

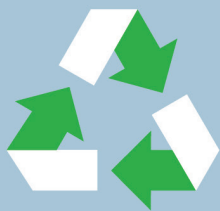
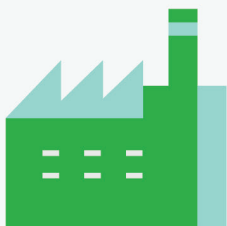
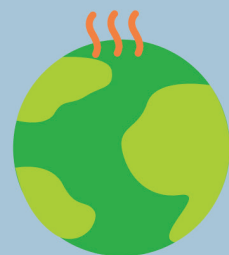
「減碳恒動 – 太陽能關懷計劃」

HANG SENG LOW CARBON FUTURE :
SOLARCARE PROGRAMME



太陽能光伏系統指南

A GUIDE TO THE SOLAR PV SYSTEM



減碳  恒動

主辦機構 Organiser



全力支持 Supported by



恒生銀行
HANG SENG BANK



我們生活的世界充滿許多矛盾。香港天文台報導 7 月份連續 15 天出現極端高溫，戶外工作者有中暑的風險同時，我們卻會於酒店、餐廳、購物中心和辦公室內感到無比寒冷。這實在難以置信吧？酷熱天氣和室內冷氣的溫差是一個緊連的因果關係，我們為了舒適而過度使用化石發電，其產生的碳排放正正導致現今的全球暖化，並再次困擾着我們。我們能作出改變嗎？絕對可以，而答案在於發展可再生能源。但我們願意改變嗎？

恒生銀行為支持低碳想創坊的理念，樹立了延續這使命的榜樣，與我們共同推出了「減碳恒動 - 太陽能關懷計劃」。我們亦很高興突破青年村能一起向青年傳播這信息，並相信年輕人將成為可持續發展世界的領導者。「減碳恒動 - 太陽能關懷計劃」會於三大方面帶來正面的影響，包括發展太陽能發電以減少碳排放、實施教育培養認識相關概念，及通過「上網電價」補貼政策於每年收入作出回贈，以支持計劃得以順利實踐。

我藉此機會感謝恒生銀行的遠見和財務上的慷慨支持，以及突破青年村為培養年輕氣候領袖作出的承諾。

We are living in a world with many contrasts. The Hong Kong Observatory reported that in July there were 15 consecutive extreme hot days. Outdoor workers are at risk of heatstrokes. At the same time, in our hotels, restaurants, shopping centres and offices, you experience freezing cold. Do you believe it? The contrasts of extreme heat days and the freezing indoor air-conditioning are connected by a causal chain. The excessive use of fossil to generate electricity for our comfort produces carbon emissions which lead to global warming and come back to haunt us. Can we change? Yes, we can. The answer lies in renewable energy. Are we willing to change?

Hang Seng Bank, in support of the CarbonCare InnoLab's mission, set an example that the will is growing. Together we have launched the Hang Seng SolarCare Programme. We are pleased that Breakthrough Youth Village joined us to spread the message to the youths. They will be the leaders of a sustainable world. The Hang Seng SolarCare Programme will generate three areas of impact, solar energy to reduce carbon emission, educational programmes to cultivate attitude change, and annual income through the Feed-In-Tariff Scheme to support the programmes.

I take this opportunity to thank Hang Seng Bank for its foresight and financial support and the Breakthrough Youth Village for its commitment to nurturing the youths to be climate leaders.

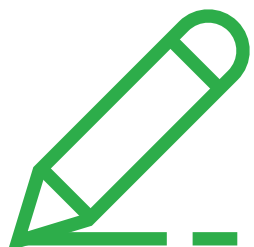
低碳想創坊
CarbonCare InnoLab

聯合創辦人及行政總裁
Co-founder and CEO

莊陳有
CHONG Chan Yau

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第一章 Chapter 1

氣候變化 Climate Change





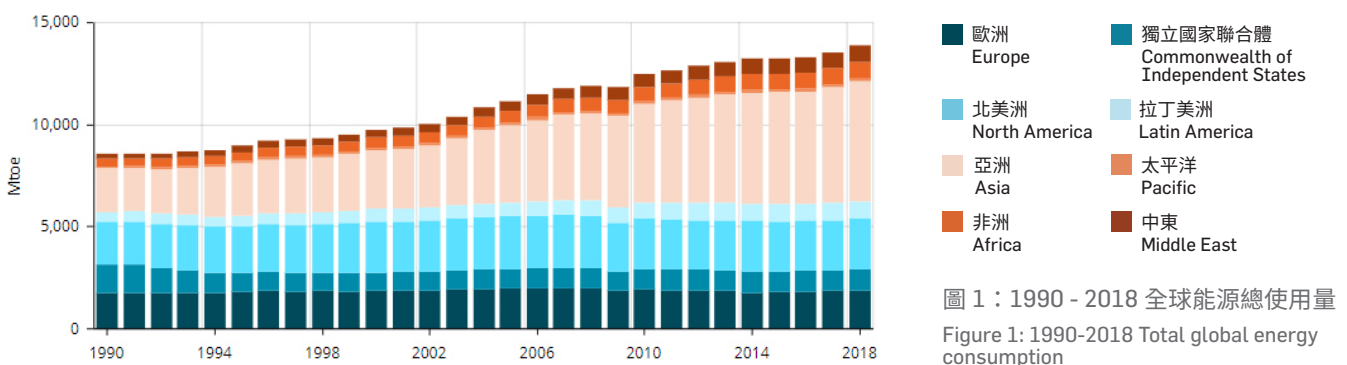
能源使用與氣候變化 Industrial Revolution and Climate Change

踏入 21 世紀，「氣候變化」成為我們談及人類未來時不可或缺的四字詞語。根據 1992 年 5 月於巴西里約熱內盧全球 154 個國家簽署的聯合國氣候變化框架公約 (UNFCCC)，各國承認人類自工業革命以來，加速發展的經濟活動增加全球溫室氣體排放，增強了自然的溫室效應，造成全球氣候變化。

縱使各國於簽署聯合國氣候變化框架公約 (UNFCCC) 承諾從能源、運輸、工業、農業等各方面著手減少溫室氣體排放，但隨著 90 年代科技飛躍發展，電子科技的普及令電子產品滲入每一戶家庭的日常生活，造成人類對能源的需求大增。從 1990 年至 2018 年，短短 28 年間，全球的能源總使用量上升了 65% (圖 1)。

Once we step into the 21st century, speaking of the future of mankind, "climate change" has become an indispensable buzzword to be mentioned. According to the United Nations Framework Convention on Climate Change (UNFCCC) signed by 154 countries around the world in Rio de Janeiro, Brazil in May 1992, all parties recognised that the accelerated development of economic activities had led to increased global greenhouse gas emissions since the Industrial Revolution. The greenhouse effect, as a natural phenomenon, had been worsened while causing global climate change.

Although every party that signed the UNFCCC has committed to reducing greenhouse gas emissions in various aspects including energy, transportation, industry and agriculture, with the rapid development of science and technology in the 1990s, electronics technology has been popularised and allowed relevant products to permeate people's lives in every household, leading to a huge increase in human demand for energy. Between 1990 and 2018, in only 28 years, the total energy consumption of mankind increased by 65% (Note: Figure 1).



人類主要透過以下途徑產生能源：燃燒化石燃料（例如煤炭、燃油及天然氣）、使用核能和使用可再生能源（例如太陽能、風能、水能）。化石燃料由於廉價和方便取得，成為最普及的生產能源方式。但是，燃燒化石燃料的過程會釋放二氧化碳，而過量二氧化碳積聚於大氣中會鎖住太陽熱力，引起「溫室效應」，造成「全球暖化」。

你現在可以透過圖像去瞭解全球暖化趨勢。「暖化條」(Warming Stripes) 由氣候學家 Ed Hawkins 發明，將全球每年平均溫度以顏色代表其高低變化 (圖 2)。從圖 2 中，你可輕易看出紅色線條集中在右邊，且愈來愈深色，代表近代的每年平均溫度愈見升高。

Humans mainly generate energy in the following ways: burning fossil fuels (such as coal, oil and natural gas), using nuclear energy and renewable energy (such as solar, wind, and hydropower). Fossil fuels have become the most employed source of electricity because they are affordable and easily available. However, the process of burning fossil fuels releases carbon dioxide, and the accumulation of excessive carbon dioxide in the atmosphere would trap the solar heat, causing the "greenhouse effect" which in turn leads to "global warming".

You can now learn more about global warming trends through images. "Warming stripes", first devised by climate scientist Ed Hawkins, use colours to represent changes in the average global annual temperature for nearly 170 years (Note: Figure 2). From Figure 2, you can easily see that the red lines are concentrated on the right side and become darker across the spectrum, representing the rising average annual temperature in modern times.



圖 2 (Figure 2)：暖化條 (Warming Stripes) 1850 - 2020

Enerdata. 2018. Total energy consumption. [ONLINE] Available at: <https://yearbook.enerdata.net/total-energy/world-consumption-statistics.html> [Accessed 17 April 2020].

Climate Lab Book. 2018. Warming stripes. [ONLINE] Available at: <https://www.climate-lab-book.ac.uk/2018/warming-stripes/> [Accessed 19 April 2020].



《巴黎氣候協議》的誕生 The Evolution of The Paris Agreement

美國知名氣候專家詹姆斯·漢森 (James Hansen)，於 1988 年以美國太空總署 (NASA) 哥達太空研究所所長身分出席國會聽證會，宣告全球暖化現象正在發生，而且暖化源於大氣層中積累的二氧化碳與其他溫室氣體，人類活動是主要原因。他的「氣候變化是人為的」理論逐漸成為國際間的共識。在 1992 年，世界各國領袖在紐約聯合國總部正式通過聯合國氣候變化框架公約 (UNFCCC)，並簽署成為國際公約，定於 1994 年 3 月 21 日起生效。

聯合國氣候變化框架公約的最終目標是控制溫室氣體濃度，令大自然的氣候系統不受過度的人為因素干擾，並足以讓生態系統自然適應氣候變化、確保糧食生產不受威脅，以及在經濟發展能夠可持續進行下的時間範圍內實踐，令經濟可持續發展。另外，在減少碳排放上，工業化國家應承擔最大責任，並向發展中國家提供氣候行動的財政支援。

《巴黎氣候協議》的目標是將全球平均氣溫升幅控制在工業革命前水平以上的 2°C 之內，並致力不超過 1.5°C，期望透過世界各國的努力，令氣候變化帶來的影響不會演變成不能逆轉的局面。

James Hansen, a renowned American climate expert, with his title as the director of NASA's Goddard Institute for Space Studies by then, attended a congressional hearing in 1988. On the occasion, he declared that global warming, caused by the accumulation of carbon dioxide and other greenhouse gases in the atmosphere due primarily to human factors, was happening. His theory stating that "climate change is man-made" has gradually become an international consensus. In 1992, the United Nations Framework Convention on Climate Change (UNFCCC) was passed at New York's United Nations Headquarters. As an international convention, it was signed by world leaders and went into effect on 21 March 1994.

The ultimate goal of UNFCCC was to control the concentration of greenhouse gases, so that the climate system would not be affected by excessive human factors, while allowing the ecosystem to naturally adapt to climate change. This was to ensure that food production would not be threatened, and that economic development is carried out sustainably with actions taken within a reasonable timeframe. In addition, in terms of reducing carbon emissions, industrialised countries should assume the greatest responsibility and provide developing countries with financial support for climate action.

The goals of the Paris Agreement were to hold the global temperature increase well below 2°C and preferably to 1.5°C. It is hoped that through the joint efforts of countries around the world, the impacts of climate change would be mitigated instead of becoming irreversible.



NOAA Climate.gov. 2016. El Niño and La Niña: Frequently asked questions. [ONLINE] Available at: <https://www.climate.gov/news-features/understanding-climate/el-ni%C3%B1o-and-la-ni%C3%B1a-frequently-asked-questions> [Accessed 10 May 2020].

NASA. 2014. What is Climate Change. [ONLINE] Available at: <https://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-is-climate-change-k4.html> [Accessed 17 April 2020].



氣候變化造成的影響 Effects of Climate Change

氣候變化所造成的影響，分別由直接影響和衍生影響所組成。
The effects of Climate Change could be comprised of Primary and Secondary Effects.

