能源效益及相關事項通訊
A Newsletter on Energy Efficiency and Related Matters

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EnergyWits 智能

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機電工程署
EMSD

香港能源效益獎
Hong Kong Energy Efficiency Awards

機電工程署舉辦的「香港能源效益獎」是一個為期12個月給私營和教育機構參與的節能比賽。比賽分為兩個組別：「商業及住宅樓宇」和「學校」。比賽的目的是把能源效益和節能的訊息向商界和教育界推廣，鼓勵大家身體力行。自比賽推出後，反應十分踴躍，共有230個參賽隊伍。

頒獎典禮已於2006年5月9日於香港會議展覽中心舉行。由環境運輸及工務局局長廖秀冬博士擔任主禮嘉賓。頒獎禮當日非常熱鬧，有超過400位嘉賓出席與得獎者分享他們的喜悅。

The "Hong Kong Energy Efficiency Awards" is a 12-month energy saving competition organized by the Electrical and Mechanical Services Department (EMSD) for private sectors and educational establishments. Participants are divided into 2 categories: "Commercial and Residential Buildings" and "Schools". The competition is an important step towards promoting energy efficiency and conservation to the public. The response was overwhelming. We received a total of 230 entries.

The prizes presentation ceremony was held on 9 May 2006 at the Hong Kong Convention and Exhibition Centre. The Hon Dr. Sarah LIAO Sau Tung, JP, Secretary for the Environment, Transport and Works officiated the ceremony. The event was exhilarating with more than 400 guests in attendance and sharing the triumph of the winners.

各得獎組別與嘉賓大合照 Group Photo of Award Winners

為使其他機構可以分享得獎者的節能心得，機電工程署在6月和7月舉辦了三場經驗分享會。此外為了使更多的人能夠欣賞得獎者為節能所付出的努力，我們還把部份獲獎者的節能措施，記錄於光碟，並在不同渠道派發，藉以希望保留及傳遞這些寶貴的經驗。

In order to let more organizations learn from the valuable experience of the award winners, the EMSD organized three experience sharing sessions in June and July 2006. Furthermore, energy saving methodologies of some of the award winners were also recorded onto a CD ROM for distribution to the public through various channels.

得獎者的節能心得

優勝者於比賽期間所實踐的措施可分為以下幾方面: (1) 管理方針(2) 內務管理措施和(3) 節能改善工程。

有效地達到節能目標的管理方針包括:

- 由上而下推動
- 設立節能管理工作小組
- 任命專員執行常規檢查確保內務管理措施適當地執行

良好內務管理措施包括:

- 減少空調的運作時間
- 提高空調溫度
- 於午飯時間和不需用時關掉空調，並於光線過份充足的地方拆除多餘的燈

節能工程項目包括:

- 採用水冷式空調系統取代氣冷式空調系統
- 優化空調系統運作從而減少浪費能源
- 更換舊光管為T5管
- 優化機電設施以更有效地使用能源

Success Factors of the Award Winners

The practices that the award winners have implemented during the competition can be divided into: (1) management practices (2) good housekeeping measures and (3) engineering work.

Management practices that are conducive to the achievement of good energy saving include:-

- drive from top management
- setting up of energy management task force
- appointment of staff to carry out regular checks to ensure proper implementation of housekeeping measures.

Good housekeeping measures include:-

- reducing air-conditioning operation time
- raising air-conditioning temperature setting
- switching off air-conditioning and computers during lunch time and when not in use
- dismantling unnecessary lamps in over-illuminated areas.

Energy saving engineering work includes:-

- converting air-cooled air-conditioning system into water-cooled air-conditioning system
- optimizing air-conditioning system operation to cut down energy wastage
- retrofitting old fluorescent lamps with T5 lamps
- fine-tuning electrical and mechanical installations to optimize their efficiency.

