機電工程署 EMSD

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12 / 2018

Liberal Studies Education Kit
for New Senior Secondary Curriculum

Energy Efficient Building

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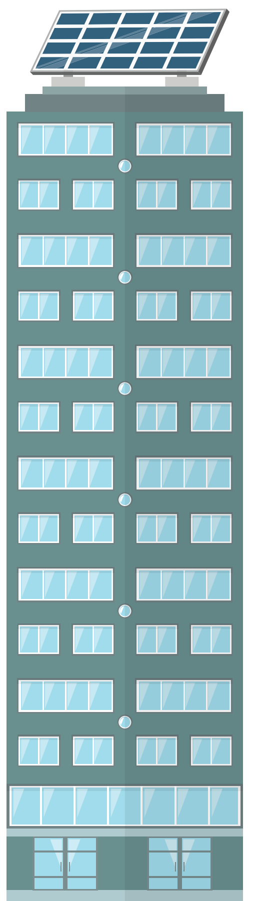
CONTENTS



PREFACE

"Building environment accounts for the major portion of energy consumption around the world, contributing to the significant emission of greenhouse gases and global warming."

Therefore, improving the energy efficiency of buildings is an obvious target for the reduction of pollutant emissions and in combating climate change. Building an energy efficient facility takes a lot of effort. It has to be carefully planned with focus on the design and construction of green architectural features as well as the deployment of energy efficient technologies in the operation and maintenance of building services. Many countries have already developed their own standards for energy efficiency for buildings. Hong Kong, with its amazing high-rise cityscapes, is also stepping up its energy efficiency building standards to help reduce the use of energy in new and existing buildings to sustain the city's future. Increasing concerns over the energy performance of a building are important as green practices conserve natural resources, improve air and water quality, reduce solid waste and contribute to the overall quality of life.

This education kit is designed for the Energy Technology and the Environment module under the "Liberal Studies Curriculum and Assessment Guide", published by the Curriculum Development Council and the Hong Kong Examinations and Assessment Authority. Energy Efficient Buildings are a commendable, and indeed a necessary, topic to be introduced into the new curriculum. Aimed at Secondary Four to Six students, this kit has been designed for use in the classroom both by teachers and students. It will help them understand the key elements related to energy efficient buildings, hand-in-hand with its core issues. The kit also covers energy use in buildings, energy efficient and green building features as well as the ongoing development and integration of various sustainable resources and renewable energy.

Liberal study aims to liberate students' minds and facilitate their independent and critical thinking. This education kit therefore encompasses news extracts and a wide variety of topics, such as energy audits and management, building energy codes, building assessment schemes, etc.

Providing a wide range of information, this education kit is produced with a number of objectives. They include helping students to acquire knowledge of the interdependence between energy and our daily life, develop critical thinking skills in interpreting and assessing the impact of different energy issues, and, more importantly, to arrive at and voice out individual judgment after considering and balancing different perspectives.

We hope that this kit will help students understand that adopting energy-efficient features in buildings is a smart move today, and facilitate their greater awareness of the energy conservation and energy efficiency issues applicable to buildings.

1 ENERGY USE IN BUILDINGS

The issues of energy efficiency and climate change are on the top of the policy agenda of many countries and economies. There is no exception in Hong Kong. Buildings in Hong Kong altogether account for about 90% of the total electricity consumption. To reduce carbon emission, it is imperative to improve energy efficiency in buildings.

Since 1998, the Electrical & Mechanical Services Department (EMSD) has issued a set of Building Energy Code (BEC) and also launched the Hong Kong Energy Efficiency Registration Scheme for Building (HKEERSB) to promote compliance with the BEC in order to improve energy efficiency in buildings. The BEC stipulates the minimum energy efficiency requirements for four key types of building services installation including lighting, electrical and air-conditioning system, as well as lift & escalator. These four types of building services installation have accounted for around 80% of the total electricity consumption of a modern office building.

HK BEAM+ Certificate

Do you know ...

Buildings use substantial amounts of energy, both in developed and developing economies, commonly accounting for between 30% to 50% of total energy consumption. Therefore about 40% of the world's energy consumption is attributed to energy usage in buildings – for lighting, heating/cooling and other operational equipment. As this represents about 21% of total greenhouse gas emissions worldwide, many governments are eagerly looking into energy efficiency in buildings to help combat climate change.

The installation of energy efficient facilities and equipment together with renewable energy technologies are thus major considerations in building energy codes, as well as in building energy efficiency registration and labelling schemes. Green building is an even wider concept that includes site management and materials selection, water usage, indoor environment quality, etc. Green building labelling schemes have thus been launched in many countries to encourage innovative methods to reduce a building's adverse impact on the environment during its life-cycle, from design and construction to operation, maintenance, renovation and demolition. Though different countries may have different schemes, their objectives and content tend to be very similar.

Australia	Green Star	new.gbca.org.au/green-star/
Japan	Comprehensive Assessment System for Building Environmental Efficiency (CASBEE)	www.ibec.or.jp/CASBEE/
Singapore	Green Mark	www.bca.gov.sg/green_mark/
UK	Building Research Establishment Environmental Assessment Method (BREEAM)	www.breeam.com
USA	Leadership in Energy & Environmental Design (LEED)	new.usgbc.org/leed

Do you know ...

There are a number of organizations dealing with green buildings in Hong Kong. They include the Hong Kong Green Building Council (HKGBC), Professional Green Building Council (PGBC) and the Building Environmental Assessment Method (BEAM) Society. Together, they have been organizing the biennial Green Building Award (GBA) since 2006.

Do you know ...

Building Environmental Assessment Method (BEAM) is a voluntary assessment scheme. It defines performance criteria for a range of sustainability issues relating to the planning, design, construction, commissioning, management and operation as well as the maintenance of buildings.

Source: Building Environmental Assessment Method (BEAM)

Mandatory Implementation of Building Energy Codes

Implementation of the Buildings Energy Efficiency Ordinance

The general belief in Hong Kong is that there is tremendous potential to improve energy efficiency and reduce greenhouse gas emissions for the territory as a whole by promoting energy efficiency in buildings. Seeking to further improve energy efficiency in buildings, the HKSAR Government decided to legislate for the mandatory implementation of the Building Energy Code (BEC) in 2008. A new Buildings Energy Efficiency Ordinance (Cap. 610) (BEEO) was thus gazetted in December 2010 for full implementation in September 2012. The BEEO gives a legislative foundation to continuously save energy use in building through the mandatory compliance of the Building Energy Code (BEC) and Energy Audit Code (EAC).

The milestones for BEC's transition from a voluntary to a mandatory scheme as well as the development of the BEEO are shown in the table below.

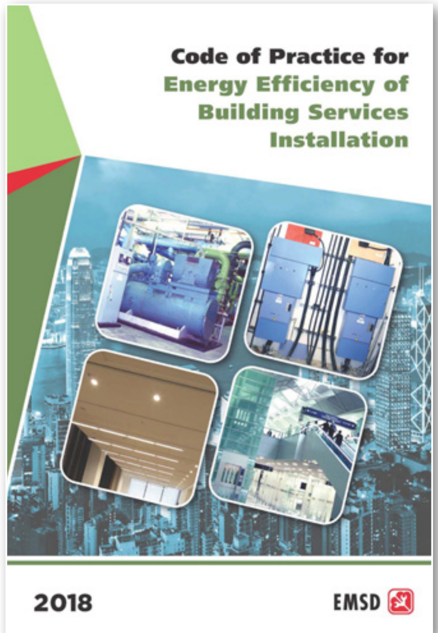
Year	Milestone
1998 - 2007	Prescriptive BEC for lighting, air conditioning, electrical and lift & escalator installations were developed by EMSD and implemented on a voluntary basis under EMSD's HK Energy Efficiency Registration Scheme for Buildings (HKEERSB)
2007 - 2008	Public Consultation on the Mandatory Implementation of BEC from December 2007 to March 2008
2010	The Buildings Energy Efficiency Bill was introduced and passed by Legislative Council (LegCo) in November 2010 and gazetted as the Buildings Energy Efficiency Ordinance (Cap. 610) in December 2010
2011	Gazetting of the subsidiary regulations and Codes of Practice
2012	Full Implementation of the Buildings Energy Efficiency Ordinance (Cap. 610) in 2012
2013	Launch of Technical Guidelines for BEC and EAC 2012 Edition
2014	Commencement of the first comprehensive review for BEC and EAC
2015	Completion of the review and gazetting of the BEC and EAC 2015 Edition
2016	Launch of Technical Guidelines for BEC and EAC 2015 Edition
2017	Commencement of the second comprehensive review for BEC and EAC 2018
2018	Completion of the review and gazetting of the BEC and EAC 2018 Edition

The BEC and EAC will be reviewed once every three years from the first edition issued in 2012 in tandem with the latest technological development. Both BEC and EAC were reviewed every three years. The primary target is to tighten and enhance the energy efficiency standards under BEC and the energy audit requirements of EAC.

It is expected that up to 2025, energy savings from all new buildings in Hong Kong will be about five billion kilowatt hours, equivalent to the total carbon dioxide emissions of about 3.5 million tonnes.