直接影響 (Primary Effects)

全球氣溫急速上升 Rapid Rise of Global Temperature

在氣候變化加劇之下，我們最容易感受到的影響便是全球氣溫上升。根據美國國家海洋暨大氣總署資料，2020 年的 3 月是近 141 年以來第二高溫的 3 月份，而全球多個地方亦錄得有紀錄以來最高溫度。(圖 3)

With the intensification of climate change, the most easily felt impact would be the global temperature rise. According to the National Oceanic and Atmospheric Administration (NOAA) in the US, March 2020 was the second hottest month in the past 141 years. Many places around the world also recorded a record-keeping highest temperature as well. (Figure 3)

冰雪加速融化 Accelerated Melting of Ice and Snow

全球升溫令冰川融化的速度加劇。根據美國國家冰雪數據中心 (National Snow and Ice Data Center NSIDC) 顯示，2020 年 3 月的北極冰帽創下 42 年來北極冰帽面積最小的紀錄。透過觀察極地衛星影像，足可證明極地冰帽多年來正不斷縮小。(圖 4)

Global warming has been accelerating glacier melting. According to the National Snow and Ice Data Center (NSIDC) in the US, the Arctic ice cap in March 2020 set a new record for the smallest Arctic ice cap in 42 years. Polar satellite images prove that the polar ice layer has been shrinking over the years. (Figure 4)

海平面持續上升，淹沒土地 Sea Level Continues to Rise and Land Flooded

冰河及冰層融化後的水會直接流入大海，令全球海平面持續上升，威脅眾多沿海國家及城市，包括香港、倫敦、紐約、上海、曼谷、威尼斯等國際主要城市(圖 5)。一些被海洋包圍的島國也深受其害，著名的例子包括圖瓦魯，當地政府估計，大部分的首都範圍將於 2030 年沉入海底。

Meltwater from glaciers and ice layers would directly merge into the sea, causing global sea levels to rise continuously. This could pose a threat to many coastal countries and cities, including major international cities such as Hong Kong, London, New York, Shanghai, Bangkok, and Venice (Note: Figure 5). Some island countries surrounded by the sea are also suffering from the negative impact. A better-known example is Tuvalu. The local government estimates that most parts of the capital city will sink beneath the ocean by 2030.

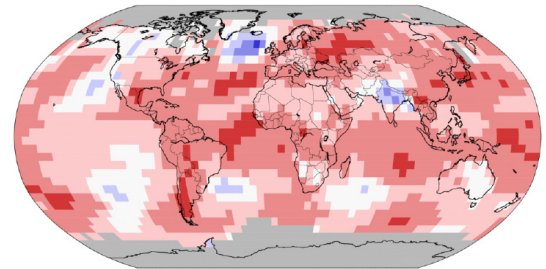


圖 3：2020 年 3 月全球陸海溫度紀錄
Figure 3: Land and ocean temperature records March 2020

有記錄以來最低溫	Lowest recorded temperature
遠低於平均溫度	Well below average temperature
低於平均溫度	Close to average temperature
接近平均溫度	Below average temperature
高於平均溫度	Above average temperature
遠高於平均溫度	Well above average temperature
有記錄以來最高溫	Highest recorded temperature

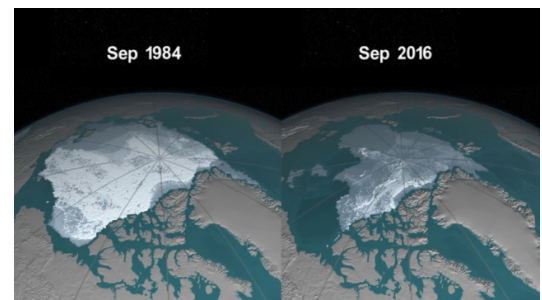


圖 4：1984 年與 2016 年的北極冰帽的變化
Figure 4: Arctic sea ice change: 1984 vs 2016

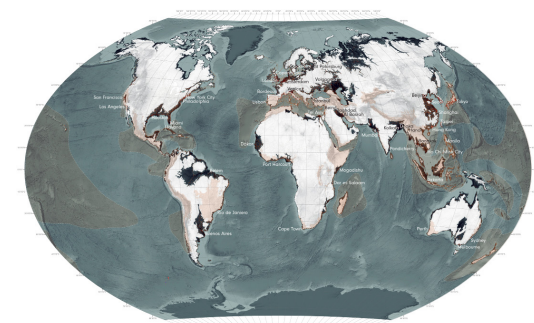


圖 5：全球土地陸沉推算地圖
(全球海平面上升 80.32 米)
Figure 5: Global land subsidence projection map
(global sea level rise 80.32 metres)

09

National Centers for Environmental Information. 2020. Assessing the Global Climate in March 2020. [ONLINE] Available at: <https://www.noaa.gov/news/global-climate-202003> [Accessed 19 April 2020].

FOX2NOW. 2018. NASA releases time-lapse of the disappearing Arctic polar ice cap. [ONLINE] Available at: <https://fox2now.com/news/nasa-releases-time-lapse-of-the-disappearing-arctic-polar-ice-cap/> [Accessed 19 April 2020].

衍生影響 (Secondary Effects)

更多極端天氣

More Extreme Weather

氣候變化為全球帶來更多極端天氣。日本於 2018 年 7 月創下最高雨量紀錄，比以往紀錄高出 7%；澳洲於 2019 至 2020 年經歷了造成人命傷亡及數十億動物死亡的山林大火；美國的得克薩斯州和俄克拉荷馬州於 2011 年經歷了長達數月接近攝氏 38°C 的高溫。此外，全球各地將出現更多不同的極端天氣，會帶來嚴重的災害，例如乾旱會引發山林大火、暴雨會引發水浸、颶風會摧毀建築物，導致人命傷亡。

Climate change brings more extreme weather events on a global scale. Japan set a record for the highest rainfall in July 2018, being 7% higher than previous records; between 2019 and 2020, Australia experienced wildfires that caused deaths and injuries, as well as killed billions of animals; in Texas and Oklahoma of US, there are also reports of high temperatures close to 38°C for consecutive months in 2011. In addition, extreme weather events will become more frequent and numerous around the world, which in turn may lead to serious hazards. For example, droughts would leave the landscape vulnerable to forest fires, torrential rain can cause flooding, whereas hurricanes destroy buildings while causing casualties.

海洋生態災難

Marine Ecological Disasters

健康的珊瑚色彩絢麗，乃由珊瑚表面的共生藻和珊瑚蟲的色素形成。當海水被污染或變暖，珊瑚表面的共生藻便會離開、甚至死亡，最終珊瑚表面只剩下呈現白色的瀕死珊瑚蟲，這便是我們經常聽到的「珊瑚白化」現象。一個健康的珊瑚礁系統，可為高達 1,500 種魚類提供棲息地。珊瑚的死亡會令眾多海洋生物失去棲息地，造成海洋生態災難。在 2016 年和 2017 年，澳洲大堡礁因海水升溫而導致大約一半珊瑚嚴重受損和白化。減緩氣候變化才能拯救對海水溫度極其敏感的珊瑚礁。

Diverse colours of healthy corals are formed by the symbiotic algae on the coral surface and the pigments of coral polyps. When the seawater is polluted or warmed, the symbiotic algae on the coral surface would leave or even die. Eventually, only white, dying polyps would remain on the coral surface, leading to the phenomenon of "coral bleaching" we often come across. A healthy coral reef system can provide up to 1,500 species of fish with habitats. The death of corals may cause the loss of ocean habitats and even marine ecological disasters. In 2016 and 2017, about half of the corals in Australia's Great Barrier Reef underwent severe damage and bleaching due to ocean warming. Only by mitigating climate change can we save corals, for they are extremely sensitive to sea temperature.

糧食危機

Food Crisis

氣候變化與極端天氣正在影響全球糧食產量。高溫嚴重影響熱帶和亞熱帶地區的農作物，例如泰國和印尼的稻田因乾旱而產量下降，洪水亦令美國的粟米及大豆的潛在產量減少，有機會造成糧食危機。

Climate change and extreme weather have negative impacts on global food production. The high temperature has severely affected crops in both tropical and subtropical regions. For example, the yield of rice fields in Thailand and Indonesia decreased due to extensive drought. Floods have also led to a reduction of potential corn and soybean yields in the US where a food crisis is a possible threat.

淡水危機

Freshwater Crisis

冰川蘊藏全球 3/4 的淡水，全球冰川融化會令大量淡水融入海水（鹹水）中，令人類可直接飲用的淡水量大大減少。淡水的成本及價格將大幅上升，一些缺乏海水化淡技術的國家及地區將會面臨食水短缺危機。

Glaciers contain 3/4 of the world's freshwater reserves. Melting of global glaciers would allow a massive amount of freshwater to mix with seawater (salt water), and the amount of freshwater that is suitable for direct consumption by humans would be significantly reduced. The cost and price of fresh water would in turn rise sharply. Countries and regions lacking desalination technology may experience shortages of fresh water.

人類健康危機

Human Health Crisis

高溫會引發多種疫症，包括登革熱、霍亂、瘧疾及寨卡病毒等。這些疫症會比以前更常出現，危害人類的性命安全。炎熱亦會令某些可致命疾病的發病率上升，包括高血壓、心臟病等。

High temperatures may lead to numerous contagious diseases, including dengue fever, cholera, malaria, and Zika virus infection. Outbreaks of such contagious diseases, in the form of either epidemic or pandemic, are more likely than before, which could endanger human safety. Heat also increases the incidence rates of certain diseases, including hypertension, heart disease and other fatal diseases.

生物多樣性受威脅

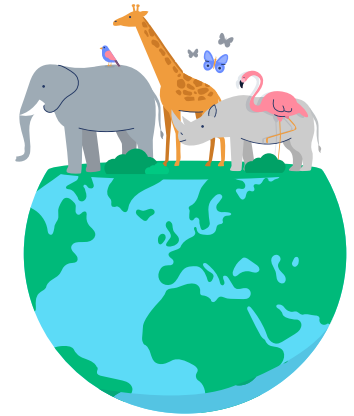
Biodiversity Under Threat

一個健康的生態系統需要大量不同種類的動物、植物與微生物來維繫，這些生物更是高度互相依存的。生態系統的生物多樣性愈豐富，各個物種的穩定性便愈高；相反，當任何物種的數量急劇下降時，生態系統便愈見單一及脆弱。以狐狸獵兔為例，狐狸與兔子的數目長期處於平衡狀態，但若果狐狸的數目急劇下降，兔子族群便會因為威脅減少而數量驟升，有機會危害其它物種的棲息地，甚至是人類的農作物。

氣候變化會威脅生物多樣性，影響動物的生活節奏（包括繁殖、遷徙、冬眠），也會擾亂開花植物的花期。氣溫上升危及眾多野生動物的生存環境，當中包括極地野生動物。北極熊依賴極地冰層獵食和作息，南極的個別阿德利企鵝族群數目亦因冰層融化下降達 90%，而一些只適應低溫環境的動物，亦需要遷移至溫度較低的高海拔地區求存。高溫亦會直接殺死某些動物，例如澳洲昆士蘭雨林中的綠色環尾負鼠，便無法於環境溫度達到攝氏 30°C 時控制自己的體溫。

A healthy ecosystem is made up of numerous animals, plants, and microorganisms of different species which are interdependent on each other. The richer the biodiversity of an ecosystem, the more stable the species. On the contrary, when the population of particular species decline sharply, the ecosystem would become more homogeneous and fragile simultaneously. Let's take foxes hunting rabbits as an example. The number of foxes and rabbits has been in equilibrium for a long time. Anyhow, if the number of foxes drops sharply, the number of rabbits would rise sharply due to reduced threat, which may lead to damage to other species' habitats or crops planted by humans.

Climate change threatens biodiversity, and affects the life rhythm of animals (including reproduction, migration and hibernation) while disrupting the flowering period of plants. Rising temperatures also endanger the living environments of many wild animals, including those in the polar regions. Polar bears rely on the polar ice layer for food and daily routines. The number of individual Adélie penguins in Antarctica has been reduced by 90% due to the melting of the ice layer. Some animals that only adapt to low-temperature environments would need to migrate to higher altitude areas with lower temperatures. High temperature also kills some animals directly. For example, the green ringtail possums from Queensland's rainforest in Australia cannot control their body temperature once the ambient temperature reaches 30°C.



香港的氣候變化趨勢及推算

Trends in Climate Change and Projections in Hong Kong

氣候變化離香港人並不遙遠。自 19 世紀以來，香港的氣候一直呈暖化之勢。根據香港天文台資料，本港全年平均氣溫由 1885 年的 21.5°C 上升至 2015 年超過 24°C；熱夜和酷熱天氣（日間最高氣溫達 33°C 或以上）的日數亦顯著增加。

根據《巴黎氣候協議》，全球各國承諾控制全球氣溫升幅不超過 2°C 並致力不超過 1.5°C。若本港於 21 世紀仍維持高濃度溫室氣體排放，氣候變化將會更趨嚴重，更難達到《巴黎氣候協議》的目標。

Climate change is not far away from Hong Kong citizens. Ever since the 19th century, the climate of Hong Kong has become warmer. Data from the Hong Kong Observatory showed that the annual average temperature in Hong Kong rose from 21.5°C in 1885 to over 24°C in 2015; the number of days with hot nights and extremely hot weather (the highest daytime temperature reached 33°C or above) also has an obvious increase.

According to the Paris Agreement, countries around the world have committed to hold the global temperature increase well below 2°C and strive to limit it to 1.5°C. If high-concentration greenhouse gas emissions continue to take place in Hong Kong through the 21st century, climate change will be intensified and it would be even more difficult to achieve the goals of the Paris Agreement.

