

Residential Air Conditioning:

An Energy Efficiency Guide

住宅空調：
能源效益指南



Introduction

Geographically located in a humid subtropical region, over 80% of households in Hong Kong rely on air conditioners to maintain thermal comfort. During the hot seasons, air conditioners can constitute more than 50% of a household's electricity bill. The purpose of this pamphlet is to provide basic information on procurement, operation and maintenance of residential air conditioning units from energy efficiency perspective.

Information on Energy Efficiency Available To Customers

Buying an energy efficient air conditioner is an important step to achieve energy efficiency. Common energy efficiency information that customers can find when buying residential air conditioners include the following:

Energy Labels

The Energy Efficiency Labelling Scheme (EELS) is an energy efficiency initiative launched by the Government of The Hong Kong Special Administrative Region. Equipment manufacturers who participate in the scheme shall affix an Energy Label to the registered air conditioner. The label has a grading from 1 to 5, with grade 1 being the most energy efficient. For further information on the EELS, please refer to the website www.emsd.gov.hk.

簡介

香港在地理上位於一個潮濕亞熱帶區域，超過80%家庭透過空調維持舒適的室溫。在炎熱的季節期間，空調可能佔家庭電費的50%以上。這本小冊子的目的是在節能層面上提供選購、操作和保養空調裝置的基本資料。

顧客接觸到的能源效益資訊

購買高能源效益的空調機（俗稱冷氣機）是達到節能的重要一步。一般顧客購買冷氣機時能找到的能源效益資料信息包括以下：

能源標籤

能源效益標籤計劃（EELS）是香港特別行政區政府展開的其中一項節能計劃。參加計劃的設備製造商需於註冊的冷氣機上貼上能源標籤。標籤分1到5級，1級最節省能源。欲知關於EELS的詳情，請瀏覽網站 www.emsd.gov.hk。

Energy Efficiency Ratio (EER)

EER is defined as the ratio between the cooling capacities (BTU/hr) of the air conditioner to the power consumption (W) of the equipment at a standard rating condition. That is:

$$\text{EER 能效比} = \frac{\text{Cooling Capacity (BTU/hr) 製冷量}}{\text{Power Consumption (W) 耗電量}}$$

EER is not in metric unit because the unit used for the cooling capacity is in BTU/hr (British Thermal Unit per Hour). The unit used for the power consumption is in W (Watt). Higher EER implies better energy efficiency. Typical range of EER is 8 to 10.

Coefficient of Performance (COP)

Similar to EER, COP is also a ratio between the cooling capacities of air conditioner to the power consumption of the equipment at standard rating condition. But, the cooling capacity, and power consumption are expressed in metric unit W (Watt). That is:

$$\text{COP 效能系數} = \frac{\text{Cooling Capacity (W) 製冷量}}{\text{Power Consumption (W) 耗電量}}$$

Higher COP means higher efficiency. Typical range of COP for a residential air conditioner is 2.3 to 2.9.

能效比

能效比是製冷量 (BTU/hr) 與空調設備耗電量 (W) 在一個標準測定情況下的比率。亦即：

能效比不是公制單位，因為製冷量的單位為英國熱量單位/小時 (BTU/hr)。耗電量的單位為瓦特 (W)。高的能效比表示良好的能源效益。一般家居冷氣機的能效比約為8至10。

效能系數

效能系數與能效比相似，是製冷量與空調設備耗電量在一個標準測定情況下的比率。但效能系數公式中的製冷量與空調設備耗電量均以瓦特 (W) 為單位。亦即：

高的效能系數表示良好的能源效益。一般家居冷氣機的效能系數約為2.3至2.9。

Sizing of Residential Air Conditioners

Correct sizing of residential air conditioner can ensure that the equipment is running in an efficient manner. An oversized air conditioner wastes energy because it is not working at its optimum condition. Additionally, it is more prone to premature failure and larger fluctuation of indoor air temperature due to frequent on/off of the compressor. On the contrary, an undersized air conditioner will not be able to meet the cooling requirement of the room.

