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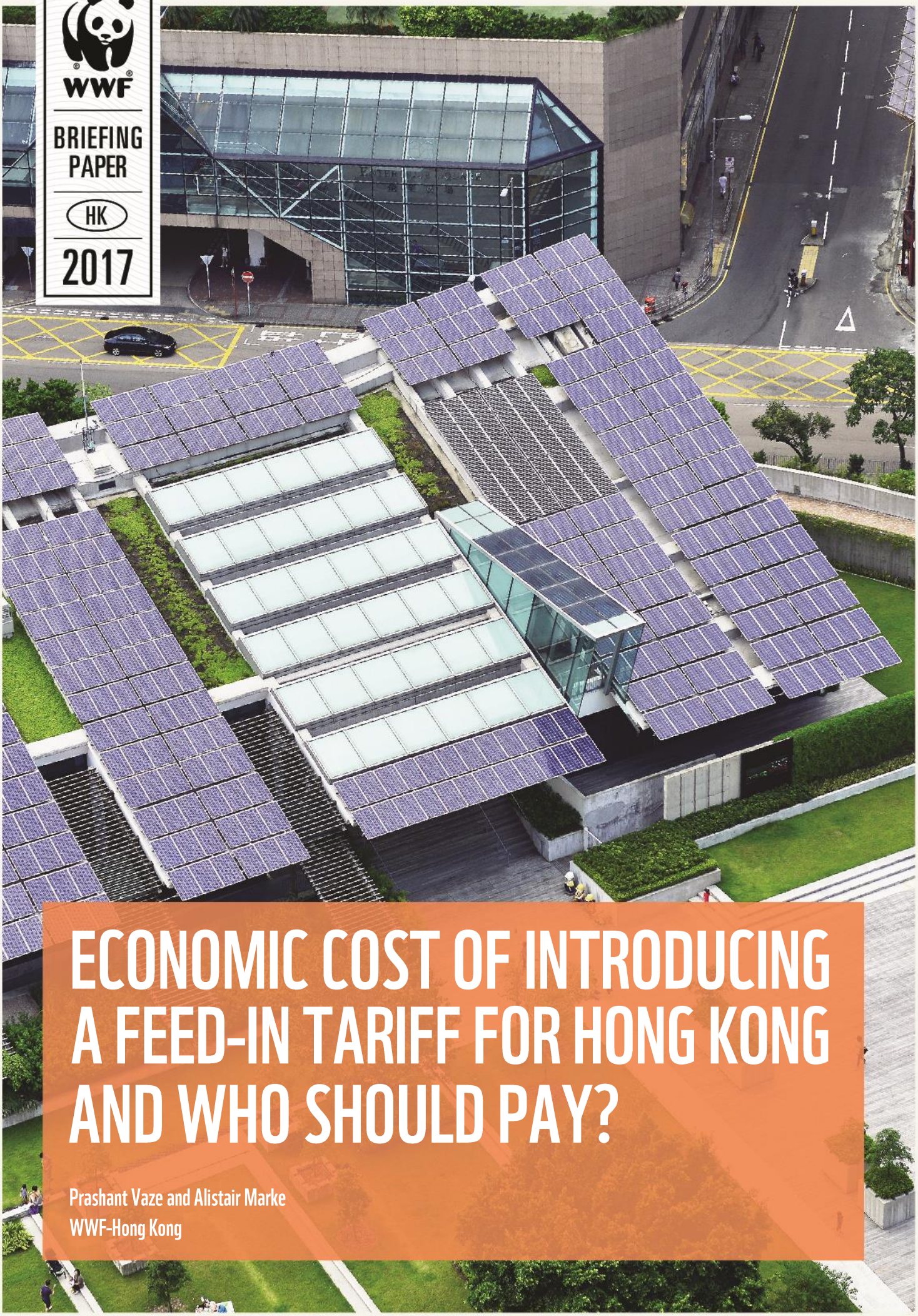

ECONOMIC COST OF INTRODUCING A FEED-IN TARIFF FOR HONG KONG AND WHO SHOULD PAY?

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CONTENT

EXECUTIVE SUMMARY

Hong Kong, unlike almost every other developed economy, has neither a target nor an effective incentive mechanism for deploying renewable electricity (RE). In April 2017, Government and the two power companies signed new Scheme of Control Agreements which will see the introduction of renewable energy certificates and feed-in tariffs (FiT) to stimulate private sector investment in RE. In this paper WWF-Hong Kong assesses the opportunities and costs of using the FiT to develop solar PV. WWF-Hong Kong also supports the use of FiTs to deploy other RE technologies like wind and electricity from biological wastes.

The FiT is popular incentive mechanism internationally: Mainland China, Germany, UK, Taiwan, some USA states and Japan all use it to support small-scale renewables like solar PV. The FiT shields investors from volatility in electricity prices over the investment's 20-year time horizon, and the level of FiT provides investors with a reasonable return on their investment. Typically FiT payment rates are set at an introductory level well above the retail price of electricity for pioneer investors, but the rates paid to later investors drop as the domestic installer industry gains experience and technology becomes established. In UK and Germany the level of payment for power generated from solar PV started at levels of around $4/kWh (per unit) three times greater than the retail price, but within a few years payment had dropped to below the retail price of electricity. Once mature, solar PV investors do not need subsidy, but the continued existence of the FiT framework remains important as it provides a predictable and fixed price, guaranteed access to the grid and simple rules allowing correctly installed solar PV to quickly connect to the grid. Even without the "subsidy" element, the predictability of the revenue makes investment easier to finance.

There have been a number of studies estimating the potential for solar PV in Hong Kong. The most comprehensive, making use of LiDAR images of building surfaces, estimates that if all open areas, and suitably sized, unshaded roofs are utilised the equivalent to 12.6% of Hong Kong's 2014 electricity demand could be met by solar. This study does not take account of the contribution reservoirs, currently being trialled in Hong Kong, might make. If a third of the area of local reservoirs were installed with solar panels and this were added to the results, then 16.1% of Hong Kong's demand could potentially be met by solar PV. Government estimates solar could supply 1.5% of electricity demand by 2030; WWF-Hong Kong considers this overly cautious, and recommends that Government should set a 5% target from RE by 2030. This should be easily achievable with appropriate policies. A FiT could also be used to support off-shore wind and energy from biological wastes.