香港天文台 1. 2019. 香港氣候推算。| Hong Kong Observatory 1. 2019. Climate Projections for Hong Kong. [ONLINE] Available at: http://www.weather.gov.hk/tc/climate_change/proj_hk_temp.htm [Accessed 19 April 2020].

香港氣候推算 - 雨量 | 香港天文台 (HKO) | 氣候變化。2020。| Climate Projections for Hong Kong - Rainfall | Hong Kong Observatory (HKO) | Climate Change. 2020. [ONLINE] Available at: http://www.weather.gov.hk/tc/climate_change/proj_hk_rainfall.htm [Accessed 18 May 2020].

平均氣溫上升 Increase in Average Temperature

若本港的碳排放量持續增加，預計香港在本世紀中 (2051 至 2060 年) 的平均氣溫會比 1986 至 2005 年高出 1.5°C (圖 6)。

If carbon emissions in Hong Kong continue to increase, it is estimated that the average temperature in Hong Kong by mid-21st century (2051-2060) will be 1.5°C higher than that of 1986-2005 (Note: Figure 6).

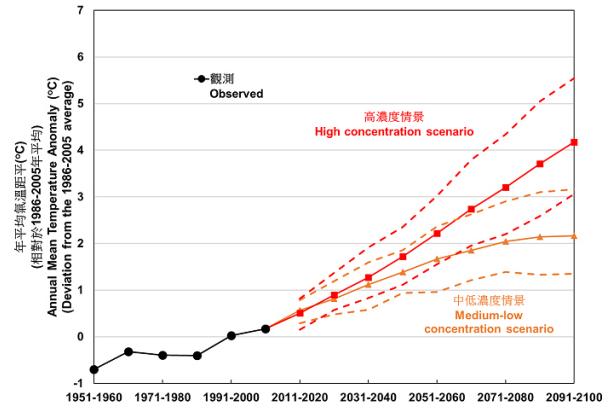


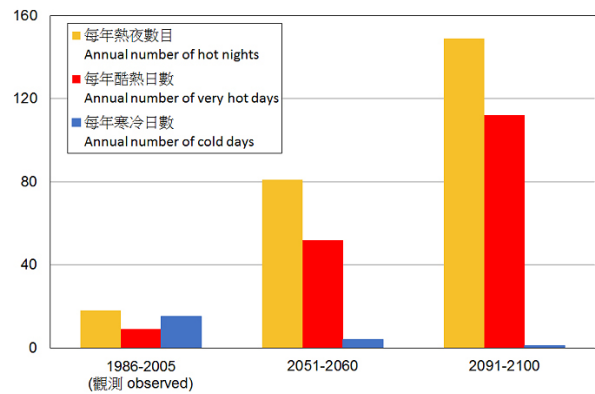
圖 6：香港年平均氣溫推算

Figure 6: Estimated annual mean temperature in Hong Kong

熱夜數目上升 Increase in the Number of Hot Nights

以 2015 年為例，該年熱夜總數為 37 天；本世紀中 (2051 至 2060 年) 的預測熱夜數目卻倍增至 80 日一年。同樣地，酷熱日數會大幅增加，而寒冷日數則會以倍數減少，香港市民將要忍受逐漸加劇的極端炎熱天氣 (圖 7)。

Taking 2015 as an example, the total number of hot nights that year was 37 days; the projected number of hot nights by mid-21st century (2051 to 2060) has, anyhow, doubled to 80 days annually. Similarly, it is very likely that a substantial increase in the number of very hot days, whereas the number of cold days is expected to decrease by a number of times. This way, Hong Kong citizens will have to endure more extremely hot days (Note: Figure 7).



圖表 7：香港年均熱夜、酷熱及寒冷日數推算

Figure 7: Estimated annual average number of hot nights, very hot and cold days in Hong Kong

極端降雨天氣 Extreme Rains

未來香港出現極端降雨的年份將會更加頻繁 (圖 8)。每年的平均降雨量亦將上升 (圖 9)。

In the future, Hong Kong will face extreme rainfall events more frequently (Note: Figure 8), whereas the average annual rainfall will also increase (Note: Figure 9).

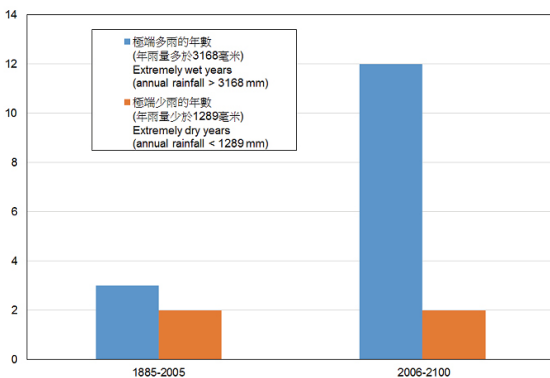


圖 8：香港的極端多雨年數推算

Figure 8: Estimated number of extremely rainy years in Hong Kong

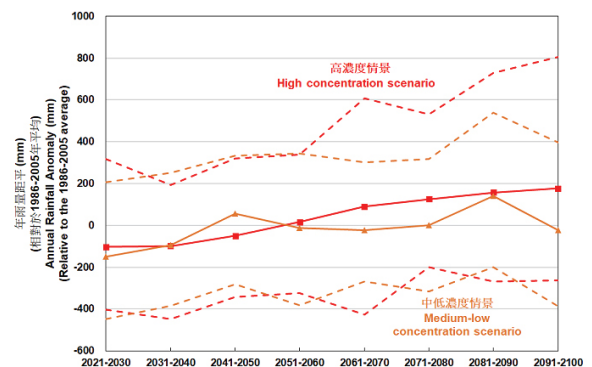


圖 9：香港全年平均雨量推算

Figure 9: Projected average annual rainfall in Hong Kong

香港天文台 1. 2019. 香港氣候推算。 | Hong Kong Observatory 1. 2019. Climate Projections for Hong Kong. [ONLINE] Available at: http://www.weather.gov.hk/tc/climate_change/proj_hk_temp.htm [Accessed 19 April 2020].

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香港及鄰近水域海平面上升 Sea Level Rise in Hong Kong and Adjacent Waters

預計到了本世紀末，香港及鄰近水域海平面的平均高度將上升接近一米，將危及本港多個沿海及低窪地區的安全（圖 10）。

另外，極端天氣將會影響我們的日常生活和安全，包括：

- 極端天氣會破壞斜坡、橋樑等基建，影響道路安全
- 極端天氣會令本地及入口農作物減少，造成糧食短缺
- 炎熱天氣會引發慢性疾病，例如心臟病、哮喘等
- 高溫增加城市對電力和水資源的需求，容易造成資源短缺
- 極端天氣有機會破壞電力系統，影響工、商業及金融業的運作

以上並未盡錄氣候變化帶來的潛在影響，卻足見氣候變化與香港人的日常生活有切身關係。我們必需身體力行，於日常生活當中減低溫室氣體排放，實行綠色生活，方可對抗氣候變化及其帶來的極端天氣和嚴重後果。

The average sea level of Hong Kong and adjacent waters is expected to rise by nearly 1 metre towards the end of this century, which is likely to threaten the safety of numerous coastal and low-lying areas in Hong Kong (Note: Figure 10).

In addition, extreme weather will affect our daily life and safety, including:

- Damage to slopes, bridges and other infrastructure, thus affecting the overall road safety.
- Extreme weather will reduce local and imported crop yields, leading to food shortages.
- Hot weather can cause chronic illnesses, such as heart disease, asthma, etc.
- High temperature drives up the demand for electricity and water resources in cities, which could easily lead to resource shortages.
- Extreme weather may damage the power system and affect the operations of industrial, commercial and financial sectors.

The above list of potential impacts of climate change is not exhaustive, yet it clearly shows that climate change is closely related to the daily lives of Hong Kong people. We must do our best to reduce greenhouse gas emissions in our daily lives, and live a green lifestyle to combat climate change, as well as the resulting extreme weather and serious consequences.

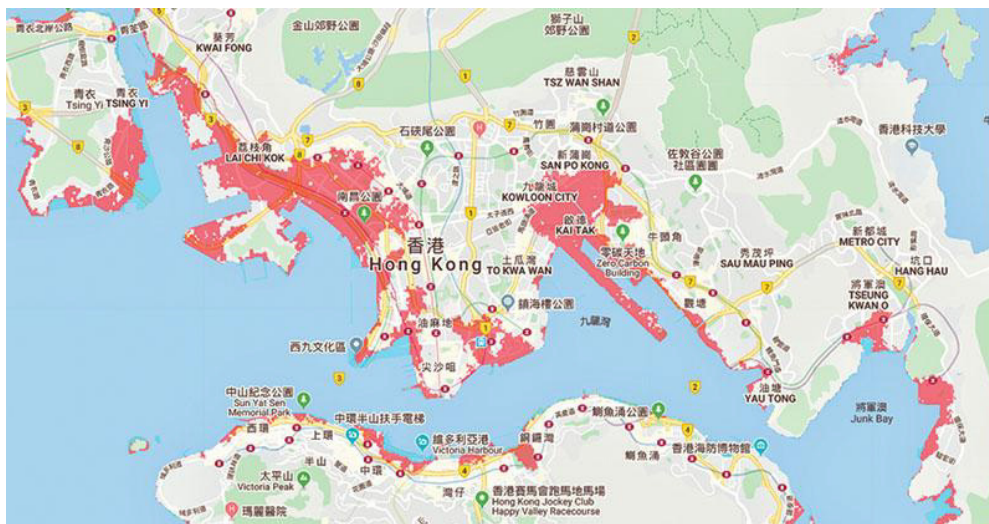


圖 10：2050 年香港海平面上升預計圖（紅色地區為研究報告預測本港會被海水淹沒的地區）
Figure 10: A map of Hong Kong's projected sea level rise by 2050
(the area marked in red indicates where in Hong Kong would be submerged by sea)

香港天文台 1. 2019. 香港氣候推算 . | Hong Kong Observatory 1. 2019. Climate Projections for Hong Kong. [ONLINE] Available at: http://www.weather.gov.hk/tc/climate_change/proj_hk_temp.htm [Accessed 19 April 2020].

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www.chinawaterrisk.org. 2020. HK Submerged? Is This Map For Real?. [ONLINE] Available at: <http://www.chinawaterrisk.org/resources/analysis-reviews/hk-submerged-is-this-map-for-real/> [Accessed 20 July 2020].

第二章 Chapter 2

太陽能發電

Solar Power Generation





各種可再生能源發電技術的比較

Comparing Various Renewable Energy Power Generation Technologies

可再生能源是天然形成於自然環境中的潔淨能源，以下為常見的可再生能源發電的例子：

Renewable energy is clean and naturally occurring. The following are a few common examples of renewable energy power generation:

太陽能

Solar Energy:

分別利用「光熱轉換」和「光伏效應」，將太陽光轉為熱能和電能。

Sunlight is converted to heat and electricity through "light-to-heat conversion" and "photovoltaic effect" respectively.

水能

Hydropower:

利用水由高處向低處流動的特性，衝擊機械渦輪帶動發電機旋轉，產生電力。

Electricity is generated with good use of the characteristic of water flow downhill, which hits the blades of the mechanical turbine that drive the generator in the form of rotation.

轉廢為能

Waste-to-energy:

利用各種技術把都市固體廢物（例如廚餘）中蘊藏的能量轉化為熱能或電能。這些技術包括堆填沼氣、厭氧分解和熱處理等。

Makes use of various technologies to convert the energy retained in municipal solid waste (such as food waste) into heat or electricity. These technologies include landfill gas, anaerobic decomposition and thermal treatment.

海洋能

Ocean Energy:

利用海洋中蘊藏的各种動能發電，這些能源包括潮汐能、海浪能等。

Making use of various types of kinetic energy in the ocean, including tidal energy and wave energy, for generating electricity.

風能

Wind Energy:

利用風力轉動扇葉，推動發電裝置產生電力。

Wind turbine blades are moved by the wind to power the electricity generation device.

地熱能

Geothermal Energy:

直接利用地球地殼深層的熱能，或將熱能轉換為電力。

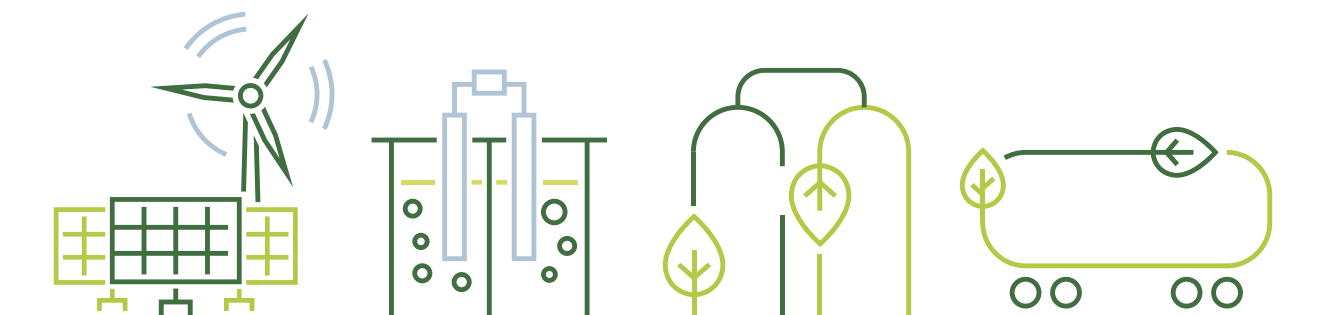
Refers to direct utilisation of the thermal energy in deep layers of the Earth's crust, or conversion of thermal energy to electricity.