The required cooling capacity of an air conditioner for a room depends on a number of factors. As an indication, assuming a room with a ceiling height of 2.7 m and good air tightness to minimize infiltration, an air conditioner with the following capacity can provide optimal cooling for the respective floor area:

估計住宅冷氣機所需的製冷量

正確估算住宅冷氣機製冷量可保證設備以高效率運行。製冷量過大的冷氣機因為不在最佳效率下運作而造成浪費能源。另外，由於壓縮機的頻繁開關，更易損壞和引起室內空氣溫度有較大幅波動。相反，製冷量不足的冷氣機將不能符合房間的製冷需求。

室內空調需要的製冷量取決於數個因素。舉例說，假設一房間高度為2.7米，門窗緊閉使外間空氣入滲減到最少，以下容量的冷氣機可為下列面積房間提供適當冷量：

Cooling Capacity of Air Conditioner (kW)* 冷氣機製冷量 (千瓦) *	Approximate Indoor Floor Area Covered (m ²) 室內樓面面積約數 (平方米)
2.05	Below 7.5 以下
2.64	7.5 - 12.0
3.52	12.0 - 23.0
5.27	23.0 - 35.0

* For cooling capacity 1 kW = 3412.14 BTU/hr
(Assumptions: Occupancy density of 2m² per person, lighting power of 30W/m² for bed room and 70W/m² for living room and other miscellaneous heat source of 10W/m²)

* 1 千瓦製冷量 = 3412.14 英國熱量單位 / 小時
(假設：使用者密度為每人2平方米，照明功率睡房為每平方米30瓦，客廳為70瓦，其他熱源為每平方米10瓦)

The above rule-of-thumb figures are for reference only and should not be taken as absolute guidelines. If the room is at the roof floor of the building, an additional 10-20% allowance should be made for the cooling capacity of the air conditioner to cater for the additional thermal loading transmitted from the roof.

上述資料僅作參考，并非絕對指標。如果房間位於大廈的頂層，應該為製冷量另外增加10-20%容限，以照顧由屋頂傳入的額外熱量負荷。

Installation of Residential Air Conditioners

An air conditioner, either a window type or a split type, usually consists of an indoor section for cooling the room and an outdoor section for rejecting heat to the outside (see fig.1).

