# PUBLIC POLICY RESEARCH FUNDING SCHEME

# 公共政策研究資助計劃

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| Principal Investigator :<br>首席研究員： | Dr LU Lin<br>呂琳博士 |
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**Title:** Study on the Development Potential and Energy Incentives of Rooftop Solar Photovoltaic Applications in Hong Kong

題目：香港屋頂太陽能光伏發展潛力和能源激勵政策的研究

**Abstract:** To promote the widely use of solar photovoltaic (PV) technology in Hong Kong, a study of development potential and energy incentives of rooftop solar PV applications was conducted in this project. Since BIPV technology has the potential of large-scale application in Hong Kong, many people, especially the policy makers are very interested in finding answers to the following questions: (1) how much PV capacity can be installed on the rooftop of buildings in Hong Kong? (2) how much electricity can be generated yearly from these rooftop PV systems? (3) what potential proportion of the total electricity is provided by PV electricity generated by rooftop PV systems? (4) what are the main reasons that restrict the development of PV industry in Hong Kong? (5) what kind of subsidies are suitable for PV installation in Hong Kong? (6) how to determine the intensity of subsidy? (7) what is the environmental benefits of developing rooftop PV systems? Therefore, this study aims to provide answers to the above questions as well as suggestions to the local policy makers to promote the rapid development of PV industry in Hong Kong.

Firstly, through combining airborne LiDAR data and spatially analysis, the total rooftop area which is available for installing PV systems was estimated. A methodology of determining the PV-suitable rooftop area using Geographical Information System (GIS) was presented. The extraction of PV-suitable rooftop area was based on the building footprint. Five important criteria, viz. ground features, rooftop barriers, shadow, slope and the minimum permission area, were used to filter the area that is unsuitable for installing PV systems during the area extraction process. The total PV-suitable rooftop area was estimated to be 39.2 $km^2$.

With the total PV-suitable rooftop area, the potential installation capacity of rooftop PV systems was estimated to be 4.67 $GW_p$ with taking the reserved array distance into account, and accordingly the annual potential energy output was predicted to be 4674 GWh, a figure which accounts for 10.7% of the total electricity used in Hong Kong in 2014. In addition, about 3 million tons of greenhouse gas (GHG) emissions could be avoided yearly by replacing the equivalent local electricity mix.

For environmental benefits, the investigation results showed that the energy payback time (EPBT) and the GHG emission payback time (GPBT) of different types of rooftop PV systems in Hong Kong ranged from 1.9 - 3.2 and 1.45 - 2.3 years, respectively, both of which are far less than the systems’ lifespan of 25 years. The energy yield ratio (EYR) ranged from 9.4-16.2, which indicates that the rooftop PV systems could generate at least 10 times the energy requirement during the system’s lifetime.

Although the development potential of building integrated rooftop PV systems is huge, the development rate of PV industry is very slow in Hong Kong. Up to now, the cumulative PV installation capacity is less than 3 MW. We found that a main reason restricting the development of PV applications in Hong Kong is the very high installation cost, which is about 3-4 times higher than that in Mainland China. In addition, there is lack of specific governmental subsidy for PV installation. If appropriate subsidies are provided by the local government and the installation cost is further reduced, PV electricity is expected to fully compete with traditional electricity modes in the near future in Hong Kong. Lastly, we provided some recommendations for policy makers regarding to make effective and reasonable PV incentives and further reduce the installation costs. In a word, the findings from this study are expected to provide a theoretical basis for local policy makers to set reasonable energy policies, development targets as well as subsidies for PV technology in Hong Kong.