The new BEC and EAC 2018 edition were gazetted on 16 Nov 2018. Meetings with 6 Working Groups members drawn from relevant professional institutions, trade associations, consultant/contractor associations, university academia, and government departments were completed.

Code of Practice for Building Energy Audit



Code of Practice for Energy Efficiency of Building Services Installation

Do you know …

About 90% of total electricity consumption in Hong Kong is contributed by buildings. Through enhancement of building energy efficiency, greenhouse gas emissions can be effectively reduced. In October 1998, the Electrical and Mechanical Services Department launched the voluntary Hong Kong Energy Efficiency Registration Scheme for Buildings to promote the application of the Building Energy Code (BEC) in both new and existing buildings.

Source: Buildings Energy Efficiency Ordinance Website

Energy Audit for Building

Energy audits provide a regular review of the energy consumed in a building to ensure that it is being used efficiently. In many ways, this is similar to financial accounting. Providing an effective means to improve the energy efficiency of a building, auditors examine the energy account – the energy consumed by equipment and the way energy is used in its various components, to identify means for improvement.

Under the BEEO, owners of commercial buildings and the commercial portions of composite buildings are required to engage a Registered Energy Auditor (REA) to conduct energy audit every ten years and to ensure the full compliance with the requirements stated in Energy Audit Codes (EAC). Meanwhile, EMSD has published "Guidelines on Energy Audit" recommending a number of technical requirements on energy audits for buildings.

In the Guidelines, three Energy Management Opportunity (EMO) categories are set out. EMOs highlight ways in which energy efficiency and conservation can be achieved. Many energy saving opportunities can thus be identified during an energy audit.

Energy Audit Benefits

By identifying and implementing ways to achieve energy efficiency and conservation, you will pay less for your energy bill. At the same time, the less energy consumed, the less fossil fuels are burnt, enabling the power supply companies to generate comparatively less pollutants and greenhouse gases. Therefore everyone concerned, contributing to the preservation of the environment and the conservation of resources, enhances sustainable development.

Energy Management Opportunity

Category I :

No direct investment costs involved with no disruption to the building's operation. This very often refers to simple and easy housekeeping practices. For example, turning off air-conditioning or lights when not in use, using natural ventilation or fans where possible and lowering window blinds or curtains to reduce direct sunlight during the summer.

Category II :

Low direct investment costs involved with some minor disruption to the building's operation. Usually, savings can be achieved with a reasonable cash outlay. For example, installing timers to turn off equipment and replacing conventional magnetic ballasts with electronic versions.

Category III :

Relatively high capital cost investment involved with significant disruption to the building's operation. This type of EMO can very often result in substantial savings. For example, adding variable speed drivers, replacing chillers and installing power factor correction equipment.

Retro-commissioning Pilot Projects in Government Buildings

Electrical and Mechanical Services Department (EMSD), as a collaborator and facilitator in energy saving and conservation, is actively pursuing "Retro-commissioning" (RCx) to further enhance energy efficiency in existing buildings.

Technical Guidelines on Retro-commissioning

RCx is a cost-effective and systematic process to periodically check the energy performance of existing buildings. Through the use of data trending, professional analysis and diagnosis, RCx aims to develop a scientific-based optimization scheme and make continuous improvement on energy performance of building services installation.

EMSD commenced a pilot study on RCx by engaging existing government premises including government offices, education services centre and municipal services buildings, etc. of different sizes, usages, ages and annual energy consumption to implement the pilot RCx project.

The pilot study for each building followed the procedures as stipulated in Technical Guidelines on Retro-commissioning (TG(RCx)) through four stages.

- Stage One (planning) - collection of building information and conducting preliminary walkthrough onsite.
- Stage Two (Investigation) - analysis of operation data with measurement and identification of Energy Saving Opportunities (ESO).
- Stage Three (Implementation) - commissioning on some out-of-calibration control sensors through quick fix and implementation of ESO to achieve optimized operation.
- Stage Four (ongoing commissioning) - reporting of improvement measures and briefing to property management personnel about effective management and maintaining high energy performance.

Checking on existing building performance and efficiency
Source: Electrical and Mechanical Services Department

Energy saving opportunities (ESOs) could be identified in the RCx projects, ranging from system tunings (such as adjusting timer setting, optimizing system control sequencing, fully utilize energy management system, recalibrating critical sensors/actuators, trimming down fresh air, set point review (temperature and static pressure), fine tuning the ratio of gas and air supply to improve boiler combustion efficiency, further adjustment of lighting level, etc..) to recommendations involving capital improvements such as inserting demand control sensors and actuators, adding variable speed drives, making modifications and upgrades of existing building management systems, performing replacement of equipment, etc.

The energy saved from these ESOs accounted for around 2,300,000 kWh per year, equivalent to around 5% of the total annual building energy consumption. The payback period of these ESOs ranges from several months to a few years, about 3 years on average. Aside from demonstrating the benefits of RCx, the pilot study provided real life examples that helped the formulation of the TG(RCx). This RCx pilot study in government buildings also serve as a reference model for other stakeholders who plan to carry out RCx. In future, more government premises are under selection to implement RCx in order to further promote building energy efficiency.

Do you know ...

What is Energy Performance Contracting (EPC)?

Some energy saving projects can involve high capital investment. Facility owners may not wish to pay or may not be able to afford such costs. Owners can however utilize their plant's or equipment's energy-saving potential to obtain financial resources to upgrade their energy efficiencies.

Energy Performance Contracting service providers can provide both financial and technical support to upgrade these premises. Guaranteed savings finance the cost of the energy efficiency installation without upfront capital expenses.

EPC is suitable for premises with high energy saving potential under regular use and where the owner is willing to adopt new technologies.

2 FEATURES OF ENERGY EFFICIENT BUILDINGS

Key Focuses of Energy Efficient Buildings

Green Building Features

Various features can be incorporated into a building for the better use of natural resources and to reduce energy consumption. Solar shading devices can reduce a building's peak cooling load and enhance its daylight use, while energy-efficient window and glazing systems, such as multiple glazing or transparent coatings, can reduce heat transfer. Green roofs can also help to alleviate the urban heat island effect, decrease heat gain from roofs and protect roofing materials with their shielding effects.

Integration of Renewable Energy Technologies

Solar, wind, tidal, wave, geothermal and hydropower are examples of renewable energy. They are inexhaustible and, generally, pollution-free. For example, solar water heating systems can be used to provide hot water, and solar photovoltaic systems can be used to generate electricity to supplement the electricity supply.

Zero Carbon Building

Do you know ...

The $450 million Building Energy Efficiency Funding Schemes were formally launched in April 2009 with funding provided by the Environment and Conservation Fund. Energy-cum-carbon audit projects and energy efficiency projects are covered in the schemes. Under the Scheme, over 1,000 applications covering more than 6,000 buildings have received subsidies.

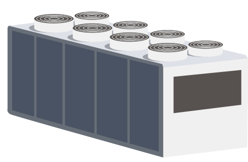
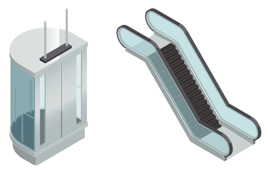
Carbon Audit 碳審計
綠色機構 Green Partner

Natural Lighting and Ventilation

Natural resources are unlimited. Their use should thus be incorporated as early as in the building's planning stages. With a suitable building design, such as the orientation of windows for example, the natural supply and flow of air can be used in the building's ventilation. Buildings can also be designed to maximize the use of daylight for lighting.

Energy Efficient Technologies in Building Applications

A building is equipped with a number of electrical installations, which while providing different services to the occupants, adds up to huge amounts of energy consumption over the life span of the building. Energy efficient technologies can be applied in various building services installations, such as air conditioning, lighting, lifts & escalators and electrical appliances among others. Even while maintaining the same levels of comfort and convenience, each of these installations can help save energy. The following table gives examples of more energy efficient technology for the different systems:

System	Technology
Air Conditioning 	• Variable speed drives • Heat recovery • Water-cooled air conditioning systems (WACS) using fresh water cooling towers • District cooling systems • Demand control system
Lifts & Escalators 	• Variable voltage variable frequency (VVVF) controls • Energy optimisers • Service on demand (SOD) escalators • Regenerative braking system for lifts
Lighting 	• Compact fluorescent lamps (CFL) • Light emitting diodes (LED) • Electronic ballast • Digital and addressable lighting interfaces (DALI) • Automatic lighting control • Daylight responsive control

Building Envelopes

A building's envelope is the boundary between the interior of the building and the outdoor environment. It includes the foundations, roof, walls, doors and windows. It is a thermal barrier as it regulates indoor temperatures, which affect the amount of energy required to maintain thermal comfort. Heat transfer through the building envelope should therefore be minimized to reduce the need for the heating or cooling of the building's spaces.

Building envelopes can also significantly affect the amount of lighting required. Improvements to building envelopes thus have considerable potential in reducing greenhouse gas emissions from both new and existing buildings. They also result in a variety of benefits for tenants, including lower energy bills as well as improved thermal comfort, moisture and noise controls.