WWF modelled the cost of a solar FiT introduced at $4/kWh in 2019 and reduced in line with the trajectory witnessed in Germany and UK. Over the period of 2019-28 the cost of the FiT payments would be $9.7 billion if 3.2% electricity were generated from solar PV and $19.48 billion if 6.3% were generated from solar PV. This represents an additional 1.9% or 3.8% to average electricity costs over the ten-year period.

If deployment of solar PV meets 6.3% of demand the cost is much lower than the saving in electricity bills from cutting the rate of return (RoR) on their investments received by power companies from the present value of 9.99% to 8% as agreed in the new SCAs. This means that the pressure on consumer bills from the FiT will be less than the relief in pressure on bills from the reduction in the RoR from the 2008 SCA to the new SCA.

Our study shows RE has the potential to make a sizable contribution to meeting Hong Kong's electricity demand. The cost of a feed-in tariff is likely to be less than 5% of spending on electricity. Given the reduction in the rate of return agreed in the SCA consumer prices would not be impacted. WWF-Hong Kong recommends:

- Government to set a target for Hong Kong to reach at least 5% RE by 2030 which the WWF believes can easily be met,
- SCA to introduce a FiT for households' and private companies' RE with an introductory level of $4/kWh for solar PV,
- Clear and simple set of codes to allow small generators to connect, an obligation on power companies to connect suitably certified small generation and a guaranteed grid access,
- This could be funded by the reduction in RoR agreed in the Scheme of Control. This means there is no increase in consumer bills as a result of the new FiT policy,
- Government to facilitate an inclusive solar PV deployment available to residents in all sorts of different building. This will require generous grants for 120 pioneering installations to trial solar PV on their buildings, and
- Government and power companies should make maximum use of the new Eco-Building Fund to finance cost-effective energy efficiency solutions in buildings along the lines of those supported by the Building Energy Efficiency Fund that was operated by the Hong Kong Government

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1. OBJECTIVES

The Hong Kong Government in its *Climate Action Plan 2030+*[1] signalled its intent to introduce the feed-in tariff and/or renewable energy certificates (RECs) so as "to create the conditions to facilitate the private sector adopting renewable electricity (RE)". On 26 April 2017 Government and the power companies signed the new Scheme of Control Agreements (SCA) covering the period 2018-2033. The new Agreements introduce the feed-in tariff and the Renewable Energy Certificate (REC) to Hong Kong. Both mechanisms are found in other countries. The Feed-in tariff pays RE investors a fixed tariff for electricity they generate for an agreed number of years. This price is decoupled from future retail price of power. The REC allows the two companies to sell certified RE generated locally to customers who chose to pay a premium for 'green electricity'. Any revenue raised from selling these RECs offset operational costs borne by electricity companies rather than adding to profits.

WWF-Hong Kong has undertaken this analysis to inform the level of ambition and the detailed policy design of the FiT and ensure that Hong Kong is realistic and suitably ambitious in setting its RE policy.

This briefing paper specifically concentrates on the feed-in tariff (FiT) policy instrument and focusses on solar PV RE technology. This policy instrument and technology in combination have allowed households, businesses and small investors world over to participate in electricity generation. Other RE technologies that could be deployed in Hong Kong particularly off-shore wind and energy from bio-wastes are outside the scope of this paper. WWF-Hong Kong believes that the policy environment should be amended to allow these RE technologies to also play a full part in electricity generation and should enable them to export power to the grid and receive a fair price for any RE they generate.

WWF hopes this paper provides useful input to the Hong Kong Government and the power companies in their consideration of the level to set the FiT through the SCA.

THE OBJECTIVE OF THIS BRIEFING PAPER IS TO UNDERSTAND THE ECONOMIC IMPACT OF INTRODUCING A FIT TO SUPPORT SOLAR PV. THE SPECIFIC RESEARCH QUESTIONS ARE:

- What different policy mechanisms are used in other countries to incentivise RE?
- How much electricity could be generated using solar PV?
- What level of FiT is needed to stimulate RE in Hong Kong?
- In total how much would a FiT policy cost the people of Hong Kong?
- How might this cost be shared between electricity customers, power companies and Government?

2. FINANCIAL INCENTIVES FOR RENEWABLE ENERGY

When RE is first introduced into a new market, like Hong Kong, incentives are needed to help projects compete with fossil fuel generation. These are needed for two main reasons. Firstly, technologies like solar PV or wind though well-established elsewhere in the world, are initially expensive to deploy in a new market; in a few years with the correct support local deployment costs should fall. Secondly, RE suffers relative to fossil fuel power plant because of its cost structure. RE has high capital costs and low running costs, this contrasts with technologies like gas which has low capital costs and high running costs. This feature of RE means investors face financial risks due to their exposure to uncertain electricity prices (which tend to reflect global fossil fuel prices) much more than fossil fuel plants which have the option of cutting production and saving on their running costs when power prices fall.

Governments around the world have assisted RE by developing to several types of incentive. These incentives are either applied to operating expenditures or capital expenditures.

OPERATING INCENTIVES

Developers receive operating incentives when they successfully generate renewable electricity, increasing the price received per unit of electricity sold once the RE plant is successfully operating. These either reduce the unpredictability of power prices (derisking) or by increase the average level of price paid for RE generation. The investor still has to bear all the financing and construction risks. As renewable technologies have become more mature, and are perceived as less risky by the investor community incentives have tended to switch from capital to operating incentives.

Operating incentives typically reward renewable project on a per kilo-watt hour generated basis, increasing the financial reward the renewables project receives for successfully generating renewable power.

TAXES ON FOSSIL FUELS AND EMISSIONS TRADING SCHEMES

Many countries have created policies to price carbon. These are not specifically designed to aid RE but to increase the cost of using fossil fuels; they have the incidental impact of aiding renewable energy.

Increasing taxes on fossil fuels increases the price of electricity generated from fossil fuels, which determines the price received by renewable electricity. This can level the playing field for renewable energy sources. Closely related to this type of incentive is the removal of fossil fuel subsidies. By altering the price of fossil fuels they indirectly benefit RE schemes to reducing the amount of fossil fuel demanded. Several countries around the world have implemented environmental emissions trading schemes (like the EU-ETS) which in the EU include power generation within the participating industries.