**摘要：**為了促進太陽能光伏發電技術在香港的廣泛使用，本專案對在建築屋頂使用太陽能光伏系統的發展潛力以及相關的能源激勵政策進行了深入研究。 由於建築一體化光伏系統在香港有著廣泛應用的潛力，能源政策的制定者們非常希望能夠獲得如下問題的答案：(1) 香港所有的建築屋頂總共能安裝多少太陽能光伏系統? (2) 這些屋頂光伏系統每年可以產生多少電力? (3) 光伏系統生成的電力占全香港耗電量的比例是多少? (4) 限制香港光伏產業發展的主要原因是什麼? (5) 哪些補貼政策比較適合香港的光伏產業發展? (6) 怎樣確定政府補貼力度? (7) 發展屋頂太陽能光伏發電能帶來怎樣的環境和能源效益? 因此，本研究的目的就是尋找以上問題的答案並為政策制定者提供相關的政策建議與措施以促進太陽能光伏產業在香港的快速發展。

首先，通過機載雷達數據與空間分析相結合我們對全香港適合安裝光伏系統的總屋頂面積進行了預估並建立了一套使用地理資訊系統來確定適合安裝光伏系統的屋頂面積的方法。適合安裝光伏系統的屋頂面積的提取和統計是根據建築形狀完成的，並且在這個識別和提取過程中使用了 5 種評判標準，即地面特徵、屋頂圍欄、陰影遮擋、屋頂傾斜角以及最小許可安裝面積，來過濾不適合安裝光伏系統的屋頂面積。最後得到全香港適合安裝光伏系統的總屋頂面積，即可供光伏有效利用的總屋頂面積，約為 39.2 $km^2$。

根據可供光伏有效利用的總屋頂面積，在考慮陣列之間間距的條件下預計全香港光伏屋頂系統的安裝潛力約為 4.67 GWp，其每年的發電潛力約為 4679 GWh，相當於 2014 年全香港總耗電量的 10.7%。此外，通過取代等量的傳統化石能源電力，屋頂光伏系統產生的電力每年可以減少約 300 萬噸溫室氣體排放。

我們對於發展建築一體化屋頂光伏系統所帶來的能源和環境收益進行了深入研究。研究結果表明香港不同類型屋頂光伏系統的能源回收期和溫室氣體排放回收期分別

為 1.9-3.2 年和 1.45-2.3 年，二者均遠遠短于光伏系統 25 年的生命週期。光伏系統的能量產生率約為 9.4-16.2 倍，意味著在整個生命週期內光伏系統產生的能量至少是所消耗的能量的 10 倍。

儘管香港發展建築一體化屋頂光伏系統的潛力很大，但是其發展速度相當緩慢。截止到目前為止，累計光伏裝機容量還不足 3MW。通過研究我們發現導致香港光伏產業發展緩慢的主要原因就是光伏裝機成本過高，是中國內地光伏裝機成本的 3-4 倍。另外一個原因就是本地政府缺乏明確的光伏發電補貼政策。如果政府能夠提供合適的補貼政策並且光伏系統的裝機成本能夠逐步下降，那麼在不久的將來光伏發電一定可以與傳統電力進行競爭。為此專案最後我們就如何制定有效、合理的太陽能光伏激勵政策以及怎樣進一步降低系統的裝機成本為政策制定者提供了政策建議。總之，本專案的研究成果將有望為本地的能源政策制定者制定合理的能源政策、可再生能源發展目標以及光伏補貼政策提供理論依據和幫助。

## 1. PV-suitable rooftop area

Most previous studies focused on using different methods to assess the development potential of roof-top PV systems. The main difference between these methods is how to evaluate the PV-suitable roof area. The commonly used methods can be classified into three types, viz. assuming the roof area ratio per capita, establishing correlation between the population density and roof area, as well as aided by geographic information systems (GIS). In this project, a study of PV potential with combination of airborne LiDAR data and spatially analysis was conducted. An insolation model was first built based on the Digital Surface Model (DSM) of the study area with parameters of diffuse proportion and transmissivity in 2012. The extraction of PV-suitable rooftop areas were based on the building footprint. Shadows were masked based on the insolation model. The pixels of steeply slope, ground features and barriers on rooftop were also filtered by the decision tree method. Thus, the results were then vectorised and spatially joined, the PV-suitable areas on rooftops could be determined. The rooftop extraction results using this technology are listed in Figure 1 as an example: Figure 1 (a) shows the original image with 25 buildings roofs; Figure 1 (b) shows the extracted results with green building outlines; Figure 1 (c) displays the binary results of building roofs; Figure 1 (d) shows the ground truth data. From these figures, it is seen that the method is suitable for recognizing and extracting the rooftop area. The research results indicate that there are 233,152 buildings suitable for implementing rooftop PV systems in Hong Kong. The total PV-suitable rooftop area was estimated to be 39.2 $km^2$.