住宅冷氣機的安裝

無論是窗口式或分體式冷氣機，通常包括一個用作冷卻房間的室內組件和一個用作散熱的室外組件（參考圖1）。

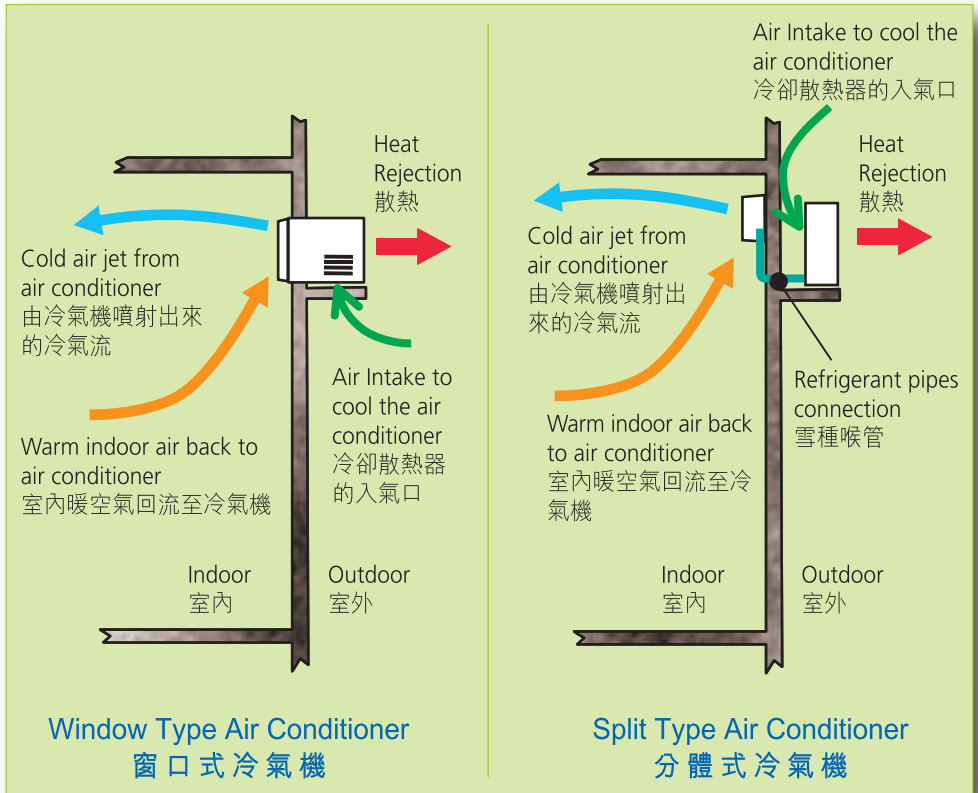


Fig 1. - The indoor section and outdoor section of an air conditioner
圖1. - 冷氣機的室內及室外組件

The following installation considerations can make the air conditioner working more efficiently:

For the indoor section:-

- Ensure no blockage to the air flow such that cold air jet from the air conditioner can be directed to the activity area of the room such as the dining area or the sitting area.
- Ensure the occupants can easily remove the air filters of the air conditioner for regular cleaning.
- Do not place heat generating appliances close to the return air path of the air conditioner which may affect the temperature control of the air conditioner.
- If the air conditioner is a window type air conditioner, make sure that the gap between the wall/window opening and the air conditioner body is properly sealed to prevent infiltration.

For the outdoor section:-

- Allow sufficient clearance between the air conditioner and the building structure to ensure smooth air flow for heat rejection.
- Avoid direct sunlight exposure. Direct sunlight will raise the temperature of the equipment and lower its efficiency during operation. If the unit is to be operated under direct sunlight for a long period of time, a sun shade for the outdoor unit may be desirable for efficiency improvement.

以下安裝時的考慮可增加冷氣機運作效率：

室內組件：-

- 確保由冷氣機噴射出來的冷氣無阻擋地送到房間內的活動範圍，例如飯廳或客廳。
- 確保使用者能容易地拆除冷氣機的隔塵網作定期清潔。
- 不要把發熱的電器放置在冷氣機的空氣回流路徑，以免影響冷氣機的溫度控制。
- 如冷氣機是窗口式，切記把牆壁或窗口與冷氣機身之間的空隙適當地密封防止外間空氣滲入。

室外組件：-

- 應在建築物與冷氣機間預留足夠的空間，確保散熱空氣流通。
- 避免陽光直射。在操作期間，陽光直射會提高冷氣機的溫度并降低它的效率。如冷氣機需長期在陽光直射下運作，為冷氣機室外組件裝上遮陽擋有助改善效率。

- If the air conditioner is a split type unit, make sure that the outdoor unit is accessible for regular cleaning and inspection.
- For split type unit where the outdoor unit and the indoor unit is separated with a distance, make sure that the separation is minimal and within the recommended length by the equipment manufacturer.

- 如果冷氣機是分體式，應確保室外組件位置容易接近，以便作定期清潔和檢查。
- 如果冷氣機是分體式，室外組件和室內組件應保持最小的分隔距離，以及在設備製造商建議的長度之內。

Operation of Residential Air Conditioners

There are certain points to observe in order to reduce wastage of energy when an air-conditioner is operated:

Preliminary:-

Occupants of the room should wear appropriate clothing to avoid unnecessary lowering of the room air temperature for thermal comfort.