參加2006年6月和7月舉行的經驗分享會人數眾多
Many people attended the experience sharing sessions in June & July 2006

太陽能熱水系統的規劃和設計
Planning and Design of Solar Water Heating System

採用太陽能熱水系統是應用可再生能源的其中一個簡單方法。在開始設計系統時，應進行實地考察和了解現場環境，以決定安裝太陽能集熱器的合適位置。此外，亦須取得有關現有熱水系統的資料例如熱水用量數據。

Solar water heating (SWH) is one of the simplest ways to harness renewable energy. In the planning of a SWH system, it is essential to carry out a site survey and record the site conditions so as to determine a suitable location for installing the solar collectors. It is also important to obtain details of the existing hot water system such as hot water consumption data etc.

確定熱水需求量

如能夠測量到熱水實際需求量，便應根據測量結果來決定太陽能熱水系統的規模。如無法測量熱水需求量(例如在新大廈)，則應作出適當估計。

我們可根據一些國際設計標準*，估計大廈的熱水需求量。

Determining The Required Capacity

If the hot water demand can be measured, it is ideal to size the SWH system based on measured demands. If the hot water demand cannot be measured, for example, in a new building, we will need to make a close estimate.

For the estimation of the daily hot water consumption demand of a building, we can make reference to some international design standards*.

太陽能集熱器的種類和大小

最常用的兩種太陽能集熱器是平板型和真空熱管型。由於真空熱管型集熱器的製造過程比平板型集熱器精密，價格也比較昂貴。#但是，它的集熱效率比較高，而所佔用的空間也比較小。

真空熱管型集熱器
Evacuated Heat-pipe Collector

平板型集熱器 Flat-plate Collector

Selection and Sizing of Solar Collectors

The most common types of solar collectors are flat-plate and evacuated heat-pipe solar collectors. Evacuated tube collectors are generally more expensive due to a more complicated manufacturing process. #However, they are more effective than flat plate collectors and occupy less area.

太陽能集熱器面積的大小取決於太陽照射率和平均系統效率。香港的平均太陽照射率可向香港天文台查詢。香港的長期平均太陽照射率是每年5,300MJ/m^{2}作為計算數據。

平均系統效率取決於多種因素，例如系統的排列方式、集熱器的種類、水管和儲水缸的熱流失量、集熱器被附近建築物或樹木遮蔽的情況等。由於在設計階段無法充分評估這

There are two important parameters to sizing the area of a solar collector, namely solar irradiation and average system efficiency. Solar irradiation data of Hong Kong is available from the Hong Kong Observatory. The long-term average annual solar irradiation of Hong Kong is 5,300MJ/m^2.

System efficiency depends on various factors such as the system configuration, type of solar collectors, heat losses in pipes and storage tanks, shading effects of nearby buildings or plants etc. Since all these factors cannot be

些因素，一般都會根據系統設計師的假設條件而估計系統的效率。一些外國進行的研究指出，設計和安裝良好的平板型系統效率大約為30%至40%，而真空熱管型系統的效率則大約為40%至45%。

受各種因素限制(例如財政或地點限制)，太陽能熱水系統通常只會用來提供部份的熱水需求。系統一般也會配上一個輔助熱水器來滿足整體的熱水需求。

能源產量和節省的費用

太陽能熱水系統利用太陽能把水加熱，收集所得的熱量能取代一般氣體或電熱水器消耗的能源。所以，每年節省下來的能源可用根據太陽能熱水系統收集所得熱量Q_{SUN}估計，亦即是每日熱量需求Q_{HW}。

以一般氣體或電熱水器作比較，太陽能熱水系統分別可從每兆焦耳中節省大約0.2元和0.3元。

##本文列舉的計算方法能較快地估計出太陽能集熱器的表面面積及每年節省的能源。如需進行詳細的能源計算和分析，須使用電腦模擬技術模擬太陽能熱水系統的表現。

* 例如，英國特許屋宇設備工程師學會出版的指引B (CIBSE Guide B) 或英國水務工程學會出版的設計指引 (Plumbing Engineering Services Design Guide)

fully evaluated at the design stage, it is common to estimate the system efficiency based on the designer's assumptions. Some overseas studies suggest that the average system efficiency for a well designed and installed SWH system with flat-plate collectors is about 30% to 40%. If evacuated heat-pipes are used, the efficiency can be increased to about 40% to 45%.

Due to various considerations such as budgetary constraints, site limitations, etc. It is quite often that the SWH system of a building will only be designed to meet a certain proportion of its hot water demand. An auxiliary heater will normally be installed to raise the water temperature to meet operational requirements.