Siu Sai Wan Complex
Source: Signature Limited

Do you know ...

Overall Thermal Transfer Value (OTTV) is a measure of the average heat gain in a building absorbed through the building envelope.

As a minimum energy efficiency requirement, the Building (Energy Efficiency) Regulation (Cap.123M) specifies controls on the OTTV of building envelopes to limit solar heat gain: the OTTV for towers must not exceed 24 W/m^2, and the OTTV for podiums must not exceed 56 W/m^2.

3 ACHIEVING ENERGY EFFICIENT BUILDINGS

Minimizing Energy Consumption in Buildings

An energy efficient building can make use of passive design to minimize its energy requirements. Design measures for energy efficient buildings include adopting green building features, using sustainable resources and applying energy efficiency technologies.

Green Building Features

Solar Shading

Sunlight shining into a building affects the building's energy consumption in different ways. In summer, excessive heat gains increase cooling requirements and thus energy consumption. In winter, sunlight can provide passive solar heating. Throughout the year the sun provides daylight. Well-designed shading devices can therefore significantly reduce building peak cooling loads and enhance daylight utilization in buildings. Shading devices can also avoid glare by reducing contrast ratios in the building's interior.

The shading of external windows can be provided by natural landscaping such as trees and hills, or by building elements such as overhangs, awnings, fins and trellises. Installing fixed shading devices can be an efficient means of providing thermal and visual comfort to occupants. The design of the fixed shading devices will depend on the daily and yearly variation of the sun's position. For example, the use of overhangs is most effective on south-facing windows in the summer when sun angles are high. In the winter, overhangs allow the low winter sun to enter south-facing windows. However, the same horizontal device is ineffective in blocking low morning and afternoon sun from entering east- and west-facing windows respectively in the winter.

Victoria Park Swimming Pool
Source: Information Services Department

Common External Shading Strategies for Buildings

- Use fixed overhangs on south-facing glass to control direct beam solar radiation. Diffused (indirect) radiation should be controlled by other measures such as low-e glass.
- Limit the areas of east- or west-facing glass. Vertical or egg-crate fixed shading can be considered if shading projections are fairly deep or close together; however these may limit views. As north-facing glass receives little direct solar gain at Hong Kong's latitude, usually no shading is required in this direction.
- Interior shading devices such as Venetian blinds or vertical louvers do not reduce cooling loads since the solar gain has already been admitted indoors. However these interior devices do offer glare control.
- The durability of shading devices should be considered. Operable shading devices usually require more maintenance and repair.

External shading devices are particularly effective in conjunction with clear glass facades. However, various types of high-performance glazing, such as low-e glass, are now available. As the amount of solar heat gain admitted into a building using such glass is very low, these new glass products reduce the need for external shading devices. Nevertheless, installation of well-designed fixed shading devices is most effective in minimising direct solar heat gain.

EMSD External Shading Devices
Source: Electrical and Mechanical Services Department

Glass Curtain Wall

Windows and Glazing

Glazing forms an important element in buildings, offering daylight and ventilation for building interiors. A number of studies show that health, comfort and the productivity of a building's occupants are improved with a well-ventilated indoor environment and with access to natural light. However, windows also represent the major source of heat gain or loss as well as of visual and thermal discomfort. In residential and commercial buildings, considerable amount of heat energy was consumed due to unwanted heat gain or loss transmission through the windows.

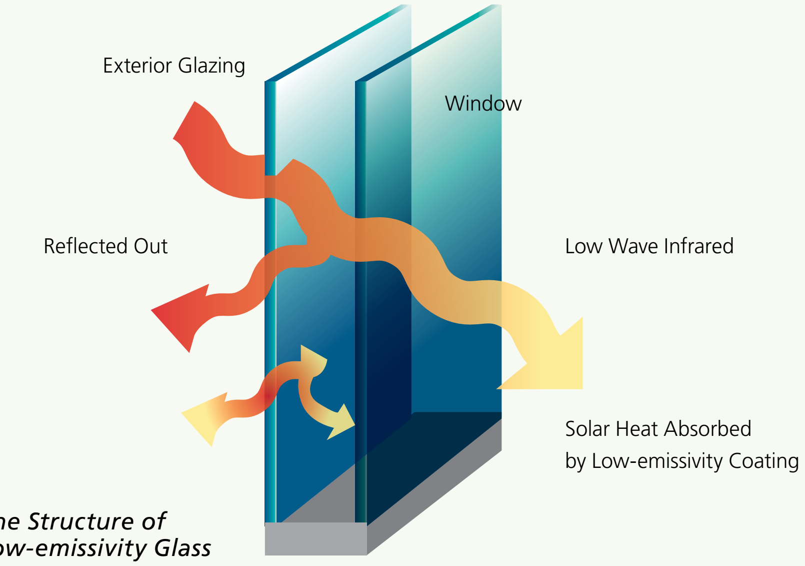
Windows have undergone a technological revolution in recent years. Energy-efficient window and glazing systems are now available, dramatically cutting a building's energy consumption. These high-performance windows feature multiple glazing, specialized transparent coatings, insulating gas in between glass panes and improved frames. All these features reduce heat transfer, thus cutting the energy burden caused by the window openings.

The materials, techniques used, and the degree to which various schemes are applied, determine the characteristics of each glazing unit.

The best glazing selection depends on local climate, orientation, shading and interior space usage, to achieve low thermal conductivity, low radiant heat transmittance and high visibility. The Overall Thermal Transfer Value (OTTV) can be used to measure how well a building performs in terms of solar heat gain and thermal conductance.

Do you know ...

Low-e glass stands for low-emissivity glass. This type of glass has a special transparent metal coating, which is able to reflect most of the infrared rays while transmitting most of the visible sector of the solar spectrum. This low-e glass manages the sun's heat by filtering out the sun's long-wave radiation. This cuts down the amount of solar heat gain in the building.



The Structure of Low-emissivity Glass

Do you know ...

Solar Control Window Film can reduce heat gain from the window while providing a visual connection with the outdoor environment. EMSD has published a pamphlet on its application and selection.

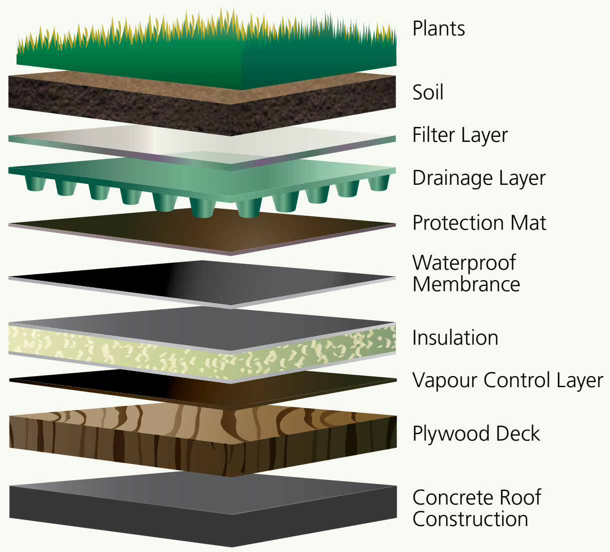
Green Roofs

Green roofs consist of roofing assembly, which includes a waterproof membrane together with additional component layers, as well as growth media, drainage and root protection – allowing for the propagation of vegetation across all or parts of the roof surface. Green roofs have many applications, from industrial facilities to residences and offices to other commercial properties.

Green roof at DSD Kowloon City No. 1 and No. 2 Sewage Pumping Stations
Source: Drainage Services Department

Do you know ...

A typical green roof consists of various layers, which perform different functions in the system: providing plant nourishment and support, protecting underlying waterproofing systems and allowing drainage. The figure below illustrates the typical structure of an extensive green roof.



Typical Structure of an Extensive Green Roof

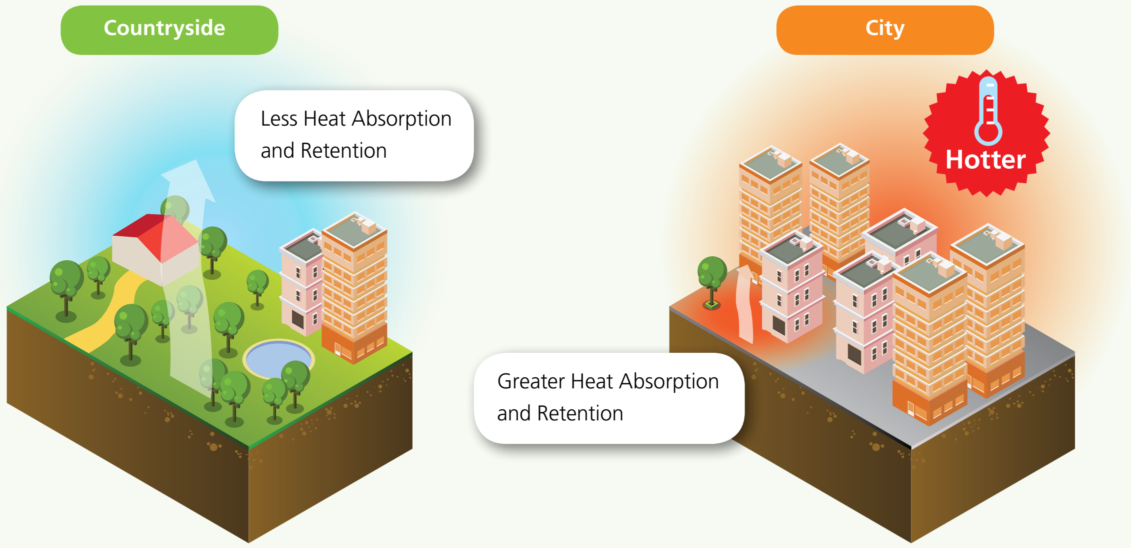
Benefits of Green Roofs Include:

Mitigating the Urban Heat Island Effect

Lowering the urban heat island effect can reduce the distribution of dust and particulate matter throughout the city as well as the production of smog. Covering conventional roofs with green roofs can significantly reduce temperatures above the roof due to the transpiration and evaporation of the plants. According to a Hong Kong case study, green roofs can reduce the roof surface temperature by 10 to 30°C compared to conventional roofing.