Occupants should also check and remove any unnecessary heat source (such as a large pot of boiling water, any switched on but unused electrical appliances, etc.) that may increase the loading of the air conditioner.

External shading or solar control window glass/film may be considered, if the window of the room to be conditioned is exposed to direct sunlight during the operation of the air conditioner. If using external shading or solar control window glass/film is not possible, the window should be internally shaded (e.g. by venetian blind, curtain etc.).

住宅冷氣機的操作

操作住宅空調時留意下列各點可減少浪費能源：

初步措施：-

房間的使用者應該穿著適當的衣物，避免不必要地過量降低室溫。

房間的使用者應該檢查和移走不必要的熱來源（例如一大窩沸水，一些開動了但未使用的電氣用品等等），以免增加空調負荷。

如果房間的窗戶在空調操作期間暴露在直射陽光中，可考慮使用室外遮陽擋或太陽隔熱膜。如果不可能使用室外遮陽擋或太陽隔熱膜的話，窗口亦應使用室內遮陽擋（如百葉簾，或窗簾等）。

Keeping the Room Air-tight:-

While sufficient ventilation should be maintained to minimize indoor air quality problems, the conditioned room should have the windows and doors closed to reduce infiltration and loss of conditioned air.

Computer simulation study on a residential apartment indicated that for a kitchen carrying out minor cooking (simmering a pot of soup), opening the kitchen's door even slightly can increase the loading of the air conditioner significantly.

Temperature Setting:-

Adjusting the set point temperature can result in a direct impact to the energy consumption of the equipment. Laboratory tests show that on average, a 1°C change in the set point within the typical operating range of the air conditioner (22°C - 27°C) can result in an energy consumption change of more than 3%.

Nowaday, although most new air conditioners are provided with a digital display in the remote controller for setting the temperature, a good quality table top digital thermometer (see fig. 2) can provide more accurate visual information to occupants on the current condition of the room.

保持房間密閉：-

在維持足夠通風以減少室內空氣質素問題的同時，亦應把空調房間的門窗關閉以減少室外空氣滲入和冷氣流失。

一個關於住宅的電腦模擬研究顯示，當廚房進行小型烹調程序時（如煨一窩湯），即使輕微地打開廚房門亦可能大大地增加空調的負荷。

室溫設定：-

調整室溫設定點會影響冷氣機的能源消耗。實驗室測試顯示在空調的典型操作範圍（攝氏22-27度）內，改變室溫設定點攝氏1度可能導致能源消耗變動超過3%。

現時，雖然多數新的冷氣機均在遙控器上附有數字顯示設置溫度，但一個質量好的座枱式數字溫度計（參考圖2）可更加準確提示當前的室溫情況。



Fig 2. - A Digital Desktop Thermometer Provides More Accurate Visual Information About the Condition of Room.

圖2. - 座枱式數字溫度計提供更加準確的當前室溫情況

Setting the unit to the coldest temperature set point when the unit is first being switched on will not cool the room faster. An air conditioner set at the lowest temperature will take the same time to cool the room to the occupant desired temperature (e.g. 25.5 °C) and will over cool the room if occupants forget to reset the temperature. This will result in unnecessary wastage.

Fan Speed Setting:-

Increasing fan speed should be considered before lowering the air conditioner's set point temperature. Increasing fan speed can maximize the heat transfer of the evaporator of the air conditioner and at the same time directing more cooling air jet to the activity zone of the room.

在剛開動冷氣機時把室溫設定點調至最低，並不能更快速地冷卻房間。冷氣機需要相同的時間才能把房間冷卻到使用者期望的溫度（如攝氏25.5度）。如果使用者忘記重新設置溫度，房間便會過冷，導致不必要的浪費。

風速設定：-

在降低空調的室溫設定點前應先考慮調高風速。增加風速可增加冷氣機蒸發器的熱交換率，同時亦可把較大的冷氣流輸送到房間的活動區域。

However, low fan speed should be selected for days when the relative humidity is high. This can allow the evaporator to cool the air to a lower temperature and better dehumidify the air before delivery to the room.