生物質能

Biomass Energy:

利用植物或動物等有機體發電、發熱及製造燃料。

Making use of organisms, such as plants or animals, for generating electricity, heat, and producing fuel.



我們就香港較常見的可再生能源發電技術作比較，評估各自的利弊。

A comparison of the relatively common renewable energy power generation technologies in Hong Kong is conducted, with an evaluation of their advantages and disadvantages.

	優點 Advantages	缺點 / 限制 Disadvantages/Limitations
 <p>太陽能 Solar Energy</p>	<ul style="list-style-type: none"> 香港每年有超過一半日子能接收充足陽光，陽光資源豐富。 產能過程不會排放溫室氣體 太陽能發電不靠可燃燃料，不需要燃料運輸。 太陽能技術正在不斷進步，電池轉化電能的效率提升，發電成本逐漸下降。在過去的 40 年裏，太陽能光伏組件的成本已經下降了 99%。 Hong Kong, with abundant solar resources, receives sufficient sunlight for more than 50% of the days of the year. The production process does not emit greenhouse gases. Solar power generation does not rely on combustible fuels and does not require the transportation of combustion materials. Solar technology has been constantly improving, and the efficiency of energy transformation of solar cells has been increasing. The cost of power generation has been the other way round. Over the past 40 years, the cost of solar photovoltaic modules has dropped by 99%. 	<ul style="list-style-type: none"> 發電設施只能設置於陽光照射到的地方，例如屋頂或空曠地方，令選址受到限制。 由於夜間照射不到陽光，太陽能發電須依賴能量儲存技術儲電，令成本上升。 太陽能電池板的生產過程會產生溫室氣體三氟化氮 (Nitrogen Trifluoride) 和六氟化硫 (Sulfur Hexafluoride)。 Power generation facilities can only be installed in places exposed to sunlight, such as roofs or open areas, which in a way limits location choices. As there is no sunlight at night, solar power generation must rely on energy storage technologies for storing electricity, which often leads to increased costs. The production process of solar panels produces nitrogen trifluoride and sulfur hexafluoride, both of which are greenhouse gases.
 <p>風能 Wind Energy</p>	<ul style="list-style-type: none"> 風能屬於潔淨能源，產能過程不會排放污染物。 大型風力發電技術成熟，已佔全球發電量約 2.5%。 Wind power is a clean energy, as the production process does not emit pollutants. The technology of large-scale wind power generation is sophisticated. Wind power accounts for about 2.5% of the electricity produced globally. 	<ul style="list-style-type: none"> 風力發電受氣流的強弱影響，供應不穩定。 極端天氣如暴風雨有機會破壞風力發電機。 風力資源豐富的地域通常位於山上或海邊，遠離市中心，令電力輸送成本增加。 Wind power generation is affected by the strength of the airflow, making the supply unstable. Extreme weather such as storms may damage the wind turbines. Areas with abundant wind resources are usually located in hilly areas or by the sea. Being far away from the city centre increases the cost of power transmission.
 <p>水能 Hydropower</p>	<ul style="list-style-type: none"> 水的密度比空氣高出 800 倍，比風力的產能更大，是效能較高的產電方法。 水力發電廠可維持長時期運作，平均壽命長達 50 至 100 年。 Density of water is 800 times higher than that of air, with a greater generating capacity than wind, so it is considered a more efficient way to produce electricity. Hydropower plants can maintain long-term operation, with a life span of 50 to 100 years on average. 	<ul style="list-style-type: none"> 旱季時雨水較少，令河流的水流變弱，影響產能。 水力發電通常需要在河道上興建水壩，令流水中斷，會影響附近河流的自然生態，例如改變魚類的遷移路徑。 興建水壩有機會造成水壩下游乾旱。 Rain is scarce in dry seasons, which weakens the water flow of rivers and affects the generating capacity. Hydropower generation usually requires the construction of dams on rivers, which may interrupt the water flow and affect the natural ecology of nearby rivers, such as changing the migration routes of fish. Construction of dams can possibly lead to droughts in downstream areas.
 <p>轉廢為能 Waste-to-Energy</p>	<ul style="list-style-type: none"> 充分利用廢物中的能源。 減少堆填區的壓力。 減少傾倒在堆填區的都市固體廢物的重量及體積，降低其處理費用。 Make full use of energy in the waste. Reduce landfill waste. Reduce the weight and volume of municipal solid waste to be dumped in processing costs. 	<ul style="list-style-type: none"> 產能過程會排放溫室氣體，包括二氧化碳 (Carbon Dioxide) 及甲烷 (Methane)。 燃燒廢物時有機會釋出致癌物二噁英 (Carcinogen Dioxin)。 The production process emits greenhouse gases, including carbon dioxide and methane. Waste burning leads to a possible release of carcinogen dioxin.

太陽能適合在香港大規模使用的原因 Reasons Why Solar Energy is Suitable for Large-scale Use in Hong Kong

可再生能源應被更大規模納入香港長遠的能源政策，長遠大幅增加可再生能源的發電比例，降低本港的碳強度及總體碳排放，以減緩氣候變化。

在多種可再生能源技術當中，香港絕對有條件大規模發展及應用太陽能發電技術，原因如下：

- 香港有大約一半日子都有充足陽光
- 香港早於 80 年代便已開始使用太陽能，發展至今，技術已頗為成熟。
- 香港有建築整合太陽能技術，使建築物本身成為一個大的能量來源，而不必用外加方式加裝太陽能板，有助減低成本。
- 研究顯示，全港有大約 75% (23 萬棟) 建築物適合安裝太陽能光伏板。
- 潛在的太陽能產能量達 4,674 百萬千瓦時一年，佔香港總能源消耗達 11%，證明太陽能於香港有發展空間。
- 香港政府已接納並採用太陽能技術 (採用太陽能的政府場地包括南丫島發電廠天台、機電工程署總部、科學園、灣仔大樓及科學館等。)

Renewable energy should be included in Hong Kong's long-term energy policy on a larger scale. In the long run, the proportion of renewable energy power generation would significantly increase. This would help reduce the city's carbon intensity and overall carbon emissions, and in turn, mitigate climate change.

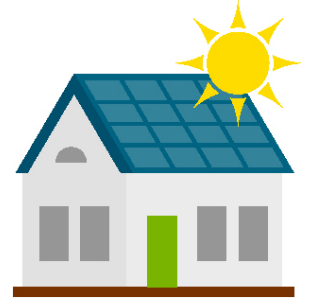
Amongst the various renewable energy technologies, solar power technology is the one with great potential to be developed for large-scale adoption in Hong Kong. The reasons are as follows:

- Hong Kong is a city with plenty of sunshine, with around 50% of the year
- Hong Kong started to use solar energy as early as the 1980s. So far, the technology has been rather mature.
- Hong Kong has building-integrated photovoltaics (BIPV) technology, which makes the buildings a huge source of energy without the need of installing solar panels via extra means, which in turn lowers the costs.
- Research shows that about 230,000 buildings (around 75%) in Hong Kong are suitable for installing solar photovoltaic panels.
- The potential solar energy generating capacity reaches 4,674Gwh/year, accounting for 11% of Hong Kong's total energy consumption, proving that solar energy has great potential in Hong Kong.
- The Hong Kong SAR government has accepted and adopted solar energy technology (government sites adopting solar energy include the rooftop of the Lamma Power Station, the ESMD Headquarters, the Hong Kong Science Park, Wanchai Tower and the Science Museum, and the like).



太陽能的發電原理 Mechanism Behind Solar Power Generation

太陽的輻射給予地球光和熱，太陽能光線由光子 (Photon) 組成。當光子接觸到你的皮膚時，它所包含的能量會被你的皮膚吸收而轉化成熱能，讓你感受到熱力。而當光子落到某些特定的物質時，則會產生電子，透過合適的儀器，能轉換成我們使用的電流。而能將光子轉換成電能的其中一種物質是硅 (Silicon)，是製作太陽能系統的光伏電池的主要材料。常見的太陽能轉換系統包括太陽能光伏系統 (以光伏電池將陽光直接轉化為電力) 和太陽能熱力收集系統 (如太陽能熱水器)。



以下將集中介紹太陽能光伏系統。

Solar radiation, made up of photons, provides light and heat for the Earth. When photons contact your skin, the energy the former contains will be absorbed by the latter and converted into heat energy, which causes the feeling of warmth. When a photon falls on specific materials, electrons would be generated. They can be converted into electricity we use in daily life with relevant equipment. Silicon is one of the substances that can convert photons into electrical energy. It is the main material used in the production of photovoltaic cells in solar systems. Common solar energy conversion systems include solar photovoltaic systems (using photovoltaic cells to directly convert sunlight to electricity) and solar thermal collection systems (such as solar-powered water heaters).

The following sections will focus on the solar photovoltaic system.



太陽能光伏系統的組成 The Components of a Solar Photovoltaic System

太陽能光伏系統使用的光伏技術將太陽輻射直接轉為直流電，再透過逆變器將直流電轉為交流電，用來推動連接的電器，或回饋至電網，即在一個較大地區內的發電、輸電系統。當太陽光照射到光伏電池上時，電池中的電子會產生定向移動，從而產生電流。太陽能系統主要由太陽能光伏板、逆變器 (Inverter)、適當的電力保護與測量裝置，以及承托與連接所有太陽能板的支架系統所組成。

The photovoltaic technology used by the solar photovoltaic system converts solar radiation directly to DC (Direct Current), which is then converted again to AC (Alternating Current) through an inverter, whereby connected appliances can be operated or offer feedback to the grid (a power generation and transmission system in a larger area).

When sunlight falls on a photovoltaic cell, the electrons in the latter would move in a fixed direction, leading to the generation of electric current.

The solar power generation system is mainly composed of solar photovoltaic panels, inverters, power protection and measurement devices, and a support system that shores up and connects all photovoltaic panels.

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explainthatstuff. 2019. Solar cells. [ONLINE] Available at: <https://www.explainthatstuff.com/solarcells.html> [Accessed 21 July 2020].

太陽能光伏板 (Photovoltaic Panel) :

太陽能光伏板由許多光伏電池 (Photovoltaic Cell) 所組成。光伏電池是一種利用太陽光直接發電的光電半導體薄片，只要被光照到，就可輸出電壓及電流。光伏電池像成人手掌般大，每塊的額定電功率很小 (大約為 5 瓦)。為了增加輸出功率，光伏電池會被組合在一起製成光伏組件，並封裝在可抵禦戶外工作環境的材料中。

標準組件的一般功率為 300 瓦到 400 瓦，不過市場上也有更高功率的組件，此外還有很多用於玩具和計算器的小型光伏組件。

Photovoltaic panels are composed of numerous photovoltaic cells. Photovoltaic cells are photoelectric semiconductor sheets that make use of sunlight for direct generation of electricity. As long as they are exposed to light, they are able to generate voltage and current output. Photovoltaic cells are the size of an adult's palm. Each has a small rated electric power of about 5W. In order to increase the output power, photovoltaic cells are put together into photovoltaic modules and encapsulated in materials that can withstand outdoor environments. Standard modules generally have a power of 300W to 400 W, but there are also higher-power modules on the market. Besides, there are also many smaller photovoltaic modules that are commonly found in toys and calculators.

逆變器 (Inverter) :

這是一個將光伏板產生的直流電 (DC) 轉換為日常使用的交流電 (AC) 的設備。直流電為沒有週期性變化的電流。交流電是具有週期性變化的電流，能減低於電網傳輸電力時的損耗。電力公司提供的市電皆為交流電。

太陽能光伏系統可以大規模安裝在地表上成為光伏電站，也可以置於建築物的房頂或外牆上，成為建築整合太陽能 (Building-Integrated PV, 即 BIPV)。

This is a device that converts DC generated by photovoltaic panels to AC for daily use. DC is a current that does not change periodically. AC is an electric current with periodic changes, which can reduce the loss when transmitting power from the grid. The main electrical supply provided by power companies falls into the category of AC.

Solar photovoltaic systems can be installed on the ground as photovoltaic power stations on a large scale, or they can be placed on rooftops or exterior walls of buildings as Building-Integrated PV (BIPV).