Do you know ...

The temperature in a city is usually higher than in its surrounding countryside. This is known as the urban heat island effect and is mainly due to the large surfaces in city areas that absorb solar heat.



Urban Heat Island Effect

Reducing Heat Gain from Roofs

Green roofs insulate buildings by preventing heat from being transmitted through the roofs. The lower heat gain from the roof reduces the energy required for air-conditioning. This effect can be maximized with low soil density and high moisture content. The benefits of this lower solar heat gain are realized most fully in warm climates such as Hong Kong, where energy expenditures on air conditioning are high. However, this benefit is less significant in multi-storey buildings, in view of the low ratio of roof area to the total exposed building facade.

Prolonging the Life of Roof Materials

Green roofs can provide protection to waterproofing materials in the roof structure. Their value as roof protection has been demonstrated by more than thirty years' experience in overseas countries. The multiple layers of the green roof protect the underlying roof materials in three ways:

- Protection from mechanical damage from humans, animals, debris, etc;
- Shielded from ultraviolet radiation;
- Buffers temperature changes, thus minimizing damage due to the daily expansion and contraction of roof materials.

Reducing Sound Transmission

The multiple layers of a green roof also insulate sound. Sound waves produced by machinery, traffic or airplanes are absorbed, reflected or deflected. The substrate tends to block lower sound frequencies while the plants block the higher frequencies.

Controlling Storm Water Runoff

During rainstorms, green roofs act as a sponge absorbing much of the water that would otherwise run off. Compared to conventional storm water runoff facilities, vegetative roof covers are unobtrusive, low maintenance and reliable.

- Others

In addition to the above benefits, green roofs can create wildlife habitats, lower the amount of carbon dioxide released into the atmosphere, reduce the size of HVAC equipment and improve the aesthetic environment.

A number of factors have to be taken into account when green roofs are being designed, including:

- Climate, especially temperature and rainfall patterns
- Strength of the supporting structure
- Size, height and orientation of the roof
- Type of underlying waterproofing
- Visibility and compatibility with architecture

Using Sustainable Resources

An energy efficient building should use more sustainable resources. This is not only a green practice, but also an economical solution.

Natural Ventilation

Natural ventilation supplies and removes air to and from an indoor space naturally, without the use of fans or other mechanical systems. It makes the best use of airflow caused by the pressure differences between the building envelope and its surroundings, to provide ventilation and space cooling.

Benefits of Natural Ventilation

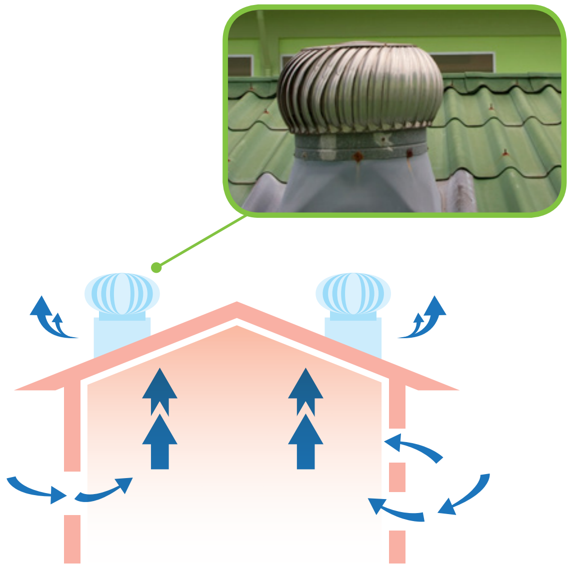
Natural ventilation supplies free outdoor air to provide safe, healthy and a comfortable environment for occupants. With careful design, natural ventilation can reduce building construction and operation costs, lowering the energy required for air-conditioning and circulation fans. Noise pollution from fans can also be avoided.

Types of Natural Ventilation

Basically, two types of natural ventilation can be used in a building, wind-driven ventilation and stack ventilation. Both are achieved by naturally occurring pressure differences. Wind-driven ventilation uses the natural force of the wind, whereas stack ventilation is caused by buoyancy as a result of differences in temperature and humidity. Hence, there are different strategies in the optimization of the two types of natural ventilation.

Wind Driven Ventilation

As naturally occurring wind blows across a building, air pressure on the windward wall increases. Wind moves around the building and decreases the air pressure on the leeward wall as it leaves, providing a suction effect. Fresh air rushes into the windward wall openings and exits the leeward wall openings of the building, relieving pressure differences on the two walls. In wind-driven ventilation, the shape of the building is a crucial factor. With proper design, it can create wind pressure that drives airflow through the openings of a building effectively.

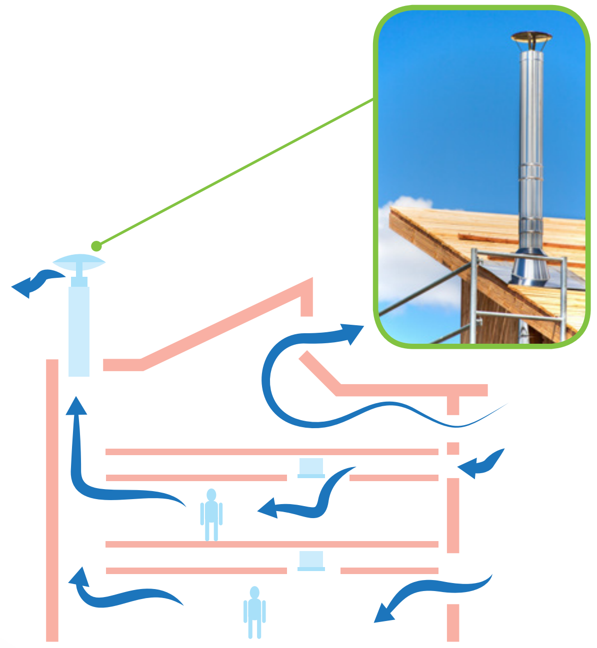


Wind Driven Ventilation

Stack Ventilation

Buoyancy ventilation can be induced by temperature (known as stack ventilation) or humidity (known as cool tower) differences. Stack ventilation is most commonly used. Air is warmed by heat from occupants and appliances and becomes less dense. As the warm air rises, cooler fresh air is sucked in from openings below.

As stack ventilation does not rely on wind, there are fewer limitations on the locations of the air intake. On hot summer days without wind, the naturally occurring stack effect takes place with relatively stable airflow. However, stack ventilation is very dependent on the internal and external temperature differences.



Stack Ventilation

Design Strategies for Natural Ventilation

The design for natural ventilation should incorporate both wind- and stack-driven ventilation design concepts. General design considerations are to either increase the airflow or lower the heat gain so that natural ventilation can effectively cool the spaces in the building. Mechanical cooling and ventilation systems will be used to supplement this natural ventilation. Lowering the heat gain means that less airflow will be required to remove the heat, thus the loading on mechanical cooling systems is reduced.

Designing a Natural Ventilation System

To build a reliable and energy efficient ventilation system, the constraints of the building must be identified for the most appropriate strategies to be used and integrated into the building's design. These constraints will include building type, local environment, climate, as well as building regulations or guidelines.

Building type usually refers to the occupancy, shape, possible building orientations, size and location of openings. Local environment refers to the prevailing wind direction, local air quality and surrounding structures. Climate refers to the local temperature and humidity. Building regulations and guidelines refer to local regulations, standards (such as ASHRAE) or guidelines.

Do you know ...

ASHRAE stands for The American Society of Heating, Refrigerating and Air Conditioning Engineers. As an international technical society, it publishes a well-recognized series of standards and guidelines relating to Heating, Ventilating and Air Conditioning systems and issues.

Source: The American Society of Heating, Refrigerating and Air Conditioning Engineers

Daylight

Another energy saving opportunity arises from the use of daylight. A well-designed lighting system integrates daylight with artificial lighting. For example, dimming or switching electrical lights off automatically in response to the presence of daylight. This saves energy by reducing the building's lighting and cooling requirements.

