each floor, two refuse disposal outlets are provided at two vertical refuse chutes for transporting solid wastes, one for recyclable paper wastes and the other for general wastes, to two large waste storage bins at the basement. The ARCS facilitates collection of solid wastes in an efficient and hygienic manner. This system also reduces the traffic of service lifts and manpower for refuse collection when compared with the conventional solid waste collection system. Whenever the wastes collected at the bottom section of the vertical refuse chutes reach a certain volume or after a certain time interval, it will be sucked into the respective container for storage and the paper wastes will be collected regularly for recycling purpose.

The ARCS is connected with a vacuum air system for maintaining a negative pressure inside the refuse chutes. The exhaust air from refuse chute is pre-treated by a dust filter and a water scrubber before discharge to the ambient. The ARCS is equipped with a built-in alarm system, which shuts down the entire system automatically in the event of blockage inside vacuum chutes so as to allow subsequent manual clearing of chute blockage. All vacuum chutes are covered with a layer of fire resisting material for minimizing the risk of fire spread through the chutes.

To achieve efficient operation as well as reduce power losses due to harmonic currents, variable speed drive supplemented with active harmonic filter is provided at the ARCS system local motor control panel.

3. CHALLENGES ENCOUNTERED IN IMPLEMENTATION

The recurring challenge during the design process is to achieve all the design objectives with due respect to the time and cost constraints. Products which are well-proven and commonly available in the market are preferred. Conscious effects were also made in sourcing materials from an 800-km radius from Hong Kong. This would help to reduce the carbon emission caused by transportation of the construction materials.

Selections among different manufacturers are exhausted. For instance, in the selection of the curtain wall glazing, products from no less than 8 glass manufacturers were gathered for on-site inspections before narrowing down to 3 for the full scale visual mock-up. Technical data and visual effects from both directions were thoroughly compared. Bespoke components are thoroughly detailed to ensure practicality in fabrication. In another instance, 6 plant species were kept on site for a full 12-month period to test their growth rate, resilience to weather and ease of maintenance before the optimal species is selected for the Green Ribbon planters.

With the concerted effort from all parties, the project was completed on time and within budget.

4. PROPERTY MANAGEMENT MEASURES

Effective building management measures should be put in place to ensure that the building is managed, operated and maintained to meet the green building design objectives. In this regard, the following objectives have been set in formulating appropriate building management measures:

- To ensure that the green features and facilities function properly;
- To facilitate sustainable development of green management; and
- To promote green features to users.

4.1 Proper functioning of green features and facilities

The building adopts an all-in-one computer software named Central Control Monitoring System (CCMS) for controlling, monitoring and managing all the building operation-related equipment such as lighting, ventilation, air-conditioning, security system, access control, fire services installation, lift and escalator, plumbing system and other engineering system, etc. This useful tool not only facilitates the management party to improve energy performance for a range of building electrical installations and technical services but also ensures proper functioning of green features equipped in the building.

Also, CCMS assists the management party to monitor and record the plant status, environmental condition and energy consumption. With CCMS in place, management party can grasp a comprehensive picture of how well each component is being operated. It also facilitates the fine-tuning and troubleshooting of performance problems. The data provides useful information for further analysis of energy saving plan and formulation of procurement strategy.

4.2 Facilitating sustainable development of green management

To facilitate sustainable development of green technology and management, various house-keeping measures are carried out, including standardising the specified average room temperature of 25.5°C during the summer months and the core air-conditioning hours with a view to maintaining the workplace as a comfortably air-conditioned environment. Other measures including adoption of task lighting, use of installed occupancy sensor and daylight sensor for lighting control, optimising the operating hours of lift services and public lighting, the use of installed timer setting of CCMS to switch off building services installations, etc. are also implemented. Each user department in the building has appointed a Green Manager and an Energy Warden to assist in implementing energy saving house-keeping measures. By means of CCMS, the building management is able to monitor energy consumption of each floor, and review the implementation of the measures and degree of energy saving.

With respect to air quality, arrangements have been made in the building to achieve "Excellent" class for Indoor Air Quality in 2016. Waste reduction and recycling programmes and floor-to-floor waste separation are also implemented. Data on the quantities of recyclable wastes collected under each category are recorded and reported to the Environment Protection Department periodically.

User's awareness and engagement is also critical to the sustainable development of green management. In addition to distributing green tips and guidelines, management party invited user departments to express their views on the facilities/ installations of the building through Building Management Committee (BMC) which comprises representatives from the user departments in the Tower. BMC meetings are held regularly to discuss, among others, issues on green management and energy saving. Messages on green management and energy saving would also be disseminated to all users in the BMC meetings.

4.3 Promoting green features to users

In order to promote energy efficiency and renewable energy technology as well as public awareness of government's initiatives on greening development, an education path is set-up in the building. Along the path, exhibition panels and signage are placed next to the green features which are accessible by building users and visitors. An interactive display, forming part of the education path is located at 1/F of the Tower, provides a virtual tour of the green features in the aspects of energy, water, indoor environmental quality and material, etc. Guided tours are regularly organised for user departments and the public to introduce and promote green building designs in the building.

5. CONCLUSION

The building projects an image of efficiency, practicality and education. The project demonstrates an exemplary performance of energy efficiency, by aiming to reducing energy consumption by around 27%. The high level of greening combines with the green features would result in a saving of around 36% in carbon emission as compared against the Building Energy Code (BEC) 2007 Baseline model.

The theme of sustainability features prominently on the outside, displaying an iconic "green" image. The green building concepts in the project are conceived from Day 1 through to completion. This principle is used throughout the complicated design process, despite controls of time and budget. The building is also an education tool – for the occupants and the public. The performance goals cannot be met unless the users appreciate them and use the building responsibly. TI Tower is a building to look at, to work in, to be served in, to play in and to learn from.

APPENDIX

Overall view from Concorde Road showing the "green ribbon"

Vertical greening on façade forming the "green ribbon"

Community hall green roof

Roof garden in office tower

Building integrated photovoltaic panels in canopy

LED lighting at part of the office areas

Photovoltaic panels on upper roof

Solar hot water panel in external landscaped area

Signage totem for education path

Interactive display in 1/F lobby as start of education path