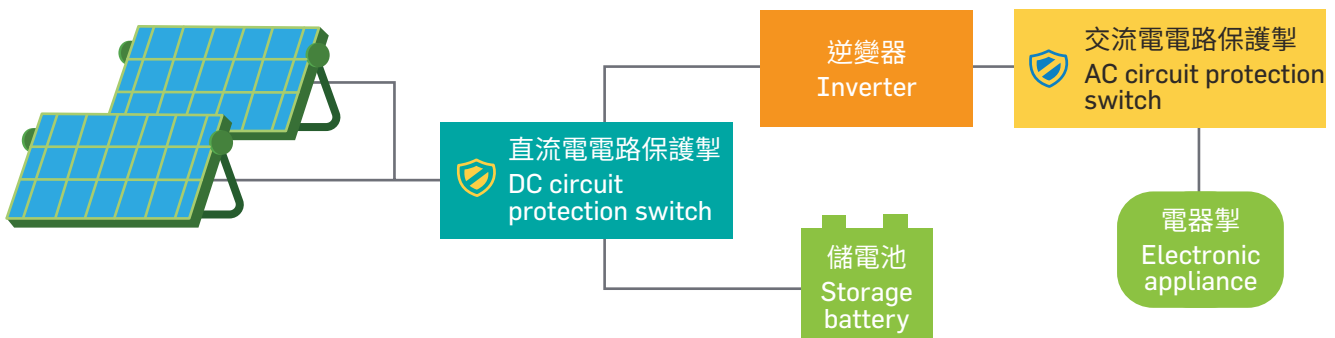
**太陽能光伏系統的供電方式****Power Supply Modes of Solar Photovoltaic Systems**

太陽能光伏系統可作為獨立系統離網使用，或接駁至電網，獲取「上網電價」。Solar photovoltaic systems can be used as an independent system off-grid, or connected to the grid for Feed-in Tariff (FiT).

離網系統 Off-grid Systems

離網型太陽能發電系統，是不依賴電力公司的電網、獨立運行的發電系統，主要由太陽能電池板、控制器和儲電池組成。離網系統需配儲電池，因光伏發電不穩定且無法控制，儲電池可將光伏板產生的電力儲存起來，在缺少太陽光時維持供電。這種沒有直接將電力輸入至電網、而是接駁至儲電池或其他電器上的太陽能系統，稱為離網系統 (Off-grid System)。

An off-grid solar power generation system is an independent power generation system that does not rely on any power grid. It is mainly made up of solar panels, controllers, and storage batteries. Off-grid systems need to be equipped with storage batteries. As photovoltaic power generation is unstable and uncontrollable, storage batteries are able to store the electricity generated by photovoltaic panels and maintain power supply when there is little sunlight. This type of system, referred to as "off-grid system", does not directly transfer electric energy to a power grid but to storage batteries or other electrical appliances.



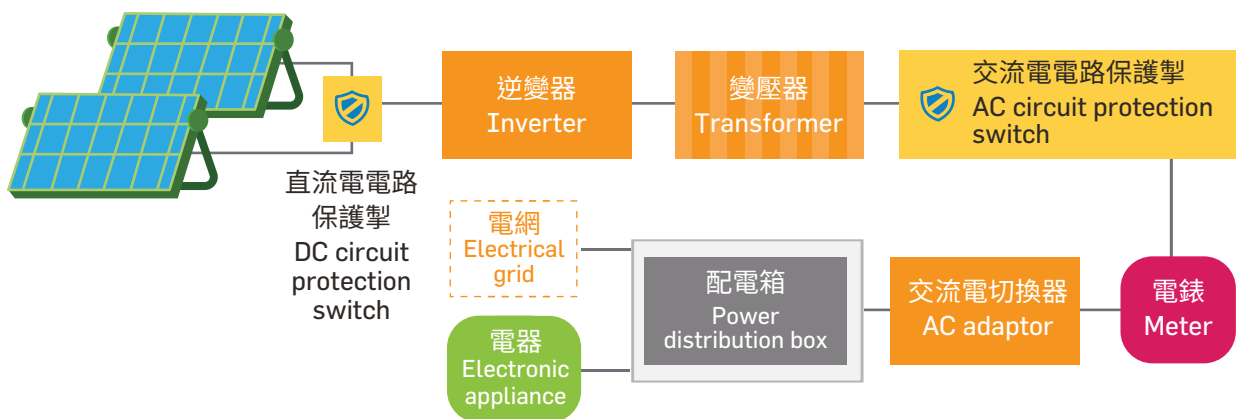
接駁電網系統 Connecting to the Grid System

若太陽能系統在技術上和 safety 上達到電力公司的要求，就可以透過一個併網式逆變器，將太陽能系統連接到建築物的配電系統，接駁電力公司的電網，並申請「上網電價」。申請者必須向相關的電力公司提出申請。電力公司將提出他們的技術要求（如保護設備設定值等），並會為該系統安裝上網電價電錶。用戶可以由電錶知悉已安裝的太陽能系統的發電情況。

當太陽能系統接駁至市電電網，並將所產生的電力輸入至電網的話，我們會稱該系統為併網系統 (On-grid System)。

If the system meets the requirements of the electric company in terms of technology and safety, it would be eligible for connection to the building's power distribution system and the power grid via a grid-tie inverter and apply for the FiT scheme. All interested parties must submit their applications to the relevant electric company. The electric company will put forward their technical requirements (such as protection equipment settings, and the like) and install feed-in tariff meters for the systems. Users can check the power generation status of their solar photovoltaic systems with reference to the meter readings.

The system is referred to as an "on-grid system" when the solar photovoltaic system is connected to the mains grid to which the generated electricity is transferred.



提供保護的組件 Protection Component

交流電路保護掣：目的是在太陽能發電系統發生事故時，可以隔開太陽能發電系統與電力公司系統，以免影響建築物的其他電力系統。

直流電路保護掣：目的是隔開太陽能板，保護逆變器。

隔離變壓器：用來防止直流電從太陽能發電系統直接注入電網的配電系統，同樣用於保護電網。

The purpose of the AC circuit protection switch is to separate the solar power generation system from the electric power system in the event of an accident involving the former, so that other power systems in the same building would not be affected.

The purpose of the DC circuit protection switch is to separate the solar panels and protect the inverter.

The purpose of the Isolation transformer is to prevent direct injection of DC from the solar power generation system into the power distribution system of the power grid. It is also used to protect the power grid.

監察系統 Monitoring Systems

不同逆變器都有自己的監察系統，提供系統的發電數據；電力公司的網頁也會提供系統的實時監察數據供客戶參考。

Different inverters have their own monitoring system to provide system power generation data; the power company's webpage also provides the system's real-time monitoring system for customers' reference.



太陽能光伏系統的效益評估 Performance Evaluation of Solar Photovoltaic Systems

每位建設太陽能系統的投資者，都希望為系統作效益評估，以預計其投資下去的成本能夠獲得多少財務及環保上的回報。我們可以根據預期安裝太陽能系統的位置及其附近環境，利用電腦模擬該安裝地點的日照，從而估算出將來的太陽能系統的效能。坊間常見的模擬軟件有 PVSyst、Helioscope 等。

以下內容讓大家了解進行效益評估時所需的資料，以及種種考慮因素。

Every investor would be ready to evaluate the efficiency of their own solar photovoltaic system, so as to estimate the financial and environmental returns with reference to the investment costs. To estimate the efficiency of a potential solar power generation system, we may simulate the sunshine at the potential installation site with the computer system based on the expected location and its surrounding environment. Common simulation software on the market includes PVSyst and Helioscope.

The following sections will cover key information on efficiency evaluations and other relevant factors.

電力單位 Units of Power

先讓大家認識以下的電力單位：

Let's take a quick look at following units of power:

瓦 Wattage (Watt; W)

「瓦」是日常生活中計算耗電量的功率單位。

"Watt" is the unit of power for calculating power consumption in daily life.

千瓦時 Kilowatt Hour (Kilowatt-hour; kWh)

「千瓦時」用來量度一段時間內電能的消耗量。1 千瓦時就是一個功率為 1,000 瓦的用電設備 1 小時的耗電量。1 千瓦時即電費單的 1 度電。例如，一個洗衣機的功率為 250W，使用 4 小時 (250W X 4) 即消耗了一度電。

"KWh" is used for measuring the consumption of electrical energy over a period of time. 1 kWh is the power consumption of an electrical device with 1,000W power supply for 1 hour. 1 kWh is equivalent to 1 unit of electricity on your electricity bills. For example, a washing machine with 250W power supply consumes 1 kilowatt of electricity after 4 hours of use (250W X 4).

光伏電池的種類 Types of Photovoltaic Cells

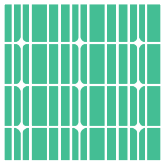
如前述，太陽能光伏板由許多光伏電池所組成。光伏電池主要分為「晶矽電池」和「薄膜電池」兩類。每種光伏電池的特性、轉換率及成本均有不同。用家應因應光伏系統的用途、光伏電池的成本及其效能，選擇適合系統的光伏電池。

As aforementioned, solar photovoltaic panels are made of many photovoltaic cells. Photovoltaic cells are mainly divided into two types, namely “crystalline silicon solar cells” and “thin-film solar cells”. Each type of photovoltaic cells is different in terms of characteristics, conversion rate, and cost. Users should select photovoltaic cells suitable for their own systems according to the purposes, costs, and efficiency.

晶矽電池 Crystalline Silicon Solar Cells

晶矽電池包括單晶矽電池和多晶矽電池：

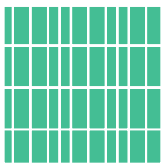
Crystalline silicon solar cells include monocrystalline silicon cells and polycrystalline silicon cells:



單晶矽電池 Monocrystalline Silicon Cells

是目前效率最高的晶矽光伏電池，由矽晶體切割出來的薄片製成。製造過程中，把有特定方向的晶核浸入熔化了了的矽當中，形成的矽晶體緩慢地提取出來。安裝接線後，便製成單晶矽電，光電轉換效率較高，價格比多晶矽略貴。轉換率約為 18% 至 20%。

They are the most efficient crystalline silicon photovoltaic cells to date, made of thin slices cut from silicon crystals. During the production process, crystal nuclei with a specific direction are immersed in molten silicon, and the resulted silicon crystals are slowly extracted. After the wiring is installed, monocrystalline silicon cells are ready for use. They have a higher photoelectric conversion efficiency, though slightly more expensive than their polycrystalline silicon counterparts. The conversion rate ranges approximately between 18% and 20%.

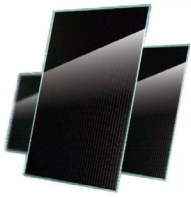


多晶矽電池 Polycrystalline Silicon Cells

由圓晶製造。將圓晶滲入雜質和安裝接線，便製成多晶矽電池。矽鑄錠在鑄成時，會多方向形成晶體，其光電轉換效率不及單晶矽，但成本較低。轉換率約為 15% 至 18%。

Manufactured with wafers. Polycrystalline silicon cells are created through permeation of impurities into the wafers and installation of wiring. When the process of silicon ingot casting is complete, crystals with lower photoelectric conversion efficiency than their monocrystalline silicon counterparts are formed in multiple directions. The production costs, nevertheless, are also lower. The conversion rate ranges approximately between 15% and 18%.

薄膜電池 Thin-film Solar Cells



薄膜電池分為非晶硅電池、銅銦鎵二硒的太陽能電池 (CIS) 和碲化鎘薄膜太陽能電池 (CdTe) 幾種。這是通過在硬性基質或者是可屈曲基質的不銹鋼薄片上施加一層硅薄膜所造成的。在滲入雜質和安裝電氣接線之後，便製成薄膜電池。

與晶硅電池相比，薄膜電池的優點是製作成本較低，並且可以應用在可屈曲的或者質輕的物體表面。不過，這類電池的轉換率會較低。非晶硅電池組件的轉換效率通常在 6% 以下。

Thin-film solar cells fall into three major categories, i.e. amorphous silicon cells, copper indium gallium diselenide solar cells (CIGS) and cadmium tellurium thin-film solar cells (CdTe). They are made by applying a thin silicon film on a hard substrate, or a flexible stainless steel substrate. Thin-film solar cells are created through permeation of impurities and installation of electrical wiring.

Compared with their crystalline silicon counterparts, thin-film solar cells have the advantages of lower production costs and applicability to flexible or lightweight surfaces. However, this type of cell has a relatively low conversion rate with photo-induced degradation. The conversion efficiency of amorphous silicon cell components is usually below 6%.