Supplementing the Air Conditioner With Fan:-

Electric fan may sometimes be used to supplement air conditioner. They can be used to help directing the cold jet from the air conditioner towards the activity area and at the same time create better air movement to improve the sensation of thermal comfort. However, it should be noted that the fan speed should be suitably controlled to minimize the discomfort due to air draft.

然而，當相對濕度高時，應該選擇低風速。這可讓蒸發器把空氣冷卻到較低溫度和在送出之前更有效地除去空氣中的濕氣。

用風扇輔助空調：-

電風扇有時可輔助空調。它們可以用於幫助導送從冷氣機噴出的冷氣流往活動區域，同時增加空氣流動，改善熱舒適的感覺。

然而，值得注意的是，應該適當地控制風速，以免氣流過大而引致不適。

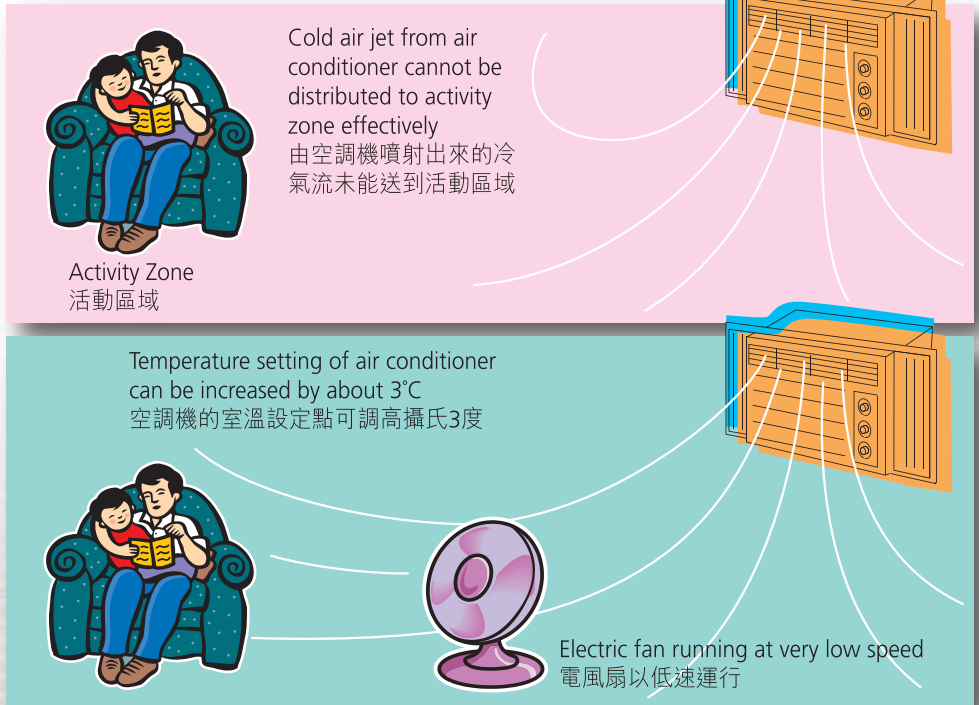


Fig 3. - Electric fan can sometimes be used to supplement air conditioner.

圖3. - 電風扇有時可用來輔助空調

Energy saving for air conditioner supplemented by fan has to be achieved through raising the air conditioner set point temperature. This is based on the fact that the energy consumption of an electric fan is much less than an air conditioner which provides an extra 1°C of cooling. Studies indicated that for residential environment, an air conditioner supplemented by a correctly operated fan has the potential of raising average indoor temperature setting by about 3°C and save substantial energy.