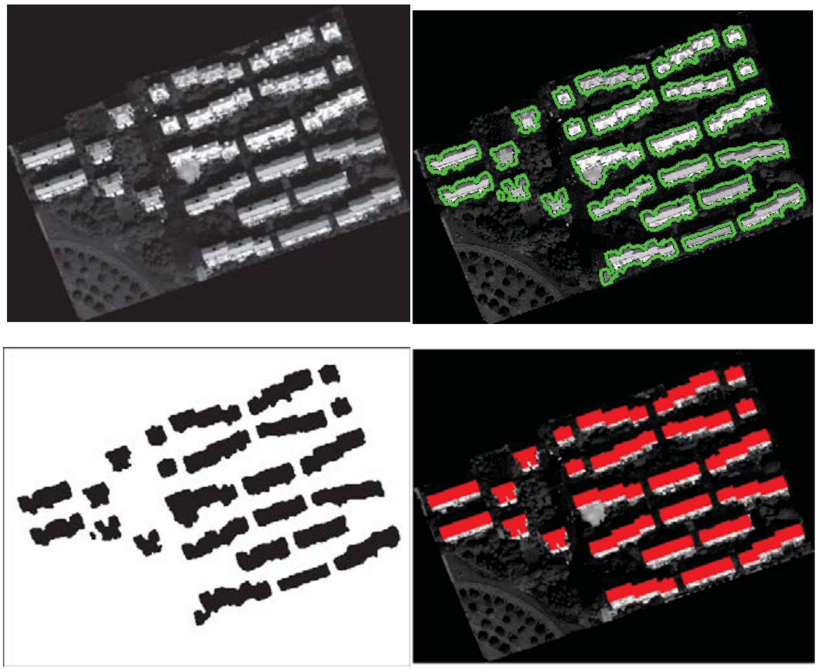

Figure 1 The extracted final results of the proposed model: (a) shows the original image with 25 building roofs; (b) shows the extracted results with green building outlines; (c) displays the binary results of building roofs; (d) shows the ground truth data.

## 2. The optimum tilted angle for rooftop PV installation

The energy output of a PV system is directly determined by solar irradiation received by the PV modules, thus such modules should be installed with the optimum orientation and titled angle to maximize the PV system' energy output. Most observatories, however, only offer total solar radiation data on a horizontal plane. Thus, it is necessary to transfer the total solar radiation on a horizontal surface into the incident solar radiation on any sloping surface and then find the optimum tilted angle for rooftop PV installation. The hourly total solar radiation incidence on a tilted surface, $G_{tt}$ (W/m$^2$), can be expressed as follows:

$$G_{tt} = G_{bt} + G_{dt} + G_r \tag{1}$$

where, $G_{bt}$ is the hourly beam solar radiation incidence on a tilted surface, W/m$^2$; $G_{dt}$ is the hourly diffuse solar radiation incidence on a tilted surface, W/m$^2$; and $G_r$ is the hourly reflected solar radiation, W/m$^2$. $G_{bt}$ and $G_r$ can be given by the following equations, respectively [1].

$$G_{bt} = G_{bh} \times R_b = G_{bh} \times \frac{\cos\theta}{\cos\theta_z} \tag{2}$$

$$G_r = \frac{\rho_o}{2} \cdot G_{th} \cdot (1 - \cos\beta) \tag{3}$$

where $G_{bh}$ is the beam radiation incidence on the horizontal surface, it can be extracted from the total horizontal radiation of $G_{th}$ (provided by the Observatory); $\theta$ is the angle of incidence; $\beta$ is the slope angle of PV modules; $\theta_z$ is the zenith angle; $\rho_o$ is the ground reflectance.