Energy Yield and Cost Saving

Using solar energy to generate hot water will save the same amount of energy required by a conventional gas or electric heater in heating up the water. Therefore, the annual energy saving from a SWH system can be estimated by calculating the amount of solar energy, Q_{SUN}, absorbed by the SWH system, which is equivalent to Q_{HW}, the estimated daily heat requirement.

Compared to conventional gas and electric hot water heaters, the cost savings are about $0.2 and $0.3 per MJ respectively.

##The calculation methods presented in this article provide a quick estimation on the required solar collector area and approximate annual energy saving. For more precise energy analysis, computer-modeling techniques may need to be employed to simulate the performance of the SWH system.

* For example, the Chartered Institute of Building Services Engineers (CIBSE) Guide B or Plumbing Engineering Services Design Guide published by the Institute of Plumbing and Heating Engineering etc.

#The efficiency of the evacuated pipe solar thermal collector can be expressed mathematically as follows:
#太陽能集熱器的效率可用以下數式表達：

$$\eta = k(\Theta)\cdot c_0 - c_1\cdot\frac{(T_{av}-T_{amb})}{G} - c_2\cdot\frac{(T_{av}-T_{amb})^2}{G}$$

where 其中: $k(\Theta)$ is the incident angle modifier 是入射角調整數值
T_{av} is the average fluid temperature 是平均液體溫度(°C)
T_{amb} is the ambient temperature 是環境溫度(°C)
G is the solar irradiation 是太陽照射率(W/m^2)
c_0, c_1, c_2 are coefficients 是系數

The coefficients c_1 and c_2 are the heat loss factors of the collector which characterise the heat loss behaviour of the collector under different environmental conditions.
系數c_1和c_2是集熱器的熱量散失因子，說明集熱器在不同的環境狀況下如何散失熱量。

##The daily heat requirement, Q_{HW}, can be calculated according to the following equation:
##每日熱量需求Q_{HW}可由下列公式計算出來：

$Q_{HW} = V_{HC} \times C_W \times \Delta\theta$ 每日熱量需求(MJ)

V_{HC} = Average daily hot water consumption平均每日熱水需求量(m^3)
C_W = Specific volumetric heat capacity of water水的比容熱容量(=4.2MJ/m^3/°C)
$\Delta\theta$ = Temperature difference between incoming water and the required hot water temperature
流入集熱器的水與所需熱水的溫差(°C)

(Average temperature of incoming water can be assumed at 18°C for winter months and 25°C in summer months whereas the hot water temperature for bathing can be assumed to be about 40°C)
(冬天水溫可假設為18°C，夏天水溫度可假設為25°C，而洗澡用熱水的水溫則可假設為約40°C)

The required flat plate collector surface area, A_{SC}, can be estimated by the following equation:
所需的集熱器表面面積A_{SC}可以下列公式計算：

$A_{SC} = Q_{HW} / (E_G \times \eta_{system})$

A_{SC} = collector surface area 集熱器表面面積(m^2)
Q_{HW} = heat requirement熱量需求(MJ)
E_G = annual solar irradiation全年太陽照射率(MJ/m^2)
η_{system} = average system efficiency平均系統效率

九龍灣消防局的
真空熱管型太陽能熱水系統
Evacuated Heat Pipe Solar Water Heating System at Kowloon Bay Fire Station

機電工程署最近在九龍灣消防局安裝了一套太陽能熱水系統，這系統可把沐浴用水預先加熱。有關裝置運用真空熱管型太陽能集熱器來收集熱能。與傳統的平板型太陽能集熱器不同，真空熱管型集熱器是由一組不銹鋼歧管夾着多排真空玻璃管組成。真空狀態能有效減少傳導和對流造成的熱量流失，故能提升集熱器的效能。每條真空管裏面有一條密封的熱導管，管內有少量傳熱液體和一些吸熱片。水只限在歧管裏面流動，不可流進熱管。熱管內的傳熱液體是有效的傳熱導體，能把太陽熱能從吸熱片傳送到歧管，並把在歧管內流動的水加熱。右圖說明熱管的傳熱方式，熱管內傳熱液體的蒸發冷凝循環過程能把吸熱片所吸收的熱能傳送到歧管。每個玻璃管內都沒有水管，因此漏水或阻塞的風險大為減低。