ENERGY PRODUCTION PAYMENT

Energy production payments consist of payments from the government to renewable energy developers per unit of energy produced. The feed-in tariff is a type of energy production payment. China's Ministry of Finance has introduced a set of rules that specify the subsidy level for renewable energy electricity.

RENEWABLE PORTFOLIO STANDARD

Some jurisdictions oblige electricity utilities to source an annually increasing share of their power sales from RE. This means the utility has to invest in, or purchase from third parties a certain amount of renewable electricity. Typically the utility will directly invest in green power generation itself, or enter into power purchase agreement with renewable generators buying the renewable electricity they generate. The Renewable Portfolio Standard is found in many states of USA, in South Korea and historically in Japan. Japan switched to a feed-in tariff system for plant commissioned after 2012.

RENEWABLE ENERGY CERTIFICATES

Some countries operate a system of certifying green electricity production and a market for trading it. Electricity suppliers are obliged by Government to surrender a certain number of these certificates every year, or otherwise pay a buy-out price or fine. Government can fine-tune the incentive effect by varying the amount of certificates that a kWh of green electricity gives rise to by technology. A less mature technology like off-shore wind would be given more certificates per kWh than a mature technology like biogas. The UK has operated such a scheme since 1990 but it is closed to new renewable generators in March 2017 and was replaced by an auctioned feed-in tariff contract for difference scheme, where the developer is paid the difference between a strike price and a representative wholesale power price. This complex scheme is intended for large scale renewables.

PRODUCTION TAX CREDITS

Production tax credits provide income tax deductions or credits at a set rate per kWh produced by renewable energy projects. For example, the US Federal Government has a Renewable Electricity Production Tax Credit that applies to most types of renewable energy, at a set rate of 2.2¢/kWh for wind, geothermal, and closed-loop biomass, and 1.1¢/kWh for other eligible technologies. This effective mechanism has been vulnerable to debates over its renewal, which in the US has been an annual decision.

INVESTMENT INCENTIVES

Some policies help investors during the construction phase of the renewable project. They are particularly important when investors find it difficult to raise capital for a renewable project because the technology is new and the capital costs are highly uncertain, or because credit is hard to come by in that country. Over 53 countries offer some types of direct capital investment subsidy, grant, or rebate.

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CAPITAL SUBSIDY, GRANT OR REBATE

Capital subsidies, grants or rebates are one-time payments used to subsidise the capital costs of a renewable investment. For example, Tunisia passed a law that provided a capital subsidy of 20% on solar water heating capital costs to make it competitive with liquefied petroleum gas.

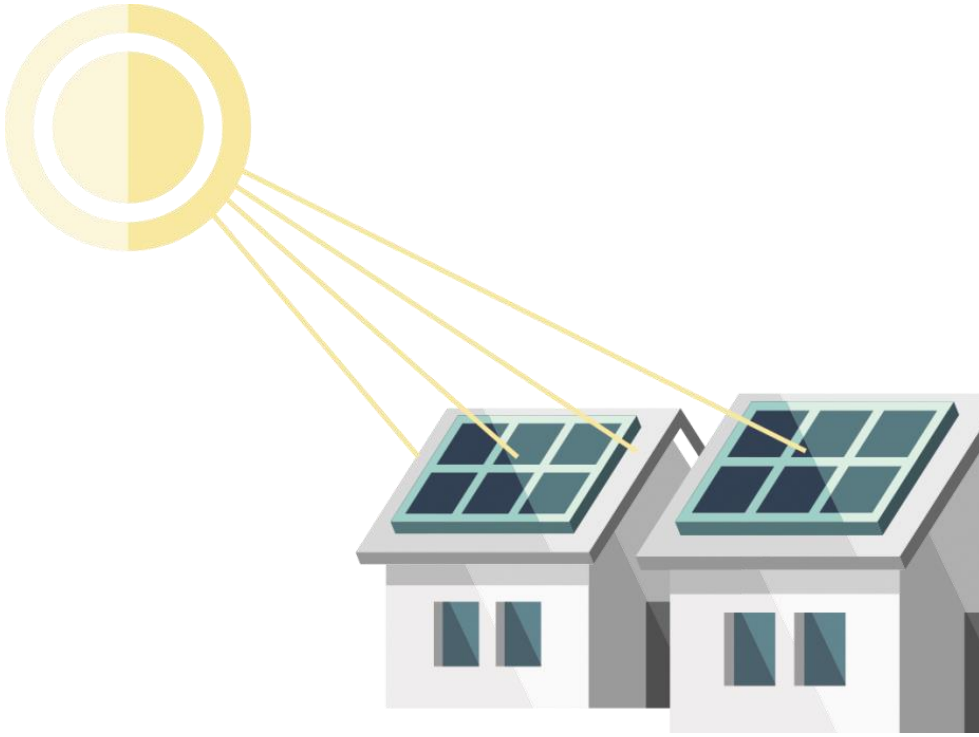
INVESTMENT TAX CREDITS

Investment tax credits provide income tax deductions or credits for some fraction of the capital investment in the renewable energy facilities. For example, the US Federal Government has a Renewable Electricity Investment Tax Credit that allows renewable energy companies to receive a cash grant of up to 30% of their capital investments.

PUBLIC INVESTMENT, LOANS, OR GRANTS

Public investment, loans or grants are interventions by government for the provision of no- or- low-interest loans and grants. For example, in India, the UNEP and two large banking groups launched as four-year $7.6 million effort in 2003 to provide low-interest loans to help finance solar home systems in southern India. This program has disbursed 19,533 loans. In a number of US states, reduced property or other taxes have been offered to attract renewable energy manufacturing. This is suited to technologies that are already mature and little support is needed, or where the objective of the policy might be remedy other problems like local political desire to create jobs, or address lack of availability of bank credit.

The feed-in tariff is by no means the only mechanism used internationally, but it is the commonest form certainly when RE is first being introduced to a country. One advantage of the FiT is that it has been road-tested in other jurisdictions and as a result gone through many design improvements.



3. FEED-IN TARIFFS

Feed-in tariffs (FiTs) are a form of energy production payment commonly used to drive investment and scale up RE. They are the commonest mechanism to reward renewable power generation around the world. The design of FiT policies typically involves three key features:

(i) An agreed long-term tariff;
(ii) Guaranteed access to the grid; and
(iii) A mechanism to finance the cost of the tariff.