In this study, the Perez model is adopted to simulate the diffuse solar radiation incidence on any tilted surface. In the Perez Model, the diffuse solar radiation incidence on a tilted surface can be calculated by equation (4) [2-3]:

$$G_{dt} = G_{dh} \cdot \left[ (1 - F_1) \cdot \left( \frac{1 + \cos\beta}{2} \right) + F_1 \cdot \frac{a}{b} + F_2 \cdot \sin\beta \right] \tag{4}$$

where, $G_{dh}$ is the diffuse solar radiation incidence on the horizontal surface, it can be extracted from the total horizontal solar radiation, $G_{th}$.

In order to maximize the annual solar radiation received by the rooftop PV module, a FORTRAN program was developed based on the above mathematic models to find the optimum tilted angle for rooftop PV installation. The simulated solar irradiance incidence on various tilted surfaces of south-facing orientation from 1998 to 2007 was obtained. It is found that the optimum tilted angle for rooftop PV installation in Hong Kong is 23 degree and accordingly the average usable solar radiation is about 1333 $kWh/m^2 \cdot yr$ during the ten years. Thus, the potential rooftop PV system in Hong Kong is recommended to be installed with this optimum tilted angle to maximize the annual energy output.

## 3. Installation potential of rooftop PV systems

In all previous studies concerning the estimation of PV installation potential, the issue of probably partial shading caused by the front rows of PV modules was not considered. In a real system however, certain space has to be reserved between the front and back rows to eliminate such partial shading effect. In this study, the array distance between the front and back rows was determined by making sure that there is no partial shading caused by the front row of PV modules between 9:00 AM to 3:00 PM during the winter solstice in Hong Kong. Figure 2 shows the schematic diagram to calculate the array distance between the front and back rows of PV modules. From this figure, it is seen that the array distance of the PV modules installed with the optimum tilted angle (23 degree in Hong Kong) can be calculated as follows [4]:

$$D = \cos\gamma \times L \tag{5}$$

where, D is the reserved distance between the front and back rows; $\gamma$ is the solar azimuth angle at 9:00AM during the winter solstice in Hong Kong. This can be calculated by equations (6) and (7); L is the projection of sun light on the roof horizontal surface.

$$\sin\gamma = \cos\delta \sin\omega / \cos\alpha \tag{6}$$

$$\gamma = \arcsin(\cos\delta\sin\omega/\cos\alpha) \tag{7}$$

where $\delta$ is the winter solstice solar declination; $\omega$ is the winter solstice hour angle at 9:00AM ; $\alpha$ is the solar altitude angle, which can be calculated as follows:

$$\sin\alpha = \sin\varphi \sin\delta + \cos\varphi \cos\delta \cos\omega \tag{8}$$

$$\alpha = \arcsin(\sin\varphi\sin\delta + \cos\varphi\cos\delta\cos\omega) \tag{9}$$

where $\varphi$ is the latitude of Hong Kong. The projection of sun light on the roof horizontal surface can be calculated by equations (10) and (11).

$$L = \mathrm{H}/\tan\alpha \tag{10}$$

$$H = \mathrm{W} \times \sin\beta \tag{11}$$

where H is the installation height of PV module; W is the width of PV module; $\beta$ is the optimum tilted angle.