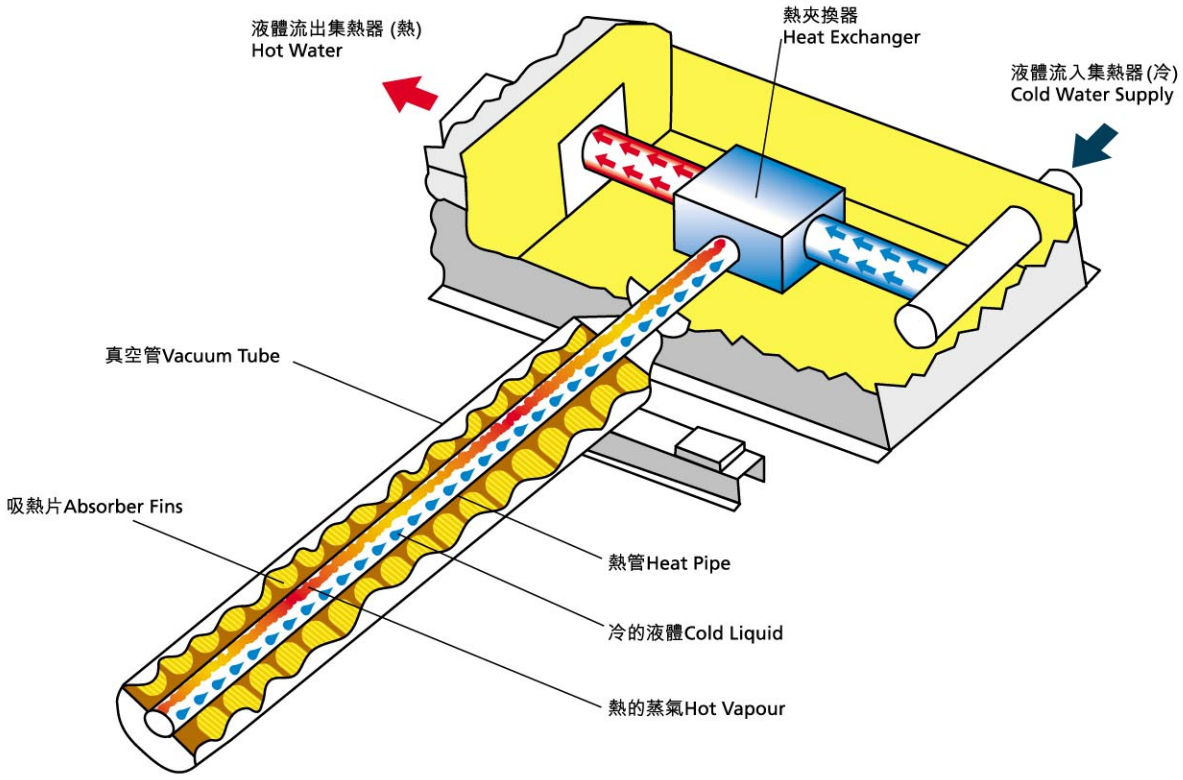
EMSD has recently installed a solar thermal heating system at the Kowloon Bay Fire Station for preheating water to the showers there. The system employs evacuated heat-pipe solar collectors for collecting thermal energy. Unlike a traditional flat plate solar collector, an evacuated heat-pipe collector consists of multiple rows of vacuum glass tubes clipped onto a stainless steel manifold. The vacuum forms a very effective shield against thermal conduction and convection losses, thus enhancing the performance of the collector. Inside each vacuum tube is a sealed heat pipe with a small volume of thermal fluid and some heat absorbing fins. Water is restricted to flow inside the manifold and cannot enter the heat pipes. The thermal fluid in the heat pipes acts as an effective thermal conductor conducting solar thermal energy from the absorber fins to the manifold and heat up the water flowing inside. The diagram on the right illustrates the conduction mechanism of the heat pipe. Thermal energy absorbed by the absorber fins is conducted to the manifold by the evaporating-condensing cycle of the thermal fluid in the heat pipe. As there is no water pipe in each glass tube, the risk of water leakage or blockage is reduced significantly.