Maintenance of Residential Air Conditioners

The efficiency of an air conditioner will inevitably deteriorate throughout its service life. Regular cleansing and maintenance can help to slow down the deterioration or reduce the possibility of premature component failure.

Rough Checking of the Air Conditioner Performance:-

A rough check on the air conditioner performance can ensure that minimal energy is consumed to provide the cooling required by the occupant. A portable air temperature thermometer can be used to measure the air temperature at the cold air outlet of the air conditioner. When the room temperature is steady, the temperature difference between the cold air outlet and the room temperature when the air conditioner compressor is running should be around 8-10°C. If the temperature difference is small, the air conditioner is not operating effectively. A detail checking by experienced maintenance personnel may be required to rectify the problem.

以電風扇輔助空調，可通過調高空調室溫設定點達到節能效果。這是因為一台電風扇的能源消耗遠比由冷氣機提供額外攝氏1度的冷卻為低。研究顯示在住宅環境，正確地以電風扇輔助空調操作，平均可把室內溫度調高約攝氏3度以節省能源。

住宅冷氣機的保養

冷氣機的效能，會不可避免地隨機齡而退化。定期的清洗和保養能幫助減慢退化的速度和減少機件過早損壞的可能性。

粗略測試冷氣機表現：-

粗略測試冷氣機可確保以最少的能源為使用者提供所需要的製冷量。一個手提式的溫度計可以用來測量冷氣機的出風口溫度。當室溫穩定而空調壓縮機運行時，冷氣出風口和室溫之間的溫度差別，應該大約是攝氏8-10度。如果溫度差別過小，表示冷氣機未能有效地運作。也許需要由有經驗的保養人員詳細檢查及矯正問題。

Cleansing of Air Filter:-

Clogged air filter will reduce the air flow through the evaporator and increase the energy consumption. The air filters should be cleaned regularly to ensure that they are cleared from any blockage due to dust accumulation. The frequency of cleaning depends on the quality of air being cooled by the air conditioner. Cleaning of air filter can be done by the users themselves. The following points however should be noted:

- Follow the procedures to take down the air filters in accordance with the operation manual.
- Care should be taken to avoid damaging the evaporator fins behind the air filter.
- Replace broken air filter.
- When refitting the air filters, ensure that the filters cover the whole area of the evaporator coil and there is no gap allowing air to circumvent the air filters and enter the evaporator directly.
- Remove the dust accumulated between the evaporator fins.

Cleansing of Other Components of the Air Conditioner:-

Even though an air conditioner is equipped with air filters, some fine dusts and particles in the air can still enter the evaporator and the fan blades of the air blower. For the condenser, since there is no air filter installed, the fins are much easier to get dirty. Blocked fins either on the condenser coil or the evaporator coil will increase the energy consumption. At the same time, cooling capacity of the air conditioner will be reduced. A thorough cleaning of the air conditioner is recommended to be done by experienced maintenance personnel.

清洗隔塵網：-

阻塞的隔塵網會減少空氣流經蒸發器，增加能源消耗。應該定期清洗隔塵網確保它們不被積累的塵埃阻塞。清洗的頻率取決於空調房間的空氣質素。清洗隔塵網可以由用戶自行完成。然而應該留意以下幾點：

- 跟據使用說明書的程序去除下隔塵網。
- 應小心以免損壞在隔塵網後的蒸發器葉片。
- 更換殘破的隔塵網。
- 當放回隔塵網時，確保隔塵網完全覆蓋蒸發器的表面，沒有空隙允許空氣繞過隔塵網直接進入蒸發器。
- 清除積累在蒸發器葉片間的塵埃。

清洗冷氣機的其他組件：-

即使冷氣機裝備了隔塵網，空氣中一些微細的灰塵和微粒，仍然可進入蒸發器和鼓風機的風扇葉片。至於冷凝器，因為沒有安裝隔塵網，葉片很容易變得骯髒。阻塞的冷凝器或蒸發器葉片會增加能源消耗。同時，亦會減低冷氣機的製冷量。徹底清洗冷氣機的工作應由有經驗的保養人員進行。

Checking the Condition of Evaporator and Condenser Fins:-

The whole evaporator/condenser is assembled with an array of light grade aluminium thin sheets. Aluminium sheets should be separated from each other in order to allow free air passage between the fins. The fins are easily crushed or bent blocking the air flow if they are subject to inappropriate mechanical forces. Users should notify experienced maintenance personnel to follow up when they identify such problem.