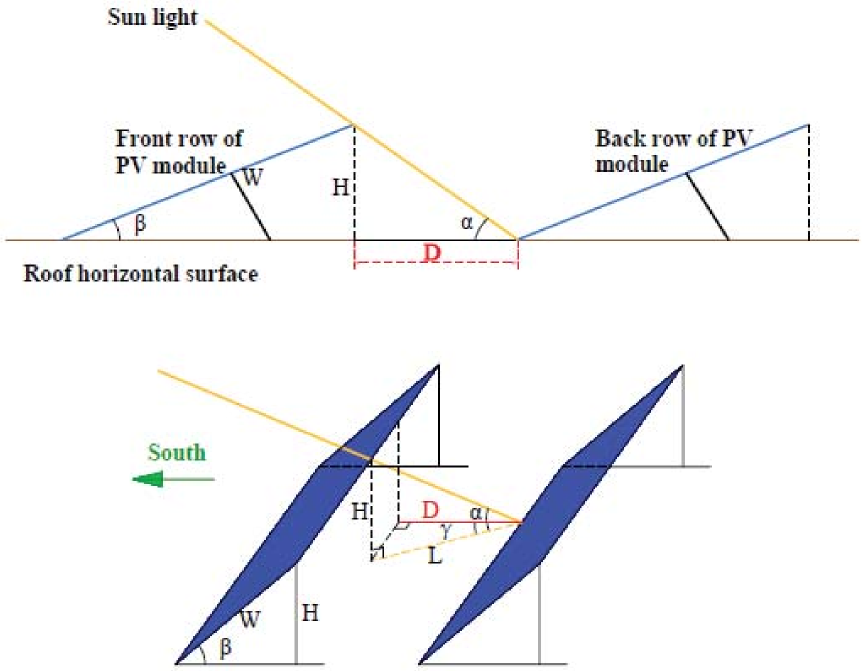


Figure 2 The schematic diagram to calculate the array distance

Thus, in order to make sure there is no partial shading between the front and back rows of PV arrays during the winter solstice in Hong Kong, the layout of PV arrays should be kept at a distance of 514 mm between the front and back rows when the PV modules are installed with the optimum tilted angle.

After taking the reserved array distance into account, installing a single standard PV module would occupy about 2.35 $m^2$ of the rooftop areas. The total active area of the rooftop PV modules can be calculated by equation (12)

$$A_{act.} = \frac{A_{pot.}}{A_{occu.}} \times A_{pv} \quad (12)$$

where, $A_{act.}$ is the potential total active area of PV modules; $A_{pot.}$ is the potential PV-suitable rooftop area in Hong Kong; $A_{occu.}$ is the installation occupancy area of a single PV module; $A_{pv}$ is the area of a single PV module. For rooftop PV application, the potential total active area of PV modules installed with the optimum tilted angle of 23° was calculated to be 27.5 $km^2$. Thus the potential installation capacity of rooftop PV system is estimated as 4.67 GWp in Hong Kong. The potential of annual energy output of rooftop PV system can be briefly estimated by the following equation:

$$E_{potential} = A_{act.} \times G_{optimal} \times \eta_{stc} \times \lambda \quad (13)$$

where $E_{potential}$ is the Hong Kong annual potential energy output of rooftop PV systems; $G_{optimal}$ is the annual total solar radiation received by the PV modules installed with the optimum tilted angle, it is about 1333 kWh/$m^2$; $\eta_{stc}$ is the PV module's energy conversion efficiency in standard testing conditions (STC), and the efficiency is 17% declared by the manufacturer; $\lambda$ is the performance ratio of PV system, it was assumed to be 0.75. The calculation result of $E_{potential}$ is about 4674 GWh for each year, which accounts for 10.7% of the total electricity use in Hong Kong in 2014 [5]. This proportion is much higher than the current set target for renewable energy development (3-4% on or before 2020) in Hong Kong. Thus, according to this result, the policy makers could develop a more positive development target for renewable energy in future and the PV technology has the potential to meet the target. It will significantly change the current energy structure in Hong Kong.

## 4. Energy and environmental benefits of PV systems

PV systems generally consume very little energy and emit little GHG during operations, thus it appears to be completely clean and with no environmental impact. However, PV technology does consume a large amount of energy and does emit a certain amount of greenhouse gases during the system's life time, such as in the manufacture of solar cells, PV modules and the balance of system (BOS), transportation, installation, retrofitting, and system's disposal or recycling [6-8]. In order to thoroughly understand the energy gains and environmental benefits of PV systems, some popular life cycle assessment (LCA) indicators, such as the energy payback time (EPBT), greenhouse-gas payback time (GPBT) and greenhouse-gas (GHG) emission rate, were used to effectively measure the sustainability and environmental friendliness of different PV systems.