岐管夾着真空熱管
Evacuated Heat-pipes Clipped onto Manifold

在真空玻璃管內的熱管和吸熱片
Heat-pipes and Fins Inside Vacuum Glass Tube

九龍灣消防局的太陽能熱水系統有大約40條玻璃管。預計在太陽照射率為1,000W/m^{2}的情況下，這系統的裝機容量將達到3.2kW。這系統的安裝工程現已完成。我們現正監察有關系統的表現，為期12個月。我們會對收集所得的操作數據作出詳細分析。

There are around 40 glass tubes in the evacuated heat-pipe solar collectors at the Kowloon Bay Fire Station. Under a solar irradiation of 1,000W/m^2, the collectors installed capacity will reach 3.2kW. The installation work has been completed. 12-month data is being collected for energy efficiency performance analysis of this type of solar water heating system.



真空熱管型太陽能集熱器的蒸發－凝結循環過程
Evaporating-condensing Cycle of Heat Pipe Solar Collector

「能源效益標籤計劃」延申至多一種產品－傳真機

Energy Efficiency Labelling Scheme Covers One More Product Type - Fax Machines

在2006年7月，機電工程署把自願參與的「能源效益標籤計劃」擴展至傳真機。傳真機的製造商、進口商及本地代理商都被邀參與採用「確認式」標籤的自願性「能源效益標籤計劃」。合資格貼這類能源標籤的產品，必須符合計劃所訂的能源效益及安全規定。

機電工程署自1995年開始推行「能源效益標籤計劃」。將傳真機納入這計劃後，標籤計劃現已涵蓋共17種家用及辦公室器具。

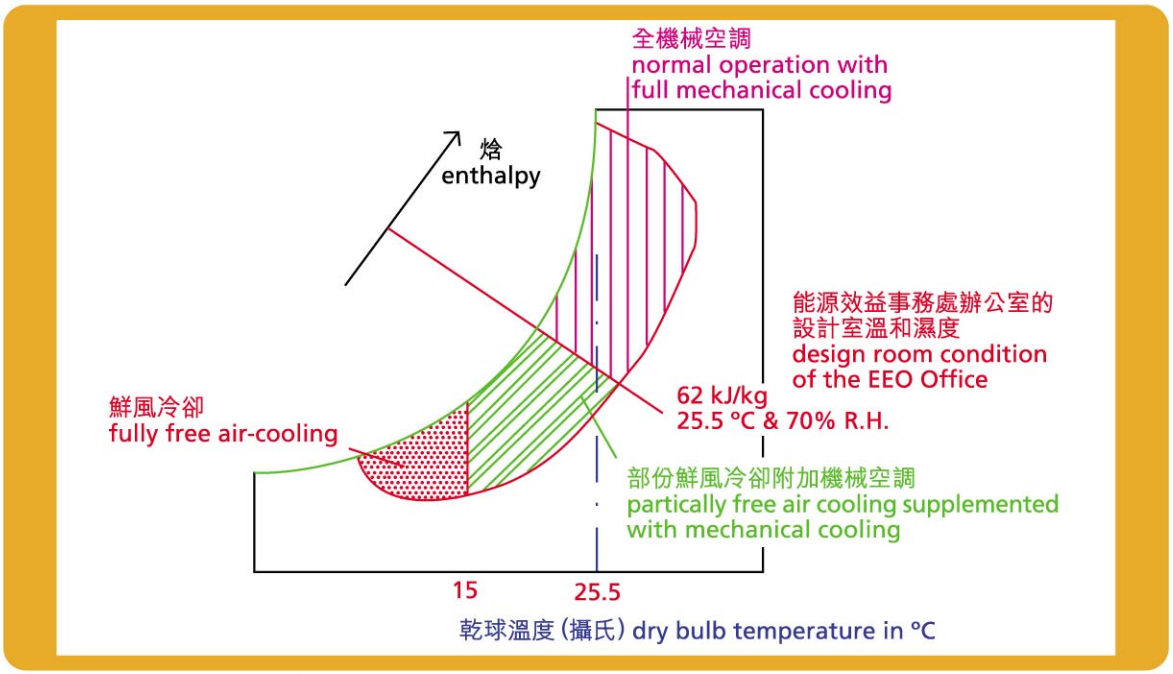
In July 2006, EMSD extended the voluntary Energy Efficiency Labelling Scheme (EELS) to cover fax machines. Fax machines manufacturers, importers, agents have been invited to participate in this voluntary scheme for the "Recognition Type" energy label. To qualify for this type of energy label, the fax machine product should comply with the safety requirements and energy performance standards of the scheme.