檢查蒸發器和冷凝器葉片的狀況：-

蒸發器或冷凝器都以鋁薄片裝配而成。鋁薄片應彼此分開，讓空氣流過。如果它們受到撞擊，便很容易破裂或彎曲阻擋著氣流通過。用戶如果發覺這情況嚴重，應該通知有經驗的保養人員作出跟進。

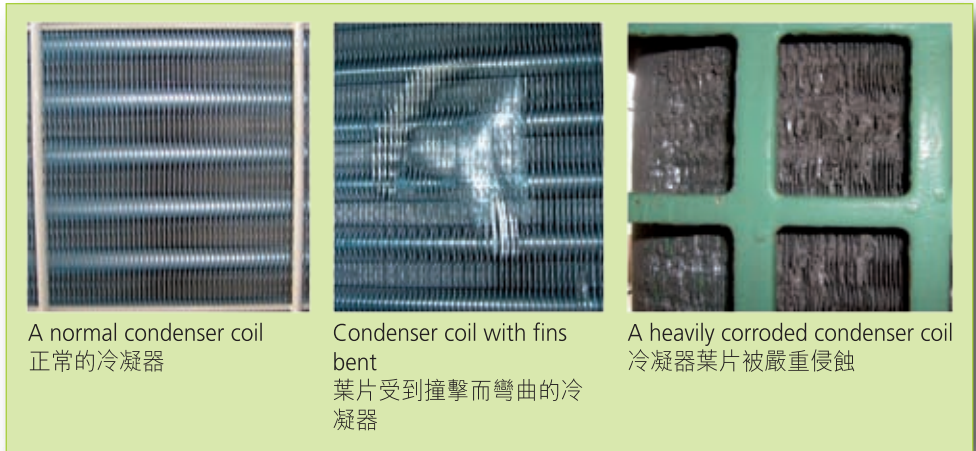


Fig 4. - Condenser coil with bent fins and corrosion lower the efficiency of an air conditioner
圖4. - 冷凝器葉片彎曲或侵蝕會降低冷氣機效率

Leakage of Refrigerant:-

Leakage of refrigerant is not uncommon for air conditioners that have been used for years. Air conditioner with insufficient refrigerant cannot deliver the designed cooling capacity and will be operated at a poor efficiency. Topping up the refrigerant can restore the capacity of the air conditioner, however, more importantly is to identify and fix the causes of leakage. Users can contact experienced maintenance personnel if they find constantly poor performance of an air conditioner.

Efficient Room Air Conditioning

Using energy efficiently in room air conditioning requires not only an efficient air conditioner, but also good operating habits and maintenance consideration. The above are only some key points to note. For more information, please contact the Energy Efficiency Office of The Electrical and Mechanical Services Department.

雪種洩漏：-

使用了多年的冷氣機出現雪種洩漏並不罕見。雪種不足的冷氣機不能提供設計應有的製冷量，並且以較差的效能運行。補加雪種可恢復冷氣機的製冷量，然而，更加重要的是找出和修理洩漏的原因。如果用戶發現冷氣機經常表現不良，應聯絡有經驗的保養人員。

高效率的空調

要在具能源效益的情況下使用空調，不僅要有高效率的空調設備，更要有良好的操作習慣和保養。以上僅是一些要注意的要點。如需更多資料，請聯絡機電工程署能源效益事務處。



機電工程署  **EMSD**

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