The indicator of energy payback time (EPBT) is defined as the years required for a PV system to generate the same amount of energy (converted into equivalent primary energy) to compensate energy used during its life cycle [9]. The EPBT calculation equation can be presented as:

$$EPBT = \frac{E_{input} + E_{BOS,E}}{E_{output}} \tag{14}$$

$E_{\mathrm{input}}$ is the primary energy requirement of PV modules during the life cycle, (MJ); $\mathrm{E}_{\mathrm{BOS,E}}$ is the energy requirement of the balance of system (BOS) components, (MJ); $\mathrm{E}_{\mathrm{output}}$ is the equivalent primary energy savings due to PV system's annual electricity generation, (MJ).

The GPBT, as shown in Eq. 15, was defined as the total GHG emissions of the PV modules and its BOS divided by the annual GHG emissions amounts in cases of local electricity mix power plants generating power equivalent to that of the PV system. As with the estimation of energy requirement, it is a great challenge to estimate the life cycle GHG emissions.

$$\mathrm{GPBT} = \frac{GHG_S + GHG_{BOS}}{GHG_{output}} \tag{15}$$

where $GHG_S$ is the embodied GHG emissions of PV modules; $GHG_{BOS}$ is the embodied GHG emission of BOS components; $GHG_{output}$ is the annual GHG emission amounts in the cases where local mix power plants generate the power equivalent to that of the PV system.

The energy yield ratio (EYR) can be defined by the number of times the energy input can be paid back by the PV system over its life cycle [10]. This ratio can be calculated by equation (16).

$$\mathrm{EYR} = \frac{\mathrm{E}_{gen} \times \mathrm{L}_{\mathrm{PV}}}{\mathrm{E}_{\mathrm{input}} + E_{BOS,E}} \tag{16}$$

where, $\mathrm{E}_{\mathrm{gen}}$ is the equivalent primary energy savings due to annual electricity generation by the PV system; $\mathrm{L}_{\mathrm{PV}}$ is taken as the designed lifespan of the PV system; $\mathrm{E}_{\mathrm{input}}$ is the equivalent primary energy input over the life cycle; $\mathrm{E}_{\mathrm{BOS,E}}$ is the energy requirement of the balance of system components.

Based on the data of cumulated energy requirement, the annually generated electricity and GHG emission rate, the indicators of EPBT, GPBT and EYR of the 5 studied rooftop

PV systems in Hong Kong, were calculated and are presented in Figure 3. From this figure, it can be seen that in Hong Kong the EPBTs and GPBTs of the studied rooftop PV systems installed with the optimum inclined angle range from 1.9 - 3.2 and 1.45 - 2.3 years, respectively. These statistics are all much less than their lifespans of 25 years. In addition, every year about 2,994,560 tons of GHG emissions can be avoided by replacing the equivalent local electricity mix with the potential PV electricity (4674GWh) generated by rooftop PV systems in Hong Kong. Thus it appears to be possible that the rooftop PV system can play a significant role in energy saving and reducing GHG emission in Hong Kong.