AN AGREED LONG-TERM TARIFF

The electricity utility buys electricity from newly connected renewable generators at a pre-announced price set by Government. The feed-in tariff is typically paid for between 15 and 25 years and the agreement sets out how the price is revised each year – often it is indexed to inflation. Typically the price is set at the time the plant is first connected to the grid and depends on the technology and size of the plant. Plant connected a year later might be paid a lower rates of FiT to reflect improvements in technology. Existing plant continues to receive the agreed (uprated by inflation) tariff when it was first connected to reflect the higher prevailing cost of the technology when the investment was made. More innovative technologies like off-shore wind will be paid more than mature technologies like on-shore wind. The price is set so that an efficient renewable developer receives a reasonable compensation for their investment and can recoup the cost of the initial investment and make a reasonable return on their investment over the 15- 25 year duration of payment. The level of FiT for new plant is reviewed periodically to ensure that any cost savings from technological innovation or installer efficiency are passed through to consumers rather than retained as excessive returns to new RE investors.

The advantage of the feed-in tariff to the renewable investor is that they have certainty about the price they will receive over their investment horizon. The price is decoupled from the prevailing retail and wholesale prices of power so the RE developer is not exposed to volatile electricity markets. This means that efficient renewable developers with good quality sites are motivated to invest in plant by a relatively reliable income stream. Other support mechanisms like the renewable obligation, or taxes on fossil fuel provide more risky returns to the renewable generator as the price paid to the developer remains linked to factors like the wholesale price of electricity which is outside of their control.

As renewable technologies, especially solar PV, have become more main-stream the cost of deployment has fallen. This has allowed Government to considerably reduce the FiT for newly installed renewables. In modern FiT schemes Government pre-announces one or two years ahead how the price for newly connected plant will evolve anticipating improvements in efficiency. These are called degression factors. They encourage developers to commission the plant sooner rather than later, and to continue bringing their deployment costs down.

GUARANTEED ACCESS TO THE GRID

A key provision of the FiT is the guaranteed and free access to the grid so long as the renewable developer abides by agreed codes designed to ensure the safety and stability of the grid, and ensure that meters are tamper proof so renewable generation is reliably recorded. The absence of such agreements would result in small generators having power they supply to the grid turned down (curtailed) or require them to negotiate access to the grid on a case by case basis. This greatly increases cost and uncertainty for the developer. To encourage households to participate in electricity generation it is important to have a stream lined procedure for connecting small developers. Long lead-times for grid connection, costly or overly long procedures to demonstrate safety, or grid connection procedures that are not fully transparent can severely inhibit mass participation.

Typically Government, in collaboration with the companies that operate the electricity grid, will establish a set of rules governing access which both parties have to abide with. These might include agreeing standards for a tamper-proof metering to accurately record renewable generation, equipment to ensure that power fed onto the grid is of the correct voltage and phase and remote controls that allow the power company to disconnect the renewable generator when the electricity company is carrying out maintenance on the electricity grid. Usually a third-party, paid for by the developer, will certify that the renewable generator is abiding by these rules before they are allowed to connect to the grid.

A FiT will typically include provisions that guarantee the utility has to buy any electricity offered. This preferential access means RE generators should not be curtailed and that they displace fossil fuel plant. This is the most efficient way of using RE, and also the most environmentally friendly, but it does have a negative impact on the economics of conventional power plants which will run fewer hours a year. Luckily in Hong Kong solar PV will tend to produce its maximum output at the same time as peak power demand. Overall this helps the Hong Kong grid and reduces the need to invest in peaking plant.

A MECHANISM TO SHARE THE COST OF THE TARIFF AMONGST CUSTOMERS

The FiT is paid to the renewable generator by the electricity utility, but the cost is typically passed through to the consumer. Usually, the utility imposes a surcharge on consumer tariffs to cover the extra cost of paying the FiT to renewable generators. There is usually a mechanism setting out which class of customer ultimately pays the bill, on what basis they pay, and whether there are any exemptions. For instance in Germany energy intensive firms are exempt from paying the feed-in tariff financing levy.

The sharing mechanism might also redistribute costs between different electricity companies. So for instance if one electricity company has a disproportionate number of renewable generators attached to its grid (because its territory is very sunny or windy) customers of that company should not bear an unduly high share of the overall costs of the national policy. Instead costs are levelised over all eligible customers in the nation so they pay the same per kilowatt-hour electricity they purchase.

In European countries like Germany, UK and Spain Governments have become concerned about the overall cost of the FiT policy and so they have put in place policies to manage the overall budget. In a sense the feed-in tariff has been a victim of its own success. The simplicity of the policy coupled with the rapid reduction in the price of modules has resulted in fast take-up rates. The same has been true of on-shore wind farms.

EXPERIENCE OF GERMANY AND UK WITH 'ADVANCED' FIT REGIME

Germany first developed a feed-in tariff in 1990. In 2000 it morphed into its modern form, with different rates for different technologies based on technologies' cost. UK adopted the FiT more recently in 2010 and restricted its application to only small-scale renewables.

Figure 1 below shows how the feed-in tariff for very small-scale and larger-scale solar have declined as the price of PV modules have fallen[2], supply chains have rooted in and the installation industry becomes more efficient. In the UK the feed-in tariff for solar PV paid halved in its first two years and six years after its introduction by 2016 was barely a fifth of the initial level. In both countries the feed-in tariff levels are lower than the household price of electricity. (However in UK the way it is applied means that consumers always receive a small bonus for RE they generate and consume onsite relative to retail price).

Capacity has continued to grow in UK and to a lesser extent in recent years in Germany despite the sharp reduction in FiT rates.

By the end of 2016 Germany had 40 gigawatts (GW) of installed solar PV capacity. Renewables provide 38% of overall electricity consumption wind provides almost 16%, biomass almost 10% and solar PV 7.5%. The German growth has been remarkably successful and the goal of 'defossilising' Germany's electricity sector is understood by most of the population. More so than wind and biomass, FiTs have democratised solar PV since the simplicity of the FiT allows home or business with access to sunlit space to take-part. At the end of 2016 40% of the installed capacity was owned by individuals, 20% by business and another 20% by farm owners.