不同光伏電池的優劣比較

A comparison of the advantages and disadvantages of various photovoltaic cell types

	優點 Advantages	缺點 Disadvantages
單晶硅電池 Monocrystalline Silicon Cells	<ul style="list-style-type: none"> · 高效能 · High efficiency 	<ul style="list-style-type: none"> · 製作時產生較多污染 · More pollution during production
多晶硅電池 Polycrystalline Silicon Cells	<ul style="list-style-type: none"> · 板面會有顏色 · 比單晶硅便宜 · 比單晶硅較少污染 · Tints on surface · Cheaper than monocrystalline silicon cells · Less pollution than monocrystalline silicon cells 	<ul style="list-style-type: none"> · 發電量與效能比單晶硅略低 · Generating capacity and efficiency are slightly lower than monocrystalline silicon cell
薄膜電池 Thin-film Solar Cells	<ul style="list-style-type: none"> · 美觀 · 可用於弧形及不同形狀的表面 · 比晶硅電池更有效吸收漫射陽光 (即是能吸收更多陽光) · Better aesthetics in appearance · Can be used on surfaces of varied shapes, including curved · Absorb diffuse sunlight more effectively than crystalline silicon cells (i.e. able to absorb more sunlight) 	<ul style="list-style-type: none"> · 效能是三者之中最低 · With the lowest performance amongst the three

安裝位置及角度 Installation Position and Angle

香港位處北半球，太陽多數會由南方照射到地面，故此於香港的太陽能系統大多會面向南方，最佳角度為向南方傾斜 15 至 17 度。

在安裝太陽能光伏系統時，亦要考慮安裝位置尤其是面向南面的一方，有沒有明顯遮擋太陽的障礙物。

Hong Kong is located in the Northern Hemisphere. The sun shines from the south to the ground, and therefore most solar power generation systems in Hong Kong face the south. The best angle ranges between 15 and 17 degrees to the south.

When installing a solar photovoltaic system, you should also pay attention to the installation location, particularly the side facing the south. Make sure there are no obstructions that obviously block the sun.

遮擋評估 Obstruction Evaluation

建築物對光伏系統的遮擋會影響發電量，嚴重的遮擋可扣減發電量超過 10%。因此，專業的遮擋評估十分重要。

工程師會留意安裝光伏系統的位置是否有陰影、陰影出現的時間及維持多久等，而兩行光伏板之間（通常朝南）需要隔開一定的距離，以減低相互之間的遮蔭效應。另外，光伏板會按照接近香港緯度的角度傾斜安裝，這樣可獲得以全年計最大的產電量，亦有助雨水沖刷掉積累的灰塵。

在現場作遮擋評估時，工程師會用魚眼鏡拍攝現場，再透過軟件計算遮擋。

Shading of photovoltaic systems by buildings would affect the generating capacity, which is possibly reduced by over 10% by severe obstruction. Therefore, professional obstruction evaluations are very important.

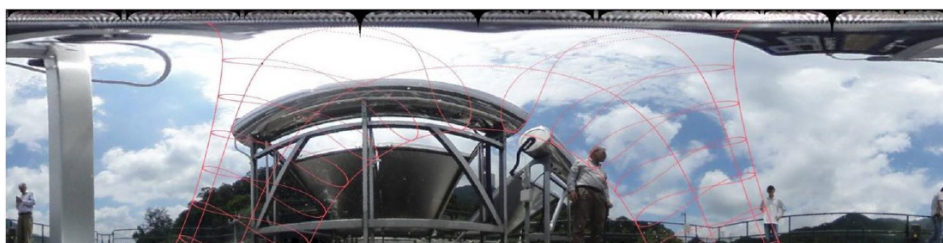
Engineers would pay attention to whether there are shadows at the location where the photovoltaic system is installed, as well as when and how long the shadows appear. The two rows of photovoltaic panels (usually facing south) are to be separated by a certain distance to minimise the shading effects on each other. In addition, photovoltaic panels would be installed obliquely at an angle close to the latitude of Hong Kong, so as to maximise the annual electricity output and to enable the rain to wash away the accumulated dust.

When obstruction assessments are carried out on-site, the engineer photographs the scene with fisheye lenses before calculating the obstruction with the help of computer software.



上方圖顯示用魚眼鏡拍攝的現場，鏡頭能拍到 360° 全景圖像。

The picture above shows a shot of the site with a fisheye lens, which is used to create a 360° panoramic image.



下方圖顯示由拍得的半球體影像變成的平面照片，軟件計算了太陽在一年四季運行的路軌（紅色線）。

The image below shows a 2D photo derived from the hemispherical image. The software calculates the track (as shown as a red line) of the sun throughout the year.

(圖片由顏子翔工程師提供) (Photo credit: Ir Ngan Chi Cheung)

發電量評估 Evaluation of Generating Capacity

太陽能發電系統發電量受三大因素影響，包括 (a) 系統所在地的太陽能輻射量；(b) 光伏板額定轉換效率及；(c) 系統本身的效率，可以用以下我們熟悉的例子作比喻—汽車的續航力取決於其油箱供應、油箱大小及汽車耗油效率（即每公升汽油可行駛距離）。在此，「太陽能輻射量」好比汽油，「光伏板額定轉換效率」就好比油箱大小，而系統「本身的效率」則等同汽車耗油效率。以下為簡要說明：

The generating capacity of a solar power generation system is affected by three major factors, including (a) amount of solar radiation at the system's location; (b) rated conversion efficiency of photovoltaic panels; (c) efficiency of the system itself, which can be compared with the following examples for easier references - the endurance of a car depends on its fuel tank supply, the size of the fuel tank, and the fuel efficiency of the car itself (i.e. possible distance travelled per litre of fuel). In this context, "solar radiation" is comparable to petrol, whereas "rated conversion efficiency of photovoltaic panel" could be the size of a fuel tank, and the "self-efficiency of the system" as the car's fuel efficiency. The following is a brief description:

(a) 系統所在地的太陽能輻射量 Amount of Solar Radiation at the System's Location

太陽輻射是指太陽不斷以電磁波發放出來的能量。一個太陽能光伏系統收集到的有效太陽能輻射量，會受系統的地理位置、當地氣候、光伏板面積、安裝角度及附近物體遮擋／反射程度所影響。若要準確評估，需要氣候、現場經緯度、支架設計、光伏板數量和面積參數，再通過專門軟件計算，是一個較為複雜的流程。

Solar radiation refers to the energy emitted by the sun continuously with electromagnetic waves. The amount of effective solar radiation collected by a solar photovoltaic system depends on the geographic location of the system, the local climate, the area of photovoltaic panel(s), the installation angle and the degree of obstruction or reflection of nearby objects. An accurate evaluation takes into account the climate, latitude and longitude of the site, the support design, the number of photovoltaic panels, and area parameters. Calculations are then performed by specific computer software, which is a relatively complicated process in itself.

(b) 光伏板的額定轉換效率 Rated Conversion Efficiency of Photovoltaic Panels

光伏板的額定轉換效率是在標準測試條件 (Standard Testing Condition) 下，太陽光能化為電能的轉化效率。轉換率反映光伏板的性能，百分比愈高，能源效益愈好。此參數可直接從光伏板標籤或說明書讀取。

Rated conversion efficiency of photovoltaic panels refers to the conversion efficiency of solar energy into electrical energy under Standard Testing Conditions. The conversion rate reflects the performance of photovoltaic panels. The higher the percentage, the better the energy efficiency. This parameter can be accessed directly from the PV panel label or manual.

(c) 系統本身的效率 Efficiency of the System

系統本身的效率受到十多個因素影響，較重要的包括光伏板運行時的溫度、光伏板面的清潔程度、系統（包括逆變器、電線及隔離變壓器等）損耗、系統 / 電網故障率等等。幸好太陽能行業在世界各地數不勝數的案例中已累積了豐富的經驗，一般正常設計、選件、安裝及保養的系統其效率約為 80% 左右。要注意的是系統效率會隨著光伏板老化而慢慢降低，估計系統光伏板 25 年後的累積效能衰減可達 20%，即系統效率在 25 年後約為 $80\% \times 80\% = 64\%$ 。

香港中小型光伏系統發電量參考：

在無遮擋及重大事故情況下，一個座北向南 1kW 光伏系統（佔用屋頂面積約為 5 m^2 ）首年的發電量平均約為 1050 kWh 至 1100kWh。在適當維護情況下，25 年的總發電量約為 24,000 kWh 至 25,000kWh。

The efficiency of the system is affected by more than ten factors. The more important ones include the temperature of the photovoltaic panels in operation, cleanliness of the photovoltaic panels, loss (including inverters, wires, isolation transformers, etc.), and system or grid failure rate. Luckily, rich experiences were gained by the solar energy industry from countless cases around the world, the average efficiency of a conventionally designed, constructed, installed and maintained system is around 80%. It should be noted that system efficiency would slowly decrease as the photovoltaic panels age. It is estimated that the cumulative efficiency degradation of system photovoltaic panels after 25 years can reach 20%, i.e., the system efficiency after 25 years would be approximately $80\% \times 80\% = 64\%$.

Typical yield of small and medium-sized photovoltaic systems in Hong Kong:

When unobstructed without major incidents, a 1kW north-to-south photovoltaic system (occupying around 5 m^2 of roof area) can generate an average of approximately 1050 kWh to 1100 kWh energy in the first year. With proper maintenance, the total yield in 25 years' time can amount to approximately 24,000 kWh to 25,000 kWh.

環境效益評估 Environmental Efficiency Evaluations

使用可再生能源取代燃煤發電能有效減低碳排放。我們可透過以下算式計算太陽能光伏系統的減碳量：

Using renewable energy to replace coal-fired power generation can effectively reduce carbon emissions. Carbon reduction of the solar photovoltaic system could be calculated by the following formula:

累積的太陽能產電量 (千瓦時/度電) Cumulative solar energy production (kWh)	X	指定電力公司的排放系數 Emission factors of designated power companies	=	太陽能可抵銷傳統化石燃料發電的二氧化碳當量 (CO ₂ -e) Carbon dioxide equivalent (CO₂-e) possibly offset by solar power generation in place of conventional fossil fuels
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* 指定電力公司的排放系數

* Emission factor of the designated electric company

指某一特定活動所產生的每公斤計二氧化碳當量。而電力消耗的排放系數，可於中電集團或香港電燈有限公司的可持续发展報告中取得。採用哪一個系數，視乎你的太陽能光伏系統的所屬位置。

Refers to the carbon dioxide equivalent per kilogram produced by a specific activity. The emission factor for electricity consumption can be obtained from the sustainability reports of the CLP Group or the Hongkong Electric Company Limited. The choice of factor depends on where your solar photovoltaic system belongs.

* 太陽能可抵銷傳統化石燃料發電的二氧化碳當量 (CO₂-e)

* Carbon dioxide equivalent (CO₂-e) possibly offset by solar power generation in place of conventional fossil fuels

以同一種單位 (二氧化碳) 來表示。舉例來說，若某機構安裝的光伏系統的累計產電量為 12,552 千瓦時 / 度電，而指定電力公司當年的排放系數為 0.62 公斤二氧化碳當量，代表該光伏系統已經減少的碳排放量便是 $12,552 \times 0.62 = 7782$ 公斤二氧化碳當量，足夠供電予 31 戶家庭，亦相等於種植 545 棵樹。

此外，在天台建設太陽能板有助調節該建築物的溫度。加州大學聖地牙哥分校在 2011 年的研究顯示，由於太陽能板能阻擋陽光的直接照射，建築物的室內溫度平均可減低約 2.8°C。

Let's say, if the cumulative power production of the photovoltaic system installed by an organization is 12,552 kWh/kWh, and the emission factor of the designated electric company for the year is 0.62 kg CO₂ equivalent, it means that the amount of carbon emissions reduced by the photovoltaic system would be $12,552 \times 0.62 = 7782$ kg of carbon dioxide equivalent. It is enough to power 31 households or equivalent to planting 545 trees.

Besides, installation of solar panels on the roof can help to regulate the building's temperature. A study in 2011 by the University of California San Diego indicates that the indoor temperature of buildings can be reduced by about 2.8°C on average, with the credit given to the solar panels which are able to block direct sunlight.

注意安全 Pay Attention to Safety

除了評估效益外，在安裝光伏系統時也要留意安全情況。特別是在天台安裝系統時，須注意天台的結構情況，如本身的設計能否承受太陽能系統的重量、防水層有否老化、大廈有否漏水問題及日後保養等。

In addition to efficiency evaluation, you should also pay attention to safety when installing photovoltaic systems, especially the condition of roof structure. Should you find out whether the original design can withstand the weight of the solar photovoltaic system, watch out for signs of aged waterproofing and water leakage problems in the building, and learn about actions to be taken for future maintenance.

6

「上網電價」計劃 The "Feed-in Tariff" Scheme

縱使香港政府的可再生能源政策保守，香港政府與兩電於 2018 年簽訂的「上網電價計劃」，以廣泛推廣太陽能及風能的普及發展，我們鼓勵廣大市民積極參與。

為鼓勵私人和私營企業投資發展可再生能源，香港政府與本港兩間電力公司（中華電力有限公司及香港電燈有限公司）簽訂協議，向任何於其處所內安裝分佈式可再生能源系統，並已經接駁到該系統身處的區域電力公司的電網的非政府機構或個人，以高於一般電費水平回購可再生能源，並透過電力公司電網向全港供電（圖 11）。現時計劃涵蓋太陽能光伏系統及風力系統。

Despite the fact that the official renewable energy policy remains conservative, the Hong Kong SAR Government and the two power companies signed the "Feed-in Tariff" (FiT) in 2018 to promote the development of solar and wind energy. The general public is encouraged to participate actively in this cause.