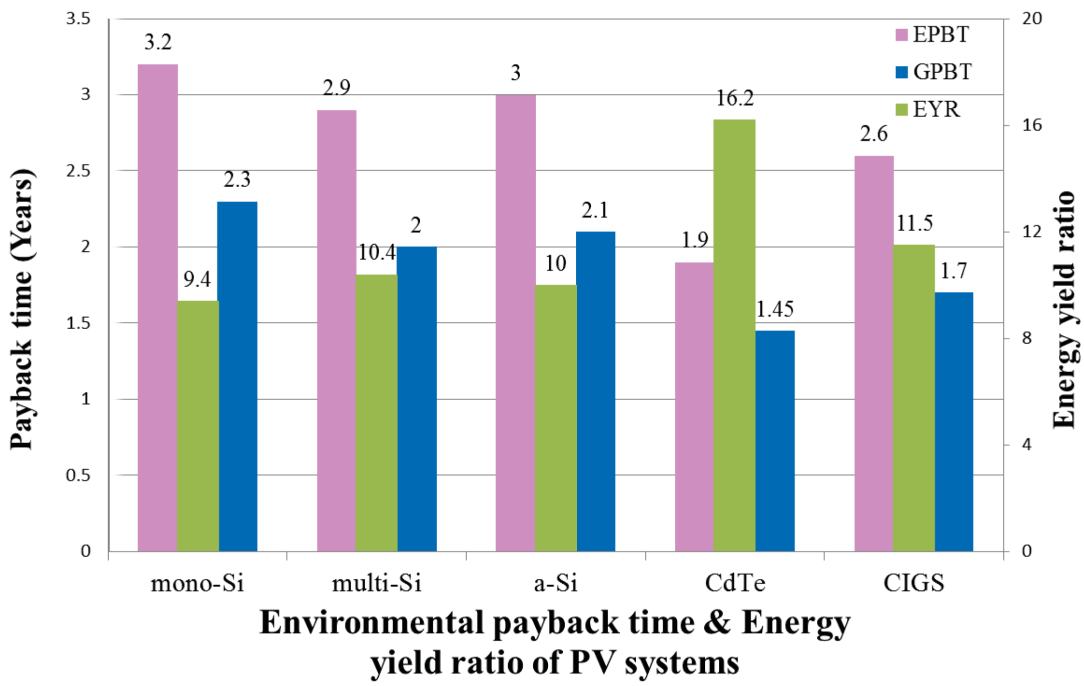


Figure 3 EPBT, GPBT and EYR of rooftop PV systems in Hong Kong

The EYRs of the studied 5 PV systems range from 9.4-16.2, which indicates that PV systems in Hong Kong can generate approximately at least 10 times of energy requirement during their lifetime. Thus, PV technologies can be definitely regarded as a sustainable energy source.

## 5. Installation cost and levelized cost of energy

In order to further investigate the PV systems' installation cost in Hong Kong and Mainland China as well as giving valuable suggestions to policy makers, project contractors and customers, much information regarding the details of installation costs was collected. The average PV installation cost in Hong Kong is approximately \$5.6/Wp, which is about 3 times higher than that in Mainland China (\$1.37/Wp). A comparison of average installation cost in different countries and regions, such as Mainland China, Germany, the United States and Hong Kong, is presented in Table 1. Compared with

Mainland China and Germany, the main cost differences for Hong Kong are the result of some hardware costs (except for PV module and inverter) and soft costs such as labour costs, project permission and coordination fee, operating overhead and supply chain costs. In addition to the relatively high installation cost, it is worth note that almost no subsidy is currently supplied to the PV industry in Hong Kong. The main reason that the PV industry can develop rapidly in other countries, especially Germany, is the vigorous support and subsidies provided by the governments during its early development stage. Local policy makers should consider paralleling this approach and providing appropriate subsidies or preferential feed-in tariff to increase users' enthusiasm regarding PV systems installation.

Table1 A comparison of average installation cost of rooftop PV systems in Hong Kong and other countries [11]

| Countries & Regions / Cost items | Mainland China | Germany | US | Hong Kong |
|---|---|---|---|---|
| PV module ($/Wp) | 0.7 | 0.8 | 0.8 | 0.8 |
| Inverter ($/Wp) | 0.15 | 0.33 | 0.40 | 0.5 |
| Other hardware [1] ($/Wp) | 0.22 | 0.33 | 0.55 | 1.7 |
| Soft costs and profit [2] ($/Wp) | 0.3 | 0.72 | 3.15 | 2.6 |
| Total costs ($/Wp) | 1.37 | 2.18 | 4.9 | 5.6 |

Usually, a levelized cost of energy （LCOE） can be used to assess the economic feasibility and completeness of an energy technology. LCOE can be thought of as the price at which this kind of energy must be sold to achieve cost-recovery over its life cycle. It presents as a net present value in terms of cents/kWh. The LCOE of a PV system can be calculated according the following equation [12].

[1] Other hardware includes cable，cable connection, steel support，switches, combiner boxes, monitor system and so on.