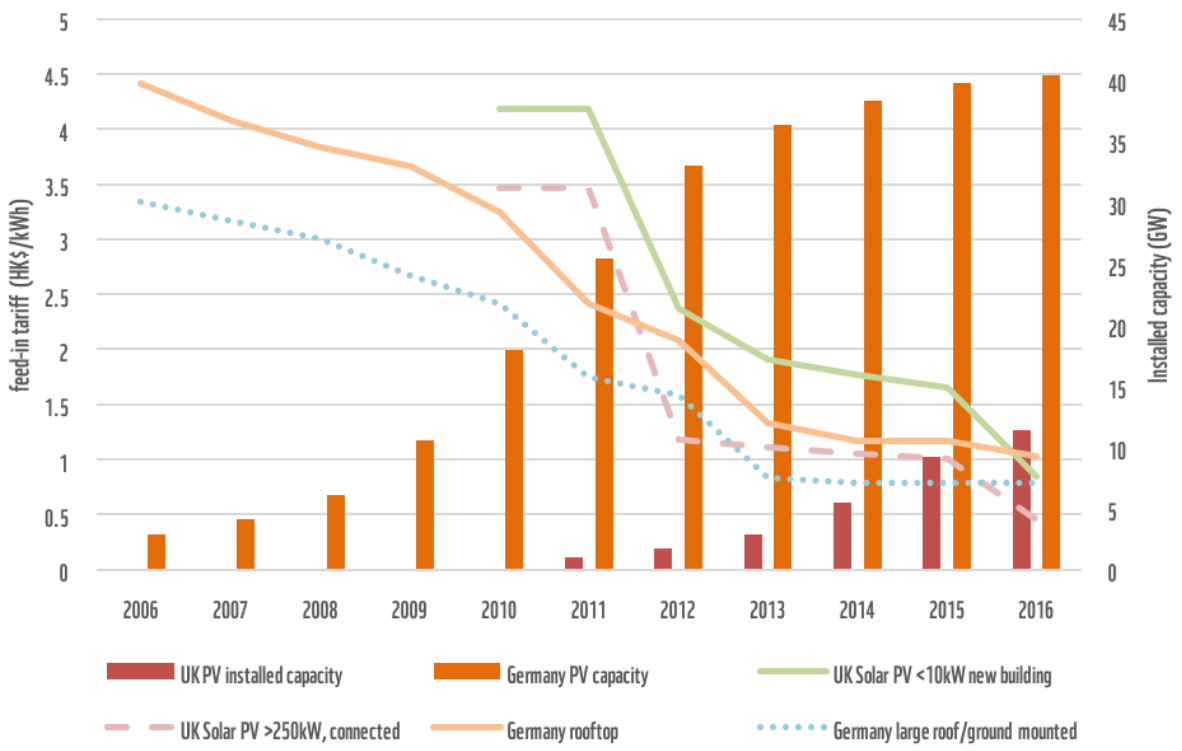
In the UK by the end of 2015, 800,000 locations had installed solar PV[3]; solar PV made up 99% of all the sites that received feed-in tariff, and accounted for 80% of capacity. In the UK, larger RE installations, chiefly wind and biomass, have been funded through a different policy instrument the Renewable Obligation.

Germany has been steadily reducing the level of the feed-in tariff. From 2020 the oldest plants will stop receiving feed-in tariffs reducing the average price paid for the policy. In the new feed-in tariff law (EEG2017) Government has set out an allowed maximum and minimum rate of growth of renewables and policies to slow down the expansion in renewables. Since 2011 large-scale German renewables reached grid parity meaning that the cost of electricity they produce is the same as the retail price of electricity. A year later roof-top solar did the same.

The German and UK experiences suggests the use of well-designed FITs is superior to alternative regulatory support mechanisms, especially when the technology is reasonably mature, and small investors comfortable risking their savings.

In summer 2016, Germany's parliament approved a plan that will change the basis for setting prices for feed-in tariff in favour of competitive auctions and clear volumes for wind energy development similar in many respects to the contract for difference being introduced in the UK. In Germany after more than a decade of support, prices for power from new renewable projects are close to new conventional generation's justifying the transition towards a more market-based approach. However, with such a high proportion of renewables the challenge of electricity storage of intermittent power becomes more significant.

FIGURE 1: FEED-IN TARIFF AND INSTALLED CAPACITY UK AND GERMANY, 2006-2016



Source: authors' calculations data from Decc, Ofgem, UK and Fraunhaufer, Germany. Current exchange rate used to convert £/€ to HK$

FINANCIAL INCENTIVES USED IN ASIA-PACIFIC COUNTRIES

Asian economies have tended to introduce RE policies later than North American and European countries, even though Taiwan, Japan and China have been important production sites for the PV modules.

Asian countries are now applying many of the design features used by Germany and UK FIT systems[4]. In Mainland China the tariff paid to generators varies between technologies, the size of the installation and the resource area because of the different climates across the country. Japan sets different tariffs according to the size of the installation. The scheme was introduced there in 2012 and has dropped steadily since its launch[5].

Not all countries use FIT schemes. South Korea now sets a Renewable Portfolio Standard on its power companies, having replaced a feed-in tariff scheme that expired in 2011. Singapore's Government has invited companies to participate in the solar leasing Solarnova programme[6]. In this programme public bodies launch a combined tender allowing social housing and other buildings to be fitted with solar PV.

Taiwan introduced the Renewable Energy Development Act in 2009 and established a FiT scheme to support, wind, solar PV, small hydro, geothermal and waste/biomass. Interestingly the PV tariffs include additional subsidy for installing high efficiency PV panels to stimulate innovation. Figure 2 shows that the rates at which the Taiwan feed-in tariff is paid have typically been lower than rates paid in Europe. Perhaps as a result the rate of deployment slower. The rate of feed-in tariff has been set to provide the investor a 5.25% rate of return which pays back the investment in 19 years, and is less attractive than the return investors in UK and Germany have received. This lower rate of return has meant that investors have had to be more selective in the locations they choose to deploy RE picking areas with lowest costs, or the highest levels of sunlight.

WWF-Hong Kong has supported the installation of three 2kW peak PV systems in village homes in Tai O, Lantau Island in Autumn 2016. The installers used modern, light-weight, highly efficient modules but the installation, connection to the grid and approval from the utility took almost three months because of the unfamiliarity of the households, installers and the utility with the processes. The total all-in cost of the installation was the around $35,000 per kW. We estimate that the panels will generate around 1120 kWh/kW installed per year. The table below shows how sensitive the cost-effectiveness of the installation is to the offered.