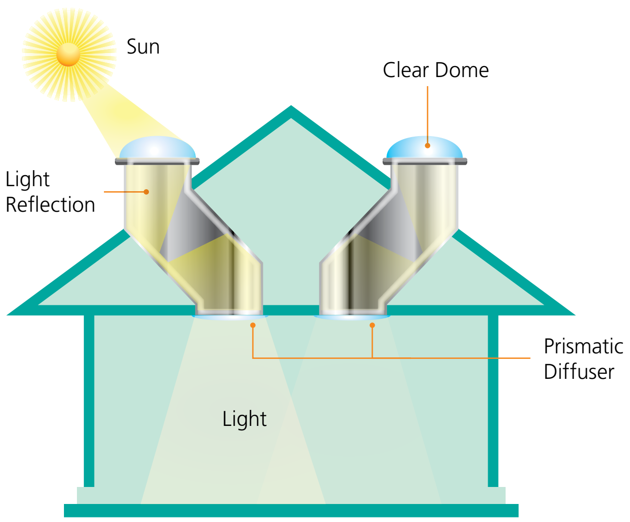
Benefits of Daylight

Daylighting also improves visual comfort. Recent studies found that daylight improves productivity and health in schools and offices, as it helps to create a productive environment for occupants.

Daylight

Daylighting Strategies

Daylight can be introduced into a building using a variety of design concepts and strategies. Daylight can be captured and directed into a building via windows, light shelves, light tubes and skylights. These openings capture the light directly or through channels to light up the relevant space. The location and design of windows influence the effectiveness of daylight utilization significantly. Building orientation, weather and potential obstructions also affect how much light is captured.



Working Principle of Light Tubes

Daylighting strategies can be divided into two main categories: side-lighting and top-lighting. The key difference of the two strategies is that side-lighting admits light from the perimeter walls of the building while top-lighting strategies admit light through the top of the building. The selection of the daylighting system will depend on the layout, the orientation and the surroundings of the building.

Side-lighting in an Office

Top-lighting at Hong Kong International Airport

In addition to the above strategies, daylight can be channelled indoors through the use of light tubes. The light tube captures daylight and reflects it into the building. It consists of an outside collector (usually on the roof), a tube with high reflectance on the internal surface and a diffuser. By using light tubes, daylight can reach, not only the perimeter areas but also the deeper zones of the building.

Daylight Design Considerations

Careful assessment should be made when designing a building using daylighting. The electrical lighting and interior design require special considerations. Designers need to think about how to bring light into the occupant space, how the electrical lighting loads will vary and how to make the equipment more efficient. These factors are described below.

Aperture Location

In determining the location of apertures for daylighting, the proportions of the rooms are important. A room that has a high ceiling will have deeper penetration of daylight whether through side-lighting or top-lighting. Higher window positions will also result in deeper penetration and more even illumination in the room. Small windows separated by wall areas will result in uneven illumination and unpleasant contrasts between windows and adjacent wall surfaces.

Reflectance of Room Surfaces

Reflectance values for room surfaces will significantly affect daylight performance and should be kept as high as possible. The most important interior surface for light reflection is the ceiling. In small rooms, the rear wall is the next most important surface because it is directly facing the window.

Integration with Artificial Lighting Controls

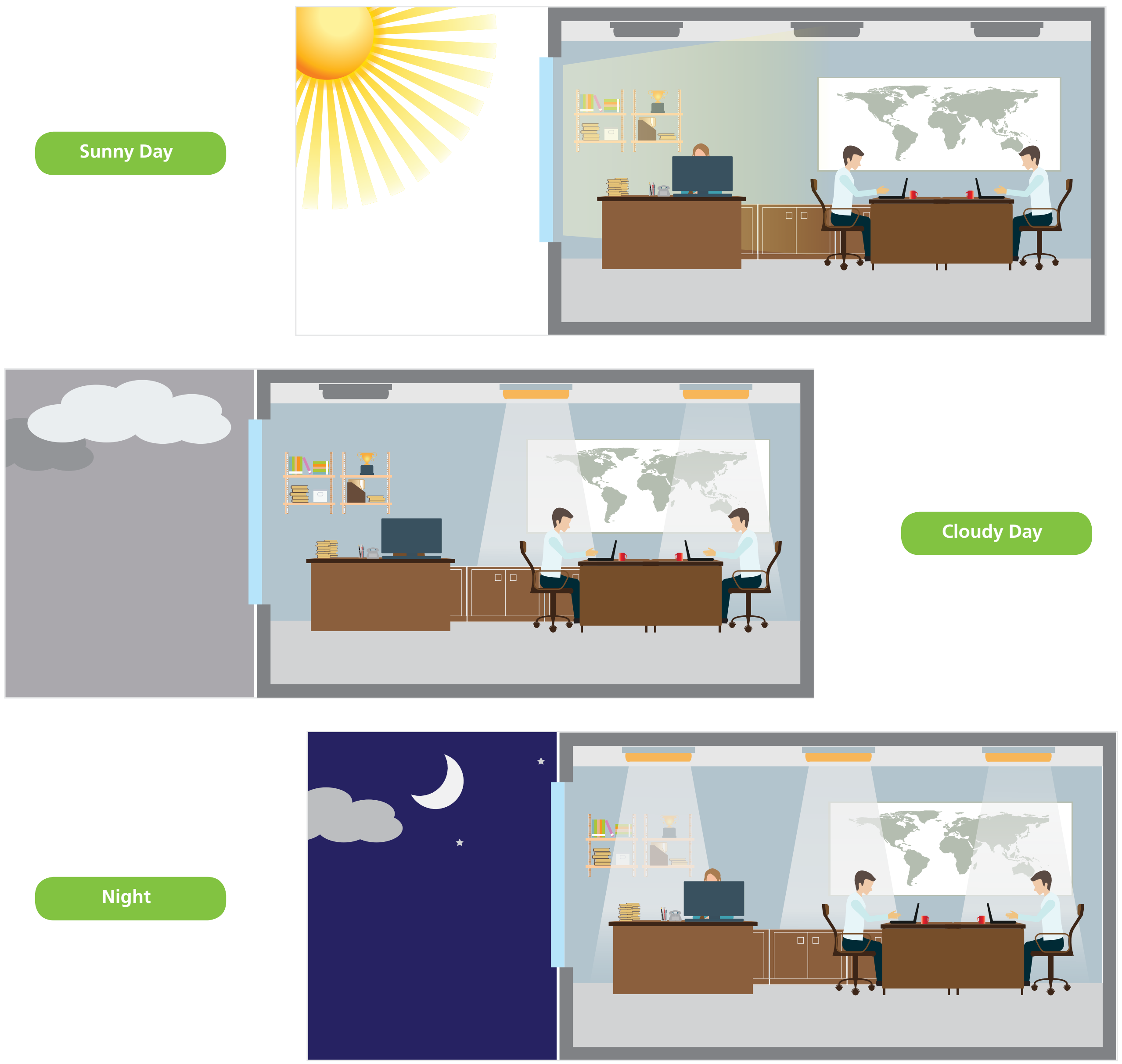
A successful daylighting design not only optimizes architectural features, it is also integrated with the artificial lighting system so that the daylighting benefits can be maximized. When daylight provides sufficient lighting levels on the working plane, corresponding lamps can be dimmed or switched off. It is now common to use motion and light level sensors to control the artificial lighting system.

Motion Sensor

Concept of Motion Sensor on Lighting Control

Coordination of Artificial Lighting Designs

The coordination of artificial lighting with the daylighting design is important for the success of the system. The layout and circuitry of the artificial lighting should be well coordinated with the position of the windows. For example, in a typical side-lighting design with windows along one wall, it is best to place the lights in rows parallel to the window wall and circuited so that the row nearest the windows will be the first to dim or switch off followed by successive rows.



Coordination of Artificial Lighting Design

Renewable Energy

Techniques to harvest renewable energy on-site for building operations should be investigated and implemented as far as possible. Each renewable energy source has its own intrinsic characteristics for effective incorporation into a building's design. The most common renewable energy resources are solar and wind.

Instead of traditional centralized grid power systems, the concept of "microgeneration" is the small-scale generation of heat and power by individuals, small businesses and communities to meet their own needs. Low or even zero carbon footprint for the building can be realized by using photovoltaic systems, small-scale wind-turbines, pico-hydro power, ground source heat pumps, etc.

Do you know ...

Tseung Kwan O Sports Ground

The main stadium for the East Asian Games, the Tseung Kwan O Sports Ground not only cultivates a sporting culture in the community, it also demonstrates the sustainable, energy saving designs of a quality international arena to the general public. One of the project's most significant sustainability features is its use of renewable and clean energy through the:

- Installation of 50 solar panels (90m^2 net area) for the hot water supply system with an estimated energy output of 76 kW.
- Installation of 58 photovoltaic (76m^2 net area) with an estimated energy output of 10 kW.