[2] Soft costs and profit include labour costs, project coordination fee, operating overhead, supply chain costs, permitting, interconnection and inspection costs, as well as contractor's profits.

$$LCOE = \frac{Q_{ic} + \sum_{n=1}^{N} \frac{Q_o}{(1+\gamma_{dr})^n} - \frac{R_v}{(1+\gamma_{dr})^n}}{\sum_{n=1}^{N} \frac{E_i \times (1-\eta_{dr})^n}{(1+\gamma_{dr})^n}} \quad (17)$$

Where, $Q_{ic}$ is the initial cost; $Q_o$ is the annual operation & maintenance cost; $\gamma_{dr}$ is the real discount rate; $R_v$ is the residual value; $E_i$ is the energy output of a PV system in the first year; $\eta_{dr}$ is the PV system's degradation rate. The LCOE of PV system is proportional to installation costs and it decreases with the reduction of installation costs.

In this study, the LCOE of rooftop PV systems in Hong Kong was calculated. It was about 24.1 cents/kWh, which is calculated by the current average installation cost of $5.6/Wp. Currently, the domestic electricity price in Hong Kong is about 13.8-24 cents/kWh depending on the amount of electricity consumption [13]. While with the price rising of fossil fuels, the domestic tariff would rise about 3-4% annually. Thus even calculated with the current installation cost, the LCOE of PV systems in Hong Kong is probably lower than the retail electricity price in near future.

With the costs of PV modules and inverters further decreasing, the installation cost in Hong Kong would probably reduce to equal that in Mainland China, hence, the LCOE of 6.4 cents would fully compete, without subsidy, with other traditional energy sources. If the environmental benefits of PV electricity, such as much lower GHG emission rates, are considered, the advantage and competitiveness of PV electricity would be stronger. The above findings are another encouragement to policy makers to develop related measures or policies to further reduce the soft costs of PV systems as well as provide a suitable subsidy or feed-in tariff.

## 6 Policy implication and recommendation:

To promote the rapid development of PV industry in Hong Kong, the following suggestions were recommended to the policy makers to set effective and reasonable PV subsidies as well as to reduce the installation costs.

### (1) Government subsidies:

The main reason restricting the development of PV applications in Hong Kong is the very high installation cost, which is nearly 2 times higher than that in Germany and 3 times higher than that in mainland China. The higher installation cost results in the higher levelized cost of PV electricity (LCOE) in Hong Kong, which is more than 24 cents USD/kWh, while the domestic tariff varies from 13.8 cents to 24 cents USD/kWh in present in Hong Kong. In order to stimulate PV development, the government should firstly manage to shrink the gap between the LCOE and the domestic tariff.

According to review results of incentive policy instruments in leading countries, we propose that the incentive policies setting in Hong Kong could follow the following strategy. Firstly, the government provides generous investment and installation subsidies to PV investors or users at the initial stage to increase their enthusiasm in installing PV systems as well as expand the PV application scale. With the increasing of PV capacity, the installation cost must go down due to the scale economic effect and thus the rate of installation subsidy can be reduced year by year. When the PV installation capacity reaches a certain scale and attracts wide public interest, the government can abolish the installation subsidy and carry out the incentive of PV feed-in tariff as a replacement because the PV feed-in tariff is more effective to stimulate the users' enthusiasm in responsibly operating and maintaining their PV systems. With the continuous decrease of installation costs, the feed-in tariff subsidy can also be reduced year by year and finally be cancelled until the PV electricity can fully compete with the traditional coal-fired electricity without any subsidies.

**(2) Reducing installation costs:**

i. Introducing more intense competition mechanisms, such as opening up the PV companies and labour in Mainland China to install PV systems in Hong Kong, to compress the relatively high profit margins of local suppliers and contractors.
ii. Training workers and engineers to improve work efficiency and developing more efficient installation methods.
iii. Simplifying the processes of grid-connection and reducing the relevant soft costs as much as possible.
iv. Effectively attracting private capital and foreign investment (mainly the famous PV suppliers or investors in Mainland China) to develop rooftop PV power plants in Hong Kong by the way of energy management contract (EMC).

**Reference:**

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