To encourage private individuals and private enterprises to invest in the development of renewable energy, the government signed an agreement with two local power companies (CLP and Hongkong Electric) on the installation of distributed renewable energy systems on any of their premises.

Non-governmental organisations or individuals connected to the power grid of the regional electric company where the system is located may repurchase renewable energy at a level higher than the general electricity rate, and supply power to the territory through the grid of the relevant electric company (Note: Figure 11). The current scheme covers both solar photovoltaic and wind power systems.

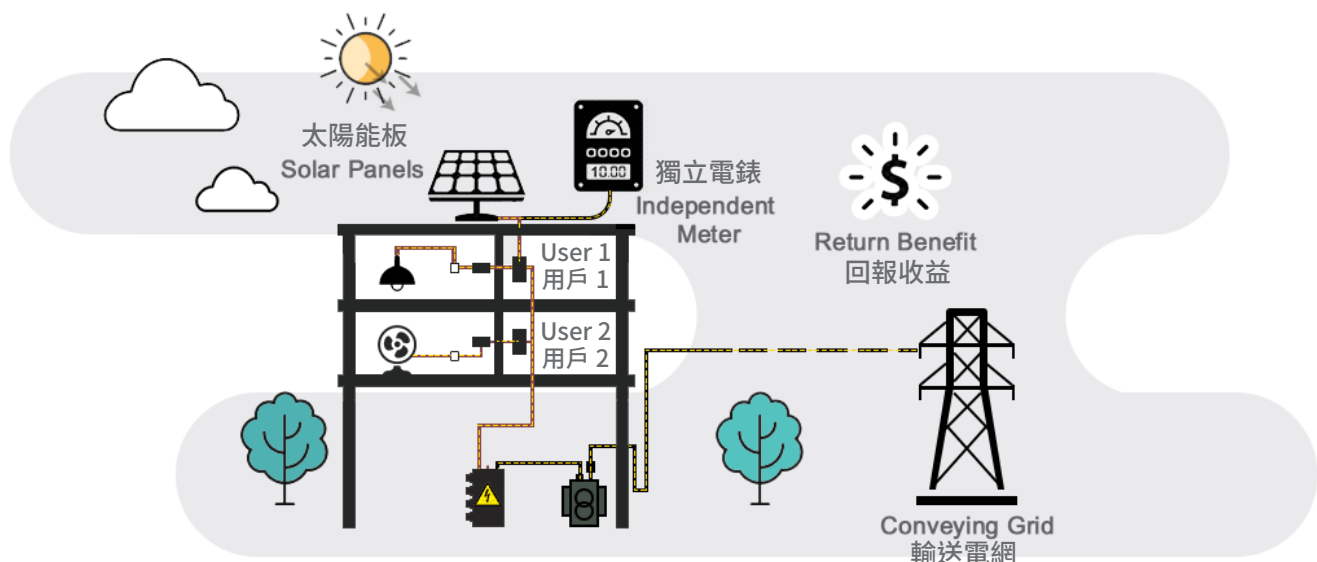


圖 11：上網電價簡介圖

Figure 11: Brief Introduction of On-grid Tariff

「上網電價」計劃 The “Feed-in Tariff” Scheme

電力公司會向不同規格的可再生能源裝置提供上網電價。在計劃開始時，上網電價為每度電 3 元至 5 元。但在 2022 年 4 月 26 日，香港政府突然宣布新的上網電價價格，表示考慮到發展分布式可再生能源系統成本顯著下降，政府和電力公司將下調價格水平：以每度電計，可再生能源系統發電容量等於或少於 10 千瓦由 5 元減至 4 元，超過 10 千瓦但不超過 200 千瓦由 4 元減至 3 元，超過 200 千瓦但不超過 1 兆瓦由 3 元減至 2.5 元，由 2022 年 4 月 27 日起生效。

According to the scheme, power companies would provide FiT for renewable energy devices of different specifications. At the beginning phase, the electric company would provide an on-grid tariff of HK\$3-5 per kWh. However, on 26 April 2022, an abrupt change in FiT rates was announced by the Hong Kong government. With the consideration of having a significant drop in the costs of developing distributed renewable energy systems, the government and power companies have adjusted the charges downward. On a per-kWh basis, with a generating capacity of 10 kilowatts or less, a tariff of \$4 per kWh would be charged instead of the initial \$5 per kWh. For a generating capacity of more than 10 kW but not exceeding 200 kW, the levy was decreased by \$1 to a tariff of \$3 per kWh. Lastly, the prevailing rate of a tariff of \$3 per kWh would be dropped to \$2.5 per kWh with a generating capacity of more than 200 kW but not exceeding 1 megawatt. All the adjustments will be effective from 27 April 2022.

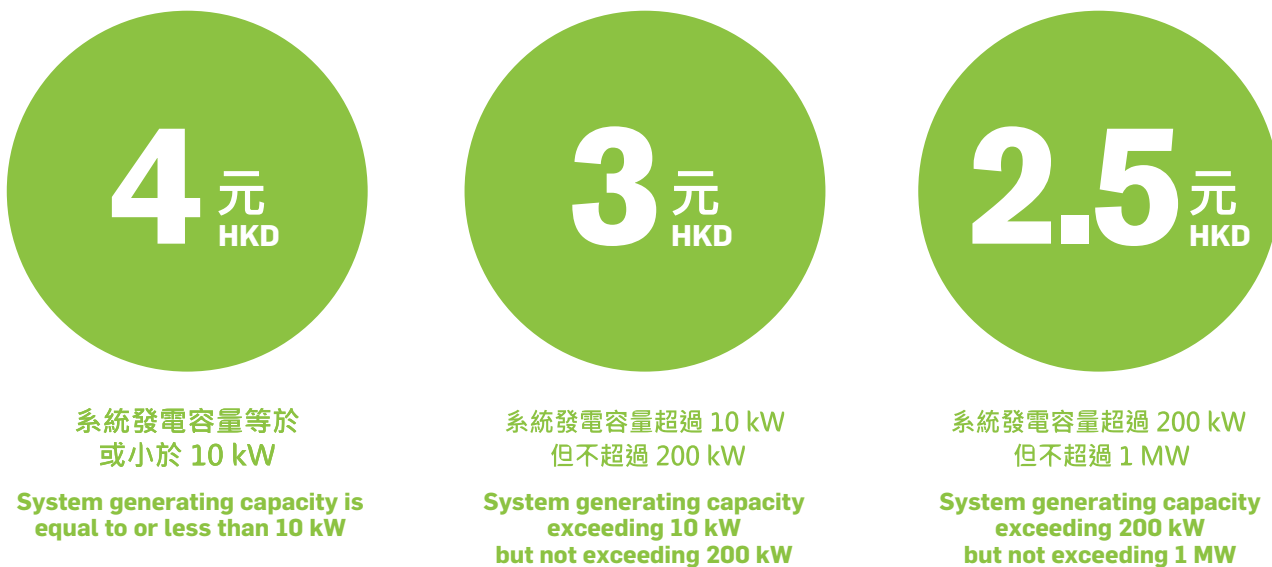
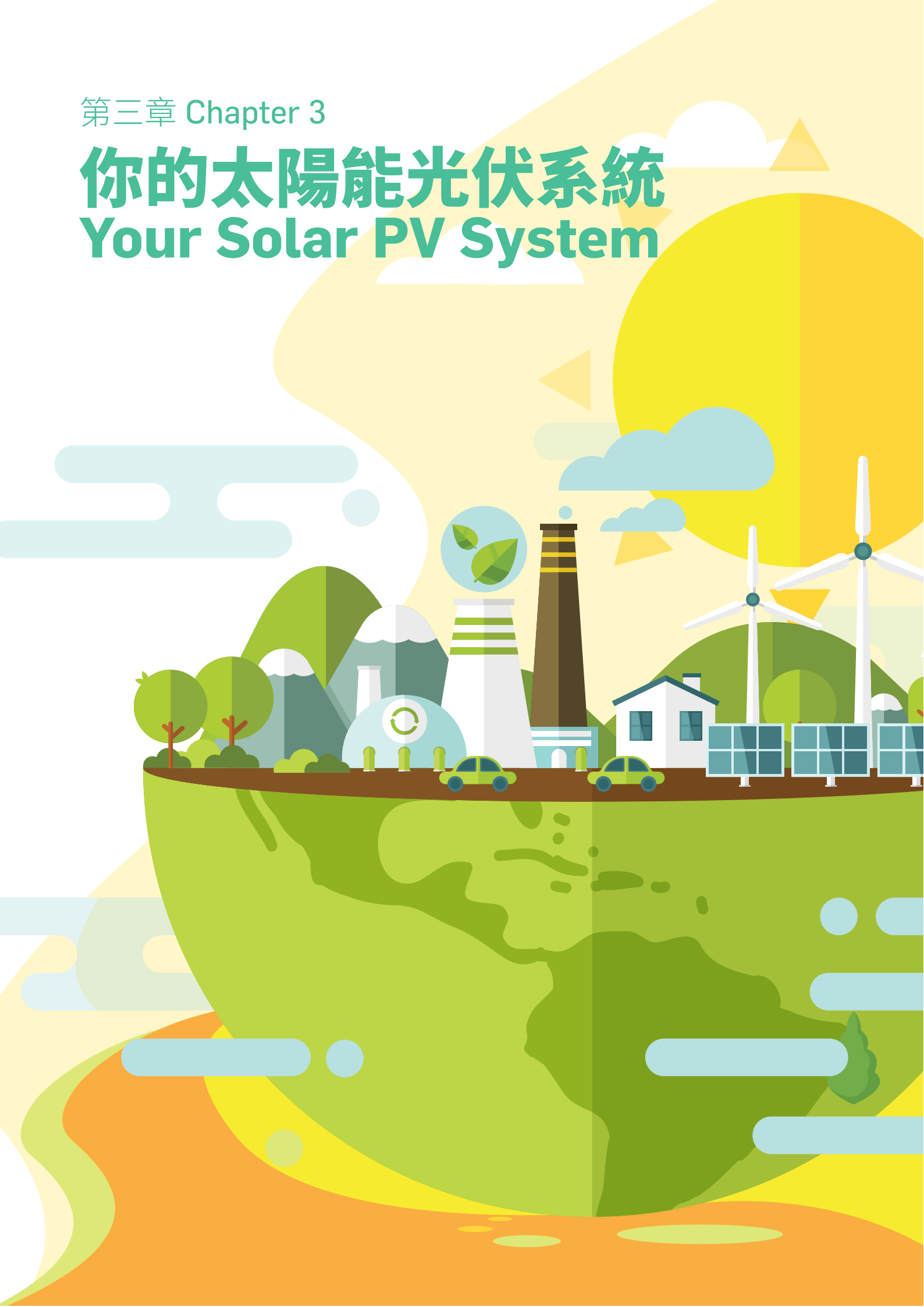


圖 12：2022 年 4 月 27 日起生效的上網電價
Figure 12: Feed-in Tariffs rates with effect from 27 April 2022