Source: Architectural Services Department

Tseung Kwan O Sports Ground

4 APPLYING ENERGY EFFICIENT TECHNOLOGY AND PRACTICES

Times Square

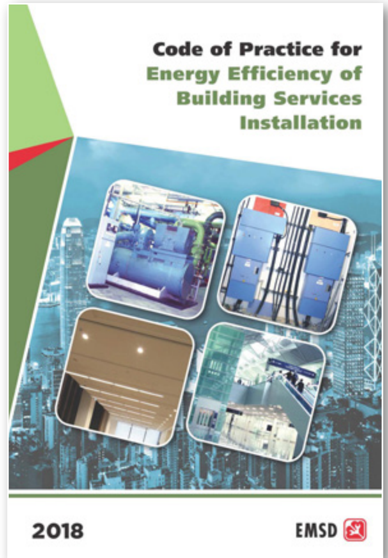
Air Conditioning

Air conditioning systems (ACSs) control the temperature, humidity, movement and quality of the air inside a building, to create a comfortable environment for occupants. Outdoor heat passes through the building envelope into the building. Heat is also generated by occupants and installed equipment. Office devices, air-conditioning equipment, lighting, electrical power distribution systems, lifts and escalators, etc. all produce heat when in operation.

The operation of air-conditioning requires large amounts of energy. In the past decade, air-conditioning systems have accounted for about 30% of the total electricity consumption in Hong Kong, being the prime energy consumer in both residential and commercial buildings. With increasing population and development, the energy consumption of air conditioning systems is likely to continue to grow.

The Code of Practice for Energy Efficiency of Building Services Installation sets out the minimum requirements for achieving energy-efficient design in AC installations in buildings. The code specifies design parameters and the control criteria for AC installations as well as the minimum coefficient of performance (COP) for AC equipment.

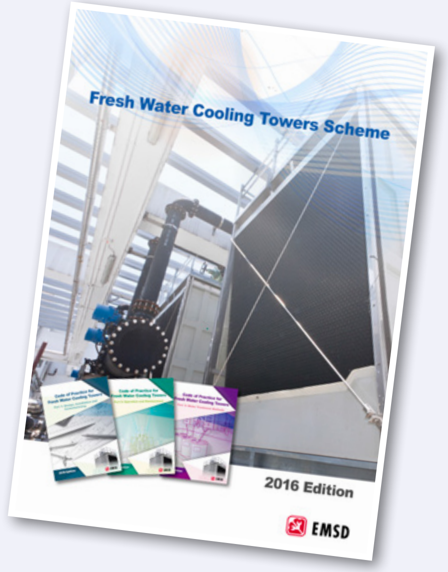
Achieving energy efficient, ACS for a building starts with a suitable sizing design. The code specifies temperature and relative humidity conditions for the loading design calculation. There should also be automatic controls for temperature regulation. The set point temperature should be adjustable to above or below the specified temperature for cooling or heating respectively.



Code of Practice for Energy Efficiency of Building Services Installation

Do you know ...

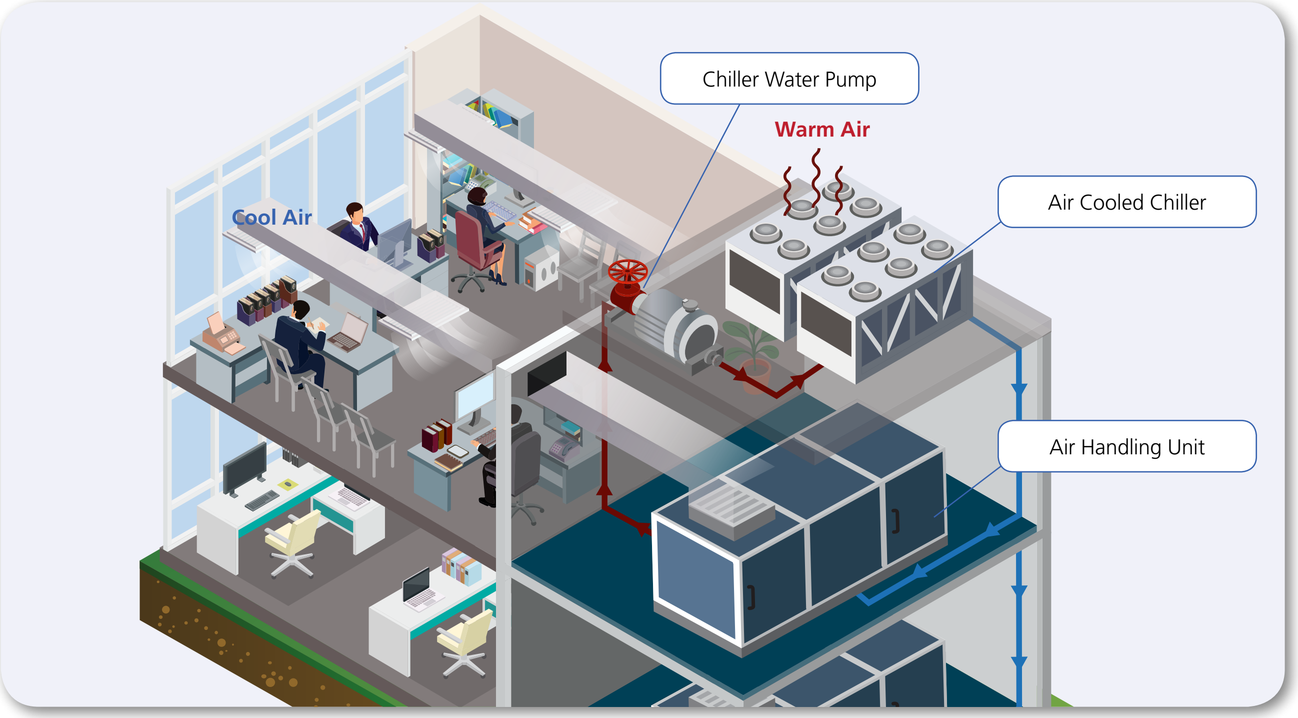
The Government launched the Fresh Water Cooling Towers (FWCT) Scheme for water-cooled ACS (WACS). It primarily aims to promote energy-efficient WACSs. This scheme applies to all new and existing non-domestic buildings and other buildings where the use of fresh water for evaporative cooling is supplied for non-domestic usage. Building owners can apply for the use of fresh water for air-conditioning installations in their buildings. EMSD has published a Code of Practice for Fresh Water Cooling Towers, providing guidelines for the fresh water cooling towers' design, installation, testing, commissioning, operation and maintenance.



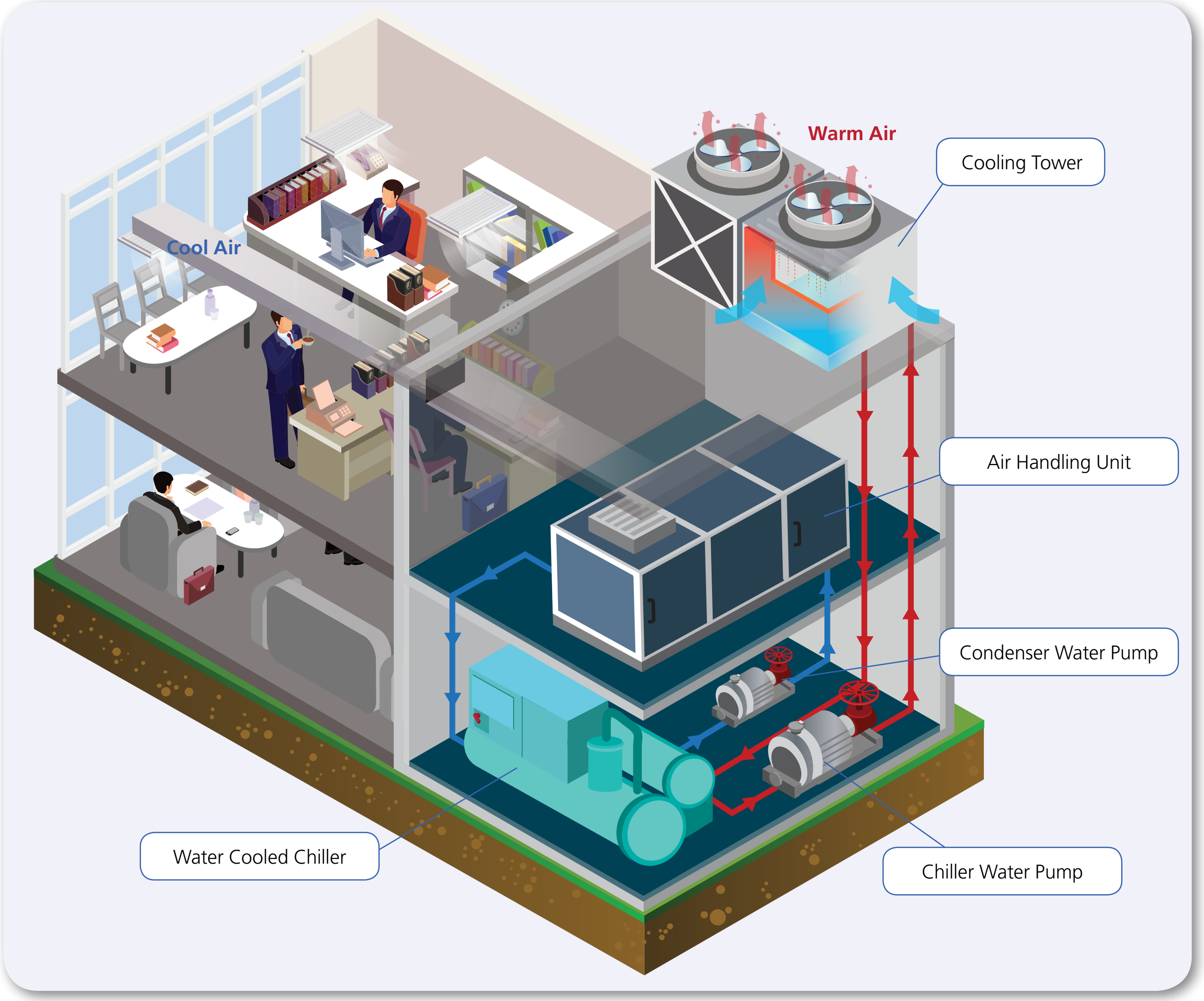
ACSs can be classified as independent systems and central systems. Independent systems deploy packaged or split type air-conditioners to cool, usually small space areas. Central systems distribute conditioned air to different spaces in a building with a full range of equipment – fans, for instance, are needed to take in and circulate air in these systems. The code specifies requirements on the fan's motor power and air leakage limits within the distribution system to guarantee the efficiency of the air circulation and limit the cooling and fan power loss due to leakages. There are also requirements on the heat insulation of the components.

Depending on the different cooling medium of the condenser, ACSs can be further divided into two categories – air-cooled and water-cooled systems. Air-cooled systems are applied to small and medium air-conditioning installations, where a convenient and reliable water source is unavailable. It requires a substantial amount of air for cooling, consuming relatively large amounts of electricity compared to the water-cooled systems.

Water-cooled ACSs are intrinsically more energy efficient than air-cooled systems. Switching from an air-cooled ACS to a water-cooled system can therefore save considerable amounts of electricity. The water pumping rate should be variable so that water supplies can be reduced when the loading requirement is lower. The code specifies variability and friction requirements for the water pumping systems of water-cooled ACSs.



Air-cooled Air Conditioning System



Water-cooled Air-conditioning System

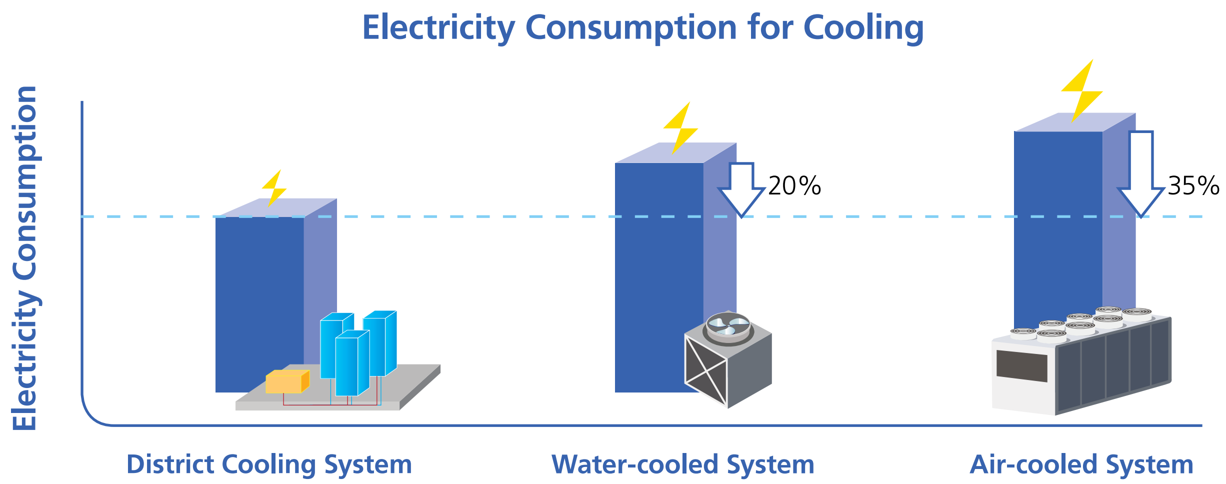
District Cooling System

District cooling system (DCS) can be regarded as a centralized air-conditioning system on a mega scale which consists of a central chiller plant, an underground chilled water-pipe network, substations in consumer buildings with connection facilities including heat exchanger, and the seawater/ fresh water system for heat dissipation. Instead of serving a single building, DCS provides cooling capacities to multiple buildings within a district. Individual users, who purchase chilled water for their building, do not need to install their own chiller plants. In countries where there is substantial heating demand, the plant can also be designed to supply hot water to form District Heating and Cooling Systems (DHCSs).

DCS is a very energy-efficient cooling solution as it takes full advantage of economies of scale, diversity in cooling demands for different buildings as well as high standards of plant operation and maintenance. Although energy savings resulting from DCSs vary according to individual DCS configurations, such as length of distribution pipelines, heat rejection methods and other plant efficiency improvement schemes, a typical electricity saving of around 35% can be achieved when compared with conventional centralized air-cooled air conditioning systems.

District Cooling Systems - District cooling plant can serve the chilled water within a territory-wide area instead of single building

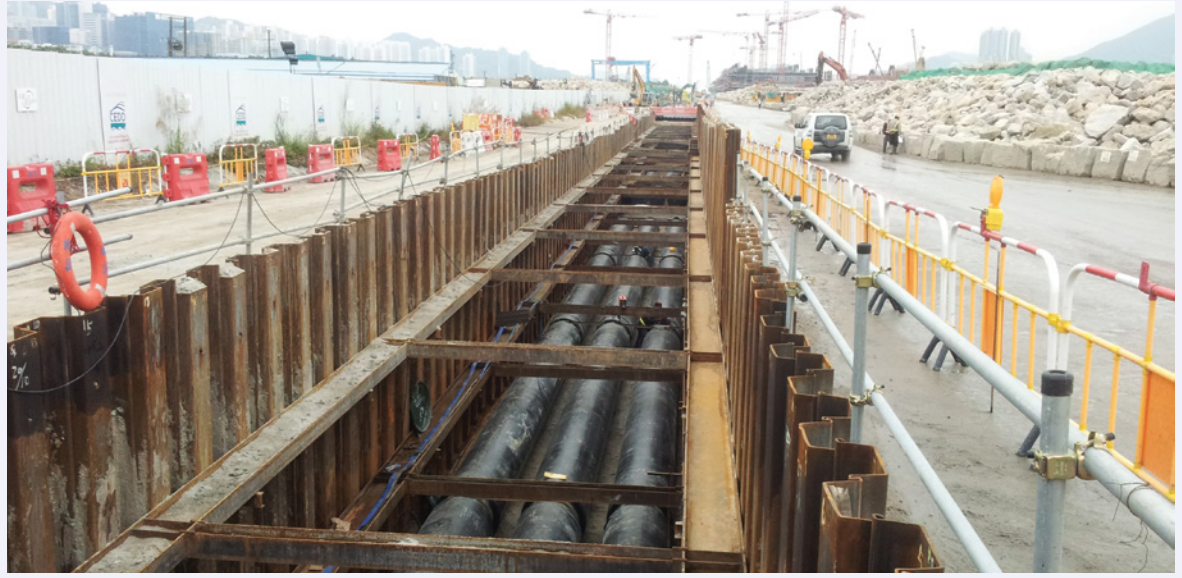
District Cooling System at Kai Tak District



Do you know ...

The Government is implementing DCS at the Kai Tak Development to supply chilled water to buildings for centralised air-conditioning. The planned 1.7 million square metres (m^2) in public and private non-domestic air-conditioned floor area will require about 284 megawatt of refrigeration (MWr) of cooling capacity. Upon completion, the maximum annual saving in electricity consumption will be up to 85 million kilowatt-hour, equivalent to a reduction of 59,500 tonnes of carbon dioxide emissions a year.

Kai Tak District Cooling Plant
Source: Electrical and Mechanical Services Department



Constructing the Kai Tak District Cooling Systems
Source: Electrical and Mechanical Services Department

Lighting

Lighting is the second largest consumer of electricity next to air-conditioning, using up about 15% of Hong Kong's total electricity consumption in the past decade. Reductions in energy consumed for lighting can be realized by using energy efficient lighting equipment and the greater use of daylight.

The Code of Practice for Energy Efficiency of Building Services Installations sets out the minimum requirements for achieving energy-efficient lighting.

Providing macroscopic control of lighting energy efficiencies, limitations on lighting power densities for different types of space are specified. Together with light efficacy requirements, this prevents space from being over illuminated. The code also requires a minimum number of lighting control points for any space other than car park according to the area, so that indoor lighting controls are easily accessible to occupants. Automatic lighting control including daylight responsive control is also introduced to reduce the electricity consumption when maximum operation of the system is not required.

Do you know …

Fluorescent Lamp Recycling Programme (FLRP)

Although Fluorescent lamps can reduce electricity consumption and greenhouse gas emissions, they contain tiny amounts of toxic mercury. Therefore, proper care in the disposal of used fluorescent lamps is required.

FLRP provides households with free collection and treatment for all used mercury-containing lamps, including compact fluorescent lamps (CFLs), fluorescent tubes and high intensity discharge lamps.

It's easy to participate in FLRP. When fluorescent lamps are spent, wrap them up to prevent breakage and bring them along to the collection points available at participating housing estates, shopping malls, and retail stores.

Source: Hong Kong Waste Reduction Website

Lift and Escalator

Lifts and escalators in multi-storey buildings serve to carry people up and down the building's floors. Electrical energy however is needed in their operation. In Hong Kong, the energy consumed by lifts and escalators is comparable to lighting installations in commercial buildings, because they have large electrical motors and operate continuously throughout the day.

Lifts and Escalators

The Code of Practice for Energy Efficiency of Building Services Installations sets out the minimum requirements for achieving energy-efficient lift, escalator and passenger conveyor installations. The power of lift motor drives carrying different loads is limited according to their speed, while that of escalators and passenger conveyor belts is limited according to their width, height/length and speed.

The code also specifies energy management for lifts and escalators. Meters measuring the electrical parameters such as energy consumption of lifts and escalators should be provided. Ventilation for idle lifts should automatically shut down and at least one lift should be in standby mode during off-peak periods. Lifts and escalators shall equip with service on demand and regenerative braking functions respectively.

Do you know …

Use Stairs Instead of Elevators or Escalators if Possible

Climbing stairs is one of the best ways of incorporating physical activity into our daily lives. It saves energy too!

Walking up stairs provides a cardiovascular workout for your heart and helps to strengthen your leg and hip muscles and bones. It is also an effective way to burn calories. If you weigh approximately 120 pounds and you climb stairs for approximately 25 minutes without interruption, you will have burned 204 calories during that time.

Start TODAY and use the STAIRS!

Use Stairs

Electrical Installation

Electrical power distribution is the final stage in the delivery of electricity to occupants. Electricity is carried by a distribution system network from the transmission system to tenants.

The Code of Practice for Energy Efficiency of Building Services Installations sets out the minimum requirements for achieving energy efficient design of electrical installations in buildings, without sacrificing power quality, safety, health, comfort, productivity or building function.

Requirements for energy efficient design of electrical installations in buildings are classified in the code into the following four categories:

- Minimization of losses in the power distribution system,
- Reduction of losses and energy wastage in the utilization of electrical power,
- Reduction of losses due to associated power quality problems, and
- Appropriate metering and energy monitoring facilities.

Distribution of electricity is more efficient using high voltage. The code requires high-rise buildings to use high voltage distribution systems. Distribution circuits must also be connected to metering devices for monitoring and auditing purposes. The code also provides requirements on transformer efficiencies for power distribution, while setting the limits for power losses in the distribution of electricity and the resistance of wires of different sizes. The code also limits the size and efficiency of motors.

Do you know ...

Building Management Systems (BMSs) are very often computer-based control systems, monitoring and controlling the mechanical and electrical equipment of a building such as lighting, ventilation, heating, air-conditioning, security and fire-alarm systems. BMSs facilitate facilities management, retrieving energy consumption data and comparing it with the forecast budget, to show savings and excess usage.

Building Management Systems

5 MAINTAINING ENERGY EFFICIENT BUILDINGS

Other than design and installation, the operation and maintenance of a building also plays a major role in achieving energy optimization in its life cycle. This however depends on the cooperation of the users and occupants of the building.

Technician in Maintenance of Escalators

Do you know …

Building Management Systems (BMSs) with features such as smart meters can record not only the total energy consumption, but also monitor the energy consumption pattern in the different systems of a building. This can help the facilities manager to identify otherwise unknown areas of energy wastage.

Proper Maintenance of Systems

Air-conditioning

- Clean the dust filter of air-condtioning system (ACS) once or twice every month to ensure that the airflow is not obstructed.
- Ensure efficient operation of ACS by cleaning its interior with a maintenance programme.
- Flush water pipes of water-cooled ACS to reduce flow friction.
- Adjust alignment of shaft of fan, pump, motor, etc.
- Repair, replace vibration isolation of fan, pump, etc.
- Replace loose/worn out insulation.
- Repair worn-out components/parts.
- Add proper lubricant to moving parts (e.g. bearings).
- Relocate sensors, such as motion sensors, CO_2 sensors and thermostats to suitable locations to properly reflect the conditions.
- Adjust control programme/algorithms to meet actual operational needs.

Regular Cleansing and Maintenance

Lighting

- Replace malfunctioning switches and sensors.
- Lower lighting levels in non-office working areas.
- Modify switching arrangements so that lighting groups can be better controlled according to end-user needs.
- Control lighting levels using electronic automatic control systems with sensors according to the lighting levels required during different hours.

Electronic Automatic Control System

Lifts and Escalators

- Let the control programme learn the demand and flow pattern of users at different time of the day.
- Isolate some lifts and escalators from normal operation during non-peak hours.
- Use lift traffic management systems: passengers indicate their destination floor in the lift lobby.
- Turn off lighting and ventilation in the lift when it is not occupied.
- Reduce decorative weight.

Lift Maintenance

Preventing Water System Leaks

Water system leaks can occur in existing and aged buildings. Even a small leak can result in the loss of large quantities of water over the time. Energy is also wasted in the distribution of the water and its pumping systems. In addition to wastage, water system leaks that are not repaired immediately can damage building structures or electrical systems. Therefore, the amount of water used in a building should be monitored regularly.

Other than aged buildings, water system leaks can occur in new construction from the improper installation of piping and fixtures, or damage to piping during the construction process. Therefore, it is important to commission the water distribution system as part of the overall building's commissioning process.

Water Pipe Maintenance

Good Housekeeping Measures

Air-Conditioning (AC) and Ventilation

Use Curtains or Blinds to Shade Against Sunlight

- Set and maintain air-conditioned room temperature between 24°C and 26°C in summer.
- Switch off the AC in offices, meeting rooms, etc. right after use. Affix “Save Energy” stickers as a reminder at the exit.
- Keep the windows and doors closed when the AC is turned on and use curtains or blinds to shade against sunlight.
- Install occupancy/motion sensors to automatically switch on and off the air-conditioning in those areas infrequently used, e.g. in conference rooms.
- Set the fan coil to "low" fan speed as the normal setting. Use a high fan speed rather than lowering the temperature setting to cater for increased cooling demand.
- Dress light to minimize use of AC.
- Consider using fan in conjunction with AC to spread the cooled air more effectively.
- Switch off lighting and heat-producing appliances that are not in use to reduce air-conditioning load.

Appliances and Equipment

- Locate equipment to avoid direct sunlight.
- Activate the energy saving mode during office hours.
- Use the power management feature to preset the computer to “sleep” or “hibernation” mode when it is idle.
- Switching off the screen can save even more energy than just letting the screen savers run.
- Use intelligent adaptor to automatically switch off peripheral devices, such as monitor and printer, for reducing standby power.
- Group essential services to a few servers and switch off others when they are not in use.

Good Maintenance

Better Energy Efficiency

Best Bet to Save the Earth

References

1. **Electrical and Mechanical Services Department** (www.emsd.gov.hk)
   - A New Chapter : The Story of EMSD Headquarters:
   - Energy Efficiency Registration Scheme for Buildings
   - District Cooling System at Kai Tak Development
   - Fresh Water Cooling Towers Scheme
   - Voluntary Energy Efficiency Labelling Scheme
   - Mandatory Energy Efficiency Labelling Scheme
   - Energy End-use Data and Consumption Indicators
   - Advanced Energy Saving Technologies
   - New and Renewable Energy

2. **Energyland** (www.energyland.emsd.gov.hk)
   - Energy Audit and Carbon Audit
   - Energy Use in Hong Kong

3. **Hong Kong RE Net** (re.emsd.gov.hk)
   - Global Perspective on Renewable Energy
   - Grid Connection
   - Wind Resource Maps
   - Energy-from-Waste

4. **Environmental Protection Department** (www.epd.gov.hk)
   - Clean Air Plan
   - Hong Kong's Climate Action Plan 2030+
   - Practical Guide on Carbon Audit and Management
   - Food Wise Eateries Scheme

5. **Hong Kong Observatory** (www.hko.gov.hk)
   - Monthly Meteorological Normals and Extremes for Hong Kong
   - Climate Change

6. **Hong Kong Waste Reduction Website** (www.wastereduction.gov.hk)
   - Waste Reduction Tips
   - Waste Reduction Programme
   - What and Where to Recycle

7. **CLP Power Hong Kong Limited** (www.clp.com.hk)
   - Renewable Energy Service
   - Energy Saving Ideas
   - Offset Carbon Footprint

8. **Hongkong Electric Company** (www.hkelectric.com)
   - Lamma Wind Power Station