FIGURE 2: FEED-IN TARIFF RATES AND INSTALLED CAPACITY IN TAIWAN

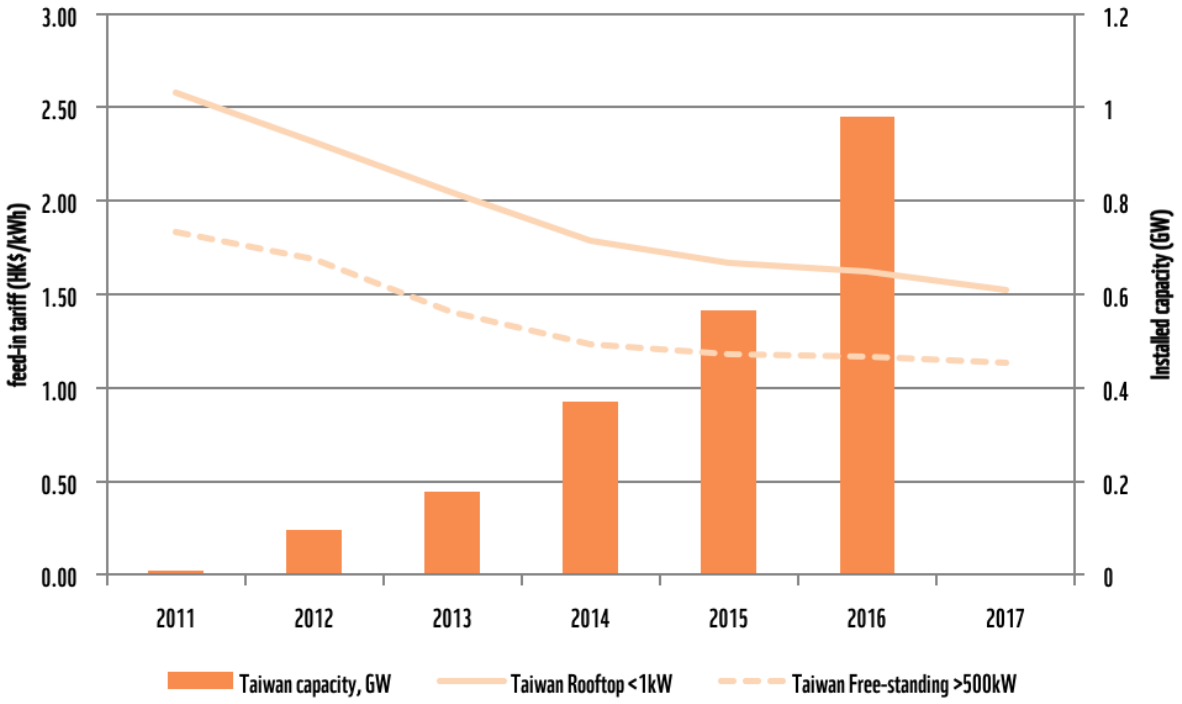


FIGURE 3: RETURN AND PAYBACK PERIOD FROM DIFFERENT FEED-IN TARIFF RATES FOR WWF-HONG KONG'S TAI O PROJECT

FIT rate	FIT Revenue	Revenue as % of cost	Payback period
$/kWh	$	%	yrs
1	1120	3.2%	31.3
2	2240	6.4%	15.6
3	3360	9.6%	10.4
4	4480	12.8%	7.8

While the industry is in its infancy here in Hong Kong, we advocate the need for a tariff of around $4/kWh to provide small household investors a reasonable payback period of 7-8 years.

LESSONS LEARNT ON THE EFFECTIVENESS OF FIT POLICIES

FiT experiences from 'advanced countries have provided some useful lessons on the effectiveness of such tariff regime.

(a) Value of the FIT should be cost-based and not linked to market price of power. This protects RE investors from fluctuations in long-run power prices driven by global fossil fuel markets;
(b) The feed-in tariff level paid for new installations need to be updated frequently to ensure that cost reduction is identified, and passed through to the final consumer.
(c) Guaranteed, non-discriminatory, straightforward access to the grid must be ensured and a purchase obligation imposed on utilities so long as the generator is certified, ideally by a third party, to meet agreed network standards;
(d) A cost recovery mechanism that is viable, transparent, explicit, and sustainable in the long term is very important; and
(e) The cost of FiT is much less an issue now than in the past as the price of solar PV modules has declined, even so it

4. DO FEED-IN TARIFFS INCREASE BILLS?

Solar PV has had a reputation for being an "expensive" technology and the FiT policy a reputation for contributing to higher energy bills. This arose largely because of the high levels of FiT that needed to be paid in the early 2000s when the technology was less mature. For instance in 2009, Germany spent approximately €13 billion for electricity from FiTs, close to €5 billion was incremental costs above average wholesale prices.

This section presents results from the WWF's modelling of the costs of supporting solar PV through a feed-in tariff.

SOLAR PV PANELS ARE NO LONGER THAT EXPENSIVE

The largest cost item in solar PV systems has traditionally been the solar modules. Between 1979 and 2015 prices of modules fell from US$200 per watt to US$1 per watt; the long term trend has been for a 22% fall in price for every doubling of installed global capacity[7]. Other elements of cost: inverters, steel frames have also become cheaper, though to a lesser extent. In most countries installation costs are also expensive initially as there is no local installer industry. But this situation changes as the industry develops creating many jobs. It should be recognised Hong Kong has high labour costs, especially in the construction sector, so small roof-top solar PV is likely to have higher construction costs than some other jurisdictions.