The EELS was introduced by EMSD in 1995. It now covers17 types of household and office appliances, including fax machines.

鮮風冷卻方案 Free Air-Cooling

鮮風冷卻利用室外自然空氣作空調，以代替機械空調，從而節約能源。

Free Air Cooling (FAC) utilizes cool outdoor air to provide space cooling in lieu of mechanical cooling thus saving energy.



濕氣圖—機電工程署送風櫃的運作模式
Psychrometric Chart — Operation Modes of EMSD's AHU

一部附有鮮風冷卻的送風櫃之運作模式可分為三類：(1)全機械空調(2)全鮮風冷卻(3)部分鮮風冷卻附加機械空調。以上濕氣圖說明了這三種運作模式。程式控制器首先會不斷把室外和空內的溫度、濕度和焓與它們的預設數值比較，繼而斷定室外空氣、回風和排放空氣應有的比例。控制器便接着調校風門到適當的位置。

機電工程署總部大樓能源效益事務處的其中一部送風櫃已安裝了鮮風冷卻裝置。這部送風櫃的送風量是每秒5立方米而風櫃在全鮮風冷卻情況下需要每秒5立方米的鮮風。由於原來的鮮風管和排氣管的容量都只是每秒1立方米，所以要加裝新的喉管。

An air handing unit (AHU) fitted with FAC has 3 operation modes: (1) normal operation with full mechanical cooling, (2) fully free air cooling, and (3) partially free air cooling supplemented with mechanical cooling. The psychrometric chart above illustrates the 3 zones. A controller will continuously compare the temperature, relative humidity and enthalpy of outdoor air and indoor air with their design values. It will then determine the fresh air, return air and exhaust air quantities required to achieve the designed indoor conditions, and adjust the dampers accordingly.

One of the AHUs in the Energy Efficiency Office (EEO) of the EMSD Headquarters has been modified with FAC facilities. The AHU has a capacity of 5,000l/s. When the AHU is operating in its full FAC mode, it requires 5,000l/s of fresh air. As the original fresh air duct and exhaust air duct each has a capacity of only 1,000l/s, additional ducts are required.

機電工程署能源效益事務處的送風櫃須加裝鮮風喉
Additional fresh air ducts are installed at the AHU in the EEO of the EMSD HQS

送風櫃加設了排氣風扇和排氣管
The AHU is fitted with additional exhaust fan and duct

冷卻塔先行性計劃的發展和工作守則
Development of Pilot Scheme for Cooling Towers and Code of Practice

冷卻塔先行性計劃的發展

冷卻塔 (先行性計劃) 旨在推廣使用淡水於節能空調系統中的蒸發式冷卻塔。現時，先行性計劃選定地區已增至78個。

我們每月平均收到約5份申請，迄今為止已收到230份。今年上半年已經有7個冷卻塔完成安裝及投入操作。估計這7個冷卻塔裝置較使用氣冷式系統每年可節省2,300,000度電力。預計今年約有20個冷卻塔的裝置會相繼完成安裝。以下顯示兩個最新完成安裝及操作的冷卻塔。

Development of Pilot Scheme for Cooling Towers

The objective of the Pilot Scheme for Cooling Towers (Pilot Scheme) is to promote the wider use of fresh water in the evaporative cooling towers of energy efficient air conditioning systems. The scheme now covers 78 designated areas.

On average we receive 5 number of applications every month. Up to now we have received 230 applications. In the first half of this year, 7 installations have been completed and put into operation. It is estimated that these 7 installations could save 2.3 million kWh annually when compared with air-cooled air-conditioning systems. It is anticipated that about 20 installations will be completed this year.