第三章 Chapter 3

你的太陽能光伏系統

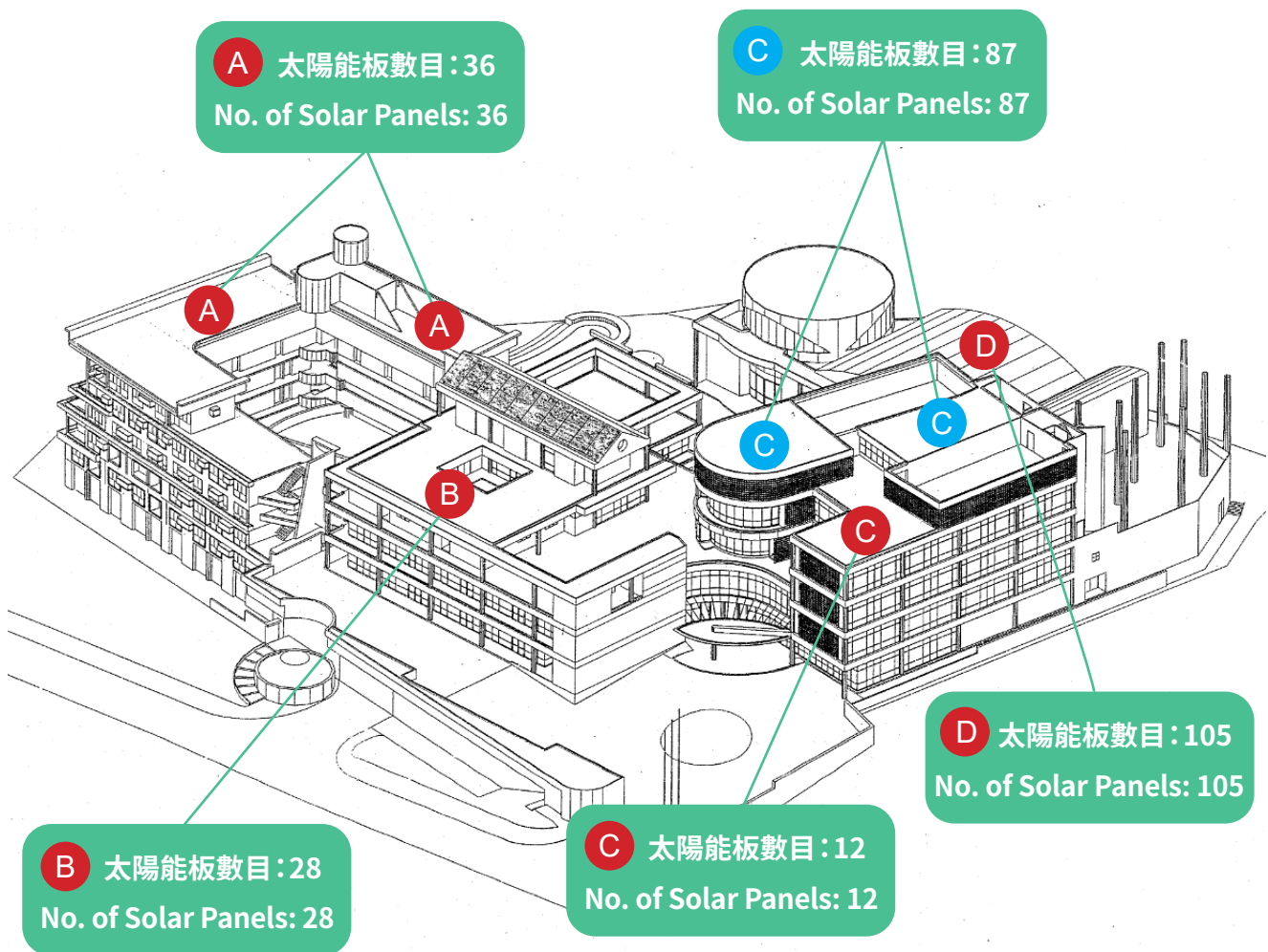
Your Solar PV System





你的太陽能光伏系統資料

About Your Solar Photovoltaic System



突破青年村各 4 座太陽能板資料：

Breakthrough Youth Village 4 Blocks Solar Panels Information:

- 單晶硅電池太陽能板
Monocrystalline Cells Solar Panels
 - 太陽能板總數：**181 塊**
Total Number of Monocrystalline Cells Solar Panels: **181 pieces**
 - ⚡ 太陽能板總電容量：**約 90,000 千瓦**
Total Capacity: **Around 90,000kW**
- 薄型太陽能軟板位置
Flexible Solar Panels
 - 太陽能軟板總數：**87 塊**
Total Number of Flexible Solar Panels: **87 pieces**
 - ⚡ 太陽能軟板總電容量：**約 30,000 千瓦**
Total Capacity: **Around 30,000kW**

合共：268 塊太陽能板，120,000 千瓦
Total: 268 Solar Panels, 120,000kW



舉行太陽能導賞團指南

A Guide to Organising Solar Tours

低碳想創坊在恒生銀行的全力支持下，盼望與一眾非牟利機構合作夥伴舉辦青年氣候教育活動，激發年輕人透過共同努力和創新意念推行氣候行動。以下指南將協助貴機構籌備太陽能光伏系統導賞團。

CCIL would also partner with the NGOs to organise youth climate education programmes that encourage young people to facilitate collective efforts and spark new ideas for climate action. The following guide will assist your organization in organizing guided tours about solar photovoltaic systems.

目的 Objectives

透過帶參加者近距離觀察太陽能光伏系統，讓他們了解氣候變化的知識、減碳的重要性、使用可再生能源如何減緩氣候變化，以及太陽能光伏系統的運作。

By showing the participants around and allow them to closely observe the solar photovoltaic system, they will gain a better understanding of climate change, importance of decarbonization, mitigation of climate change through the use of renewable energy, and the operation of a solar photovoltaic system towards the end of the tour.

準備工作 Preparation

導賞員需閱讀此導覽，並根據內容準備 Powerpoint（在活動室展示）或展示板（如在戶外展示），向參加者講解。導賞員可根據參加者的年齡及背景選取合適的內容。

The docents should finish reading this guide and prepare a PowerPoint slide deck (to be shown in the activity room) or display boards (to be shown outdoors) according to the descriptive content. The docents will select appropriate content according to the participants' age and background.

導賞員 Docents

建議安排 1 位。若參加者有特殊需要的話，建議安排多於 2 位導賞員。1 位負責講解內容，1 位提醒大家注意安全。

One for delivering the verbal explanations, you are highly recommended to provide two or more if needed. The group is recommended to be accompanied by one to two extra docents to ensure safety.

參加人數 Number of Participants

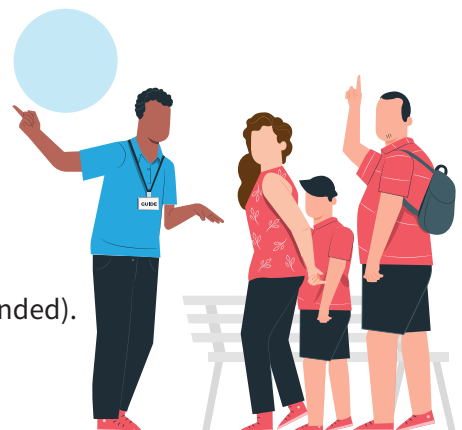
建議參加人數為 15 人。

15 per group (recommended).

參觀時間 Visiting Hours

如在夏天舉辦，建議安排在上半，避開正午的直射陽光。

Morning, for summer visits to avoid direct sunlight at noon (recommended).





太陽能導賞團講解內容
Content of the Solar Tour

內容 Content	參考 Reference	形式 Method
<p>簡介 貴機構（背景、服務內容、服務對象等）</p> <p>Introduce your organization (background, description of services, service target, etc.)</p>	<p>（按照 貴機構的準則而定）</p> <p>(According to your organization's guidelines)</p>	<p>簡報形式講解</p> <p>Explain verbally with the aid of PowerPoint</p>
<p>簡介導賞團背景（簡介「減碳恒動 – 太陽能關懷計劃」、分享參加計劃心得等）</p> <p>Introduce the background of the guided tour (introduce the "Hang Seng Low Carbon Future: SolarCare Programme" and share experience of participating in the programme, etc.)</p>	<p>「減碳恒動 – 太陽能關懷計劃」網站 (https://www.ccinnolab.org/zh/HangSengLowCarbonFuture)，此導覽冊的第二章（「上網電價」部份）</p> <p>"Hang Seng Low Carbon Future: SolarCare Programme" website (http://www.ccinnolab.org/solarcare), Chapter 2 of this guidebook (the section "Feed-in Tariff")</p>	<p>簡報形式講解</p> <p>Explain verbally with the aid of PowerPoint</p>
<p>講解氣候變化知識（帶出人類行為導致氣候變化的訊息）</p> <p>Explain climate change (bring out the message that human behaviour leads to climate change)</p>	<p>此導覽冊的第一章</p> <p>Chapter 1 of this guidebook</p>	<p>簡報形式講解</p> <p>Explain verbally with the aid of PowerPoint</p>
<p>講解能源知識，以及可再生能源與氣候變化的關係</p> <p>Explain energy, and the connection between renewable energy and climate change.</p>	<p>此導覽冊的第二章</p> <p>Chapter 2 of this guidebook</p>	<p>簡報形式講解</p> <p>Explain verbally with the aid of PowerPoint</p>
<p>講解太陽能發電知識</p> <p>Explain solar power generation</p>	<p>此導覽冊的第三章</p> <p>Chapter 2 of this guidebook</p>	<p>簡報形式講解</p> <p>Explain verbally with the aid of PowerPoint</p>
<p>帶參加者參觀 貴機構的太陽能光伏系統，作出介紹</p> <p>Show the participants around; introduce your organization's solar photovoltaic system.</p>	<p>此導覽冊的第三章</p> <p>Chapter 3 of this guidebook</p>	<p>展板形式講解</p> <p>Explain verbally with the aid of exhibition boards</p>

導賞團細節資料 Details of the Solar Tour

流程 Session	地點 Location	時間 Time
簡介 貴機構 Introduction of your organization	活動室 Activity Room	10- 15 分鐘 10-15 minutes
簡介導賞團背景 Introduction to the background of the Solar tour	活動室 Activity Room	5 分鐘 5 minutes
簡介氣候變化、能源及太陽能發電知識 Introduce climate change, energy, and solar power generation - 預留時間讓參加者發問 Set aside some time for Q&A - 講解光伏系統的參觀守則 Explain guidelines for visiting solar panels	活動室 Activity Room	20-30 分鐘 20-30 minutes
小休（讓參加者到洗手間） Short break (washroom break for participants)	/	5 分鐘 5 minutes
帶參加者到光伏系統及電錶處講解 Take the participants to a spot where the photovoltaic system is located. Electricity meters can be clearly seen and provide verbal descriptions	/	20 分鐘 20 minutes
解散 / 繼續其餘活動 Dismiss / move on to other activities	/	/

參觀守則 Guidelines for Visiting

在安排訪客參觀你的光伏系統或舉辦導賞活動時，請注意以下事項：

When arranging visits to your photovoltaic system or organizing guided tours, please note the following:

- 參觀人士須全程跟隨機構職員行走，不可擅自離隊 Visitors must follow staff of the organization throughout the tour and should not leave the group without authorization
- 行走時須注意地面情況，以免被沿著地板鋪設的電纜絆倒 Pay attention to the ground conditions when walking to avoid tripping over the cables laid along the floor
- 請勿站近天台邊緣 Do not stand near the edge of the roof
- 請穿著舒適的鞋子，勿穿露趾鞋 Please wear comfortable shoes; do not wear open-toed shoes
- 請勿觸摸太陽能系統的組件 Do not touch any components of the solar photovoltaic system
- 請勿攀上或踏在太陽能板上 Do not climb or step on the solar panels
- 請勿奔跑 Do not run
- 請勿喧嘩 Please keep quiet
- 嚴禁吸煙 No smoking
- 參觀人士應小心保管個人財物 Visitors are advised to take care of their personal belongings
- 如逗留較長時間，請適時補充水份，以及帶備帽 / 傘，以免中暑 If staying for a longer time, please rehydrate whenever necessary and bring a hat/cap/umbrella to avoid heat stroke
- 支撐太陽能板的支架很鋒利，請參觀者留意 Please remind the visitors to pay attention to the solar panel brackets
- 若參加者有違以上守則，大會有權請參加者離場 If participants violate the above rules, the organizer reserves the right to ask participants to leave the venue

惡劣天氣安排 Severe Weather Arrangements

- 請採用 貴機構的惡劣天氣安排 Please refer to your organization's severe weather arrangements.



低碳想創坊

低碳想創坊是一個獨立非政府組織，致力培育及發展活躍的社群，並以香港的年輕人和學生為重點，鼓勵他們透過創意、教育和行動來應對氣候變化和發展可持續的低碳生活。

我們致力鼓勵不同界別持份者的參與，相信群眾力量，並以尋求實際可行並具建設性的解決方案為本，以達致提高全香港社區對氣候變化議題的關注意識。我們的使命是鼓勵年輕人通過創意提供切合本土需要及全球挑戰的有效方案，議題包括氣候公義、減低碳排放、資源保育及任何有助於提升氣候應對策略、緩解氣候變化和增強面對氣候變化的抗逆能力的行動。

CarbonCare InnoLab

CarbonCare InnoLab is an NGO dedicated to nurturing and expanding active communities, focusing on the youth and students in Hong Kong, and encouraging them to mitigate climate change and develop sustainable low-carbon lifestyle through innovation, education, and action.

We put special emphasis on multi-stakeholder engagement and solution-oriented processes, as well as awareness-building across the community. Our mission is to motivate young people to provide effective solutions that meet local needs and global challenges through creativity. The themes include climate justice, carbon emission reduction, resource conservation, and anything that would help improve climate response strategies, mitigate climate change, and strengthen resilience to climate change.

請 LIKE 低碳想創坊的 Facebook 及 Instagram，獲取我們的最新消息：

Please like CarbonCare InnoLab's Facebook Page and follow our Instagram for our latest updates:



請到「減碳恒動 – 太陽能關懷計劃」網頁，了解更多計劃內容：

Please visit the official webpage of "Hang Seng Low Carbon Future: SolarCare Programme" for more details:



<https://www.ccinnolab.org/en/HangSengLowCarbonFuture>



全力支持 Supported by :



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電話：3568 2244

電郵：info@ccinnolab.org

地址：香港北角蜆殼街 9 至 23 號秀明中心 18 樓 A 及 B 室

網址：<https://ccinnolab.org>

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Tel: 3568 2244

Email: info@ccinnolab.org

Address: 18A & B Seabright Plaza,
9-23 Shell Street,
North Point, Hong Kong

Website: <https://ccinnolab.org>

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