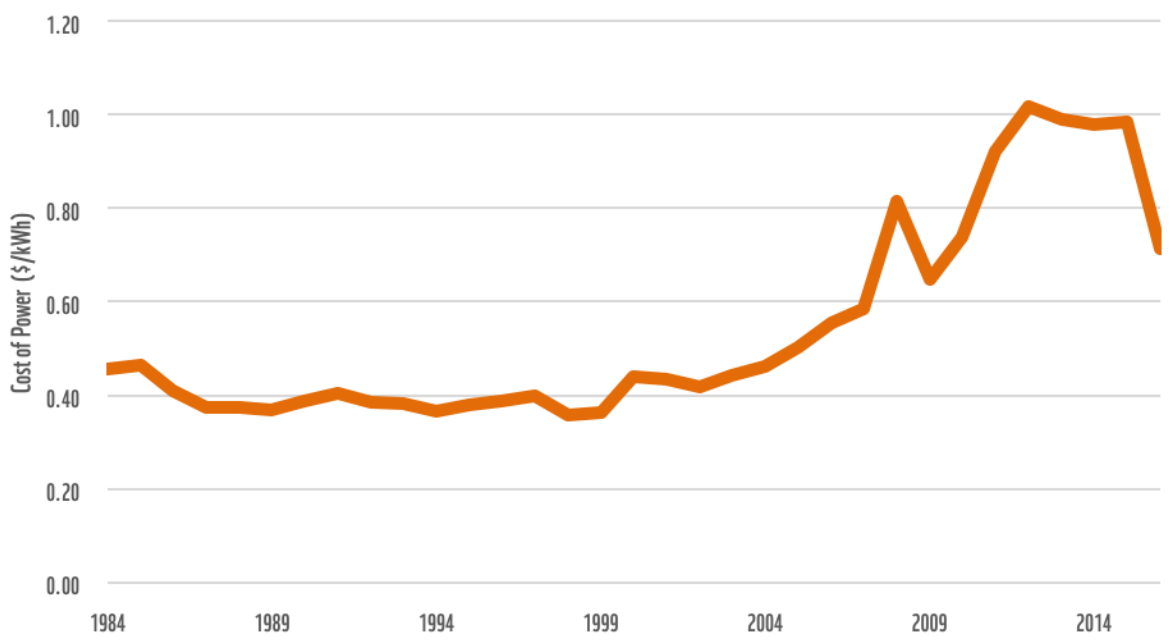
It is worth emphasising that FiT rates fell 80%-90% since their introduction in UK and Germany. Solar PV tariffs in both countries are now below the retail price of electricity. Rather than solar PV needing a subsidy relative to retail price of electricity, solar PV now imposes only an indirect rather than actual cost in the sense that the utility has to provide back-up for solar PVs' and winds' intermittent generation. These have started to become an issue in Germany where the rates of RE penetration are very high. These are unlikely to be a problem in Hong Kong because its high population density means that domestically generated RE is unlikely to ever comprise a sufficient share of overall generation that intermittency threatens the utilities ability to balance supply and demand.

HIGHER GLOBAL GAS PRICES

It is worth remembering that increased reliance on gas is not a cheap option. The Government's preferred option of expanding the fleet of CCGT plant entails substantial investment in new power plant. Each new 500 MW power station adds in the order of $5 billion to the utility's regulated asset base[8], and hence to consumer bills. The proposal to replace Hong Kong's high reliance on coal with more gas for electricity will increase the territory's exposure to global gas prices. CLP has proposed[9] a liquefied natural gas terminal be built offshore to allow the unloading and regasification of imported liquid natural gas (LNG). This is to allow Hong Kong to diversify its sources of gas away from cheap South China Sea and the Second West-East Gas Pipeline that delivers gas to Hong Kong from central Asia. The former source is cheap but is rapidly depleting. Gas from central Asia is much more expensive because of the high cost of piping gas such long distances.

The figure below shows the cost of the generating electricity using LNG in the Japanese market HK$ per kWh basis assuming the CCGT plant is 55% efficient[10], it includes the cost of constructing the power stations, but excludes the costs of maintaining the transmission and distribution network, and regasifying the LNG when it lands in Hong Kong. All of these add further to the price.

FIGURE 4: HYPOTHETICAL COSTS OF POWER GENERATED FROM JAPANESE LNG USED IN MODERN CCGT PLANT



The costs of moving from coal to gas are high because liquefied natural gas in the Asian markets is expensive. Based on the most recent price from the above figure the cost of power, including the costs of building, operating and maintaining the gas fired power plant, would be almost $0.71/kWh. This is far more than the low generation costs currently enjoyed in Hong Kong from the use of coal, and local gas sources which are fast depleting. Over the next few decades, gas can no longer be relied upon to provide cheap power. This means that the low tariffs that Hong Kong consumers presently enjoy from coal, cheap South China Sea gas and nuclear will not persist as fuel mix switches to increased amounts of gas. This means that the price of electricity in Hong Kong is likely to rise regardless of the move to renewables.

DESIGN THE FEED-IN TARIFF TO ENCOURAGE COST REDUCTION

The rate of FiT payment is determined either by Government setting a price, or by Government organising an auction of a fixed capacity of RE that it wants to see installed. Government awards the contract to the lowest bids. This approach works best for larger "utility-scale" RE projects like off-shore wind, or solar farms. It is not well suited to roof-top solar schemes where many different home owners are making discrete decisions about whether or not to purchase a solar panel from an installer.

Both approaches seek to set a FiT that is based on the actual cost of generation. In recent years because of the declining cost of solar modules the Government determined FiT rate for solar has often been more than generous than necessary resulting in unexpectedly high rates of take-up.

In jurisdictions where renewable energy can be developed in a cost-neutral manner because it is similar to the wholesale price of power FiT policy development will likely focus on how to integrate intermittent power into the grid and the economic disruptions caused to the back-stop energy sources that have to operate fewer hours a day. The number of countries where renewables are broadly cost competitive with the wholesale price of new fossil fuel power is currently limited, but will likely expand as RE continue to decline. Hong Kong's solar resources are better than those in Europe and most of USA though not as favourable as some desert countries in the Middle East.

COST RECOVERY OPTIONS

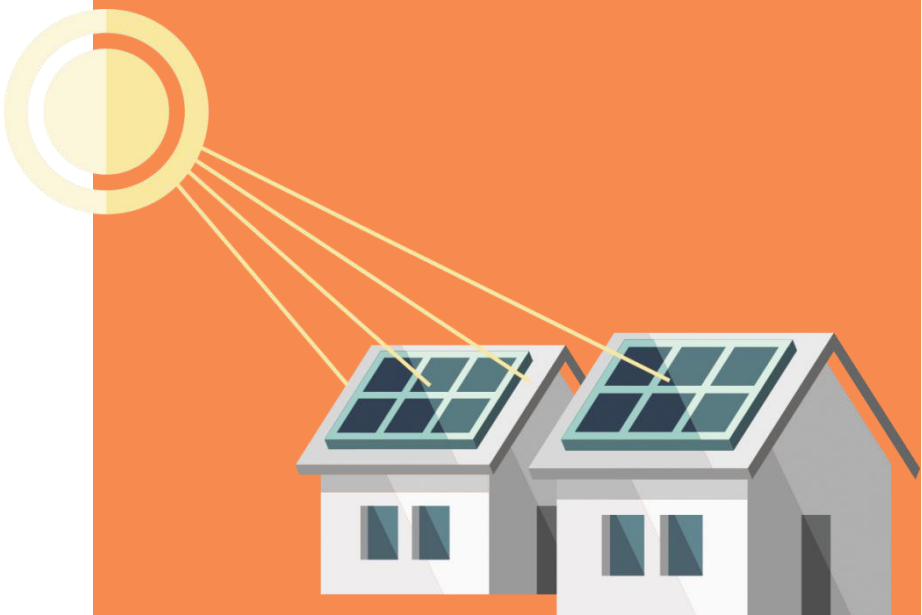
Policy makers have three primary options recovering the costs of the FiT:

(i) To pass the costs to electricity customers through a surcharge on electricity (or a similar mechanism);
(ii) To pay for the costs using government budget, passing the costs to taxpayers; and
(iii) Asking investors in the electricity utility to reduce their profit margins

It is also possible to employ hybrid approaches combining these different sources. Among the options available, policy makers in Europe have preferred recovering costs from electricity customers because it is seen as more financially sustainable in the longer term and because it is consistent with the "polluter pays" principle. Most governments like to minimise regular on-going payments and many OECD Governments have large fiscal deficits. Hong Kong is unusual in that its Government has been running large budget surplus. The financial secretary Paul Chan announced a HK$92 billion surplus in his 2017 Budget. Perhaps the new Hong Kong Government should view investment in decarbonising the territory as vital public infrastructure and use a small fraction of the capital surpluses accumulated over the years from land-taxes to fund some of the transitional costs of moving from the fossil fuel to renewable power.

One possible mechanism for supporting renewables and reducing the cost on more vulnerable groups is to exempt certain groups from cost recovery. Malaysia, Thailand and the Philippines, for example, each exempt low-income electricity customers from paying the surcharges related to FiT cost recovery.[2]

The option of utility's paying for it is discussed in the next section.



5. ANALYSIS OF THE COST OF A SOLAR PV FEED-IN TARIFF FOR HONG KONG

This section considers the cost of financing a solar feed-in tariff in Hong Kong based on the German design of the FiT. FiT payments would be available for installations on commercial and residential buildings as well as larger open spaces more instance reservoirs and suitable open ground. WWF believes all investors that provide space for the installation of solar PV or provide RE from the combustion of biogas or biomass should receive a feed-in tariff. It ensures that the host is motivated to maintain the RE apparatus in good working order, and that routine repairs and cleaning are undertaken.

QUANTITY OF SOLAR PV AND LEVEL OF FEED-IN TARIFF

There have been a number of recent estimates of the amount of solar PV that could be generated in Hong Kong. Suitable space includes the roofs and walls of existing and new buildings, open-land and reservoirs. One study[11] made by Hong Kong Polytechnic University for the Central Policy Unit estimated 5.54 TWh from adding open space (2.88 TWh) and rooftop (2.43 TWh). This study ignored reservoirs. The university undertook a detailed analysis using airborne LiDAR to map Hong Kong's surface areas on a 3m x 3m grid, and developed a three dimensional image of the upper surfaces of buildings to exclude from consideration areas that are shaded by other buildings or walls. Altogether 309,000 buildings were screened and once shaded roof spaces and rooftops too small to fit two modules were removed 233,000 buildings were deemed suitable. The researchers also used satellite images to adjust the data for the amount of cloud cover experienced in Hong Kong scaling back the estimate of solar potential further. The 2.88 TWh of capacity from open space was based on the assumption there as 24,217,705m^2 of available open space in Hong Kong. The Central Policy Unit funded a second study conducted by Hong Kong Polytechnic University which came up with an estimate of 4.67 TWh from the rooftops[12] alone. This study ignored the contribution that might be made from open space. This second study also used LiDAR to remotely sense the area and topography of roof-space in Hong Kong, but a different model to assess the impact of shading from obstructions. It took no account of cloud cover.

The above figures exclude the contribution that reservoirs might make for hosting solar PV. In 2016 a 100 kW floating solar PV array was installed on the corner of Shek Pik reservoir in Lantau. The area of Hong Kong's 17 reservoirs is 23.8km^2. If a third of these were installed with modern highly efficient solar PV arrays these have the potential to meet 3.5% of Hong Kong's electricity demand.

The calculations shown below are deliberately conservative and based on estimate of 5.54 TWh from the CPU study which excludes the contribution made by reservoirs. This represents 12.6% of total electricity demand in 2014. If reservoirs were added this would rise to 16.1%!

In the modelling below the build-up in generation is assumed to increase at 10% of its final capacity each year from 2019 so it achieves its final capacity by 2028.

In other jurisdictions like Germany, UK, Macau, China, Japan and Taiwan initial levels of FiT rate were set higher than conventional tariff to provide investors a reasonable return whilst local costs were high. In the analysis it is assumed that the feed-in tariff is introduced at $4/kWh - significantly higher than the $1.25/kWh retail price of electricity currently. If the FiT follows the same trajectory of reduction as experienced in UK and Germany where the introductory rate was around $4/kWh, it will be below the retail price of electricity in just five years. Such a trajectory implies solar PV only needs to be subsidised for a few short years after which will be able to stand on its own feet commercially.

All the calculations below assume that the electricity generated by the panels is supplied into the grid and valued at half the retail price of electricity. This reflects the value to the utility of the electricity from avoiding the costs of operating costs their gas and coal plant. The developer is only paid the feed-in tariff, the utility receives the savings from avoided gas / coal plant operation. All costs of feed-in tariff reported below are net of the value of the electricity to the utility.

COST OF THE FEED-IN TARIFF OVER THE FIRST TEN-YEARS SCHEME OF CONTROL PERIOD

Figure 4 shows how the cost of a feed-in tariff policy for solar PV might develop over the first ten years of the SCA period. The first two rows of the table provide rates of tariff for newly connected roofs, and an average for all roofs commissioned to date. Older commissioned roofs will still be paid feed-in tariff at the rate that prevailed when first connected. The next three rows show the rate of build-up of generation if Hong Kong achieves 10%, 25% or 50% of the 12.6% potential described in the