Two newly completed cooling tower installations are shown here.

九龍紅磡香港理工大學李兆基樓（冷卻塔散熱量：9,400千瓦）
Hong Kong Polytechnic University Lee Shau Kee Building at Hunghom, Kowloon (Heat Rejection Capacity: 9,400 kW)

九龍旺角始創中心（冷卻塔散熱量：15,300千瓦）
Pioneer Centre at Mongkok, Kowloon (Heat Rejection Capacity: 15,300 kW)

冷卻塔工作守則

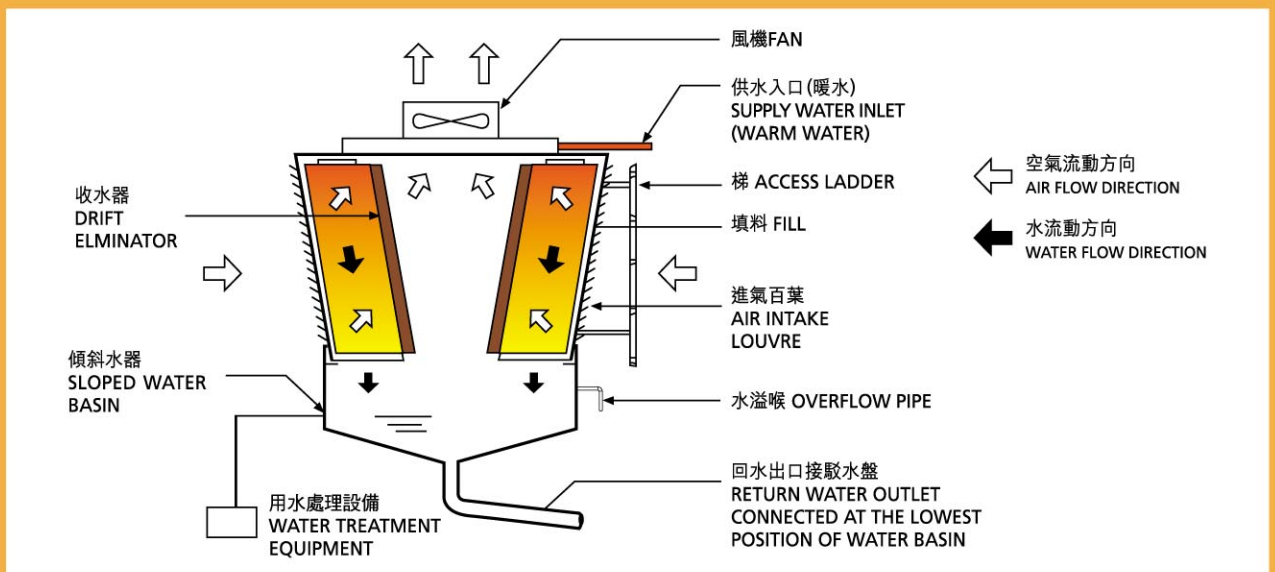
機電工程署最近編製了一份工作守則旨在推廣正確運用冷卻塔系統的方法。工作守則一共有三個部份以提供冷卻塔裝置技術指引。工作守則預計會於2007年1月開始實行。

工作守則第一部份主要詳述冷卻塔系統於設計、安裝及投用方面的最低要求及良好作業方法。範疇包括 (甲) 系統設計及結構；(乙)減低用水的流失; (丙) 冷卻塔安裝的位置；和 (丁) 系統投用。工作守則第二部份則詳列冷卻塔系統於操作及維修方面的最低要求及良好作業方法，重點分別是 (甲)保持系統於良好狀況；(乙) 控制及監察冷卻水的質量; 和 (丙) 每年操作及維修的獨立檢查。 工作守則第三部份闡述可適用於水冷式空調系統的用水處理方法，透過適當的用水處理，能將冷卻塔系統維持在最佳操作表現。有關工作守則可於機電工程署http://www.emsd.gov.hk/網頁瀏覽或下載。

Code of Practice for Cooling Towers

EMSD has recently uploaded onto its website a Code of Practice (COP) to promote the proper use of cooling tower systems. The COP consists of 3 parts, which cover the technical guidelines on the installation of cooling towers. The COP is targeted for implementation in January 2007.

Part 1 of the COP specifies the minimum requirements and good practices for the design, installation and commissioning of cooling tower systems. The scope covers (a) system design and construction (b) minimization of water loss (c) location selection, and (d) system commissioning. Part 2 of the COP specifies the minimum requirements and good practices for the operation and maintenance of cooling tower systems, emphasizing on (a) keeping the system in good condition (b) control and monitoring of cooling water quality, and (c) annual independent audit on operation and maintenance. Part 3 of the COP describes water treatment methods applicable to water-cooled air conditioning systems with the aim of optimizing the system operating performance in water treatment. The COP can be viewed and downloaded from the EMSD's website http://www.emsd.gov.hk/



冷卻塔裝置包括維修組件和用水處理設備
A typical cooling tower installation includes maintenance and water treatment equipment

新能源效益科技探索之旅
Emerging Energy Efficient Technologies

為了物色一些適合香港採用的最新節能技術，機電工程署於2006年6月派員前往美國加州進行實地考察，並參觀了數個應用有關技術的工程項目。

代表團此行主要集中考察兩類技術。第一類是使用專用操控軟件來控制可變速冷凍機（包括製冷器、冷卻塔、循環泵等），以確保系統利用最低的電能量運作來應付須求的冷凍。另一類是使用磁力軸的可變速免油離心式壓縮機。這裝置可減少電壓突降、噪音和振動的情況出現。從使用者的意見得知，似乎這兩項技術均可提供非常高的部分負載效率，並有效地節省能源。

一座附有可變速壓縮機的450噸冷凍機能達到平均效率每噸0.324千瓦
A 450-ton chiller fitted with variable speed centrifugal compressors can achieve an average efficiency of 0.324 kW/ton

代表團亦考察了一個可再生能源項目。這項目採用了一套座落在建築物天台的市電混合太陽能照明系統。系統的集中器收集了陽光，然後利用光纖把它輸送到建築物來輔助用市電的全統照明系統。

一座附有太陽追踪器的太陽能照明系統能提高供電效率
An automatic sun tracking system Is fitted to the hybrid solar lighting system to achieve a high collection efficiency

代表團除實地考察工程項目外，亦參觀了當地數家能源機構（例如加州能源委員會和落基山研究中心），並就節能措施、環境保護以及加州當局和其研究所在善用資源和可持續發展方面的觀點和計劃，與這些機構的代表交換意見。

透過這次考察，代表團有機會認識到美國在節能技術方面的最新發展，更可了解加州當局如何提高市民對能源效益的意識及利用獎勵、折扣、稅務優惠等活動來鼓勵市民節約能源。

In search of emerging energy efficient technologies that may be suitable for adoption in Hong Kong, officers from EMSD visited several project sites in California, USA in June 2006.

The visit primarily focused on two types of air-conditioning technologies. The first one is customized software that can control a variable-speed chilled water plant (chillers, cooling towers, circulating pumps, etc) to meet its system cooling requirement, whilst using the lowest overall input electrical power. The other technology is a type of oil-free variable speed centrifugal compressor which uses magnetic bearings to minimize power surge as well as noise and vibration. From the users' feedback, it seems that both technologies can provide very high part load efficiencies.

A renewable energy project site was also visited by EMSD's delegation. The technology is a roof-mounted hybrid solar lighting system which uses a concentrator to collect and transmit sunlight via optical fibres into the interior of a building to supplement the conventional light fittings to provide illumination.

The delegation also visited a number of energy organizations such as California Energy Commission and Rocky Mountain Institute to exchange views on the implementation of energy efficiency and conservation initiatives, as well as vision and plans which the California State or research institutes may have in pursing the efficient use of resources to achieve a sustainable society in the long run.

The visit provided EMSD the opportunity to appreciate the latest development in energy efficient and renewable energy technologies in USA. Furthermore, it was also a good opportunity for EMSD to have a better understanding of the various programmes being implemented in the California State which use incentives, rebates, special tariffs and recognitions to encourage efficient use of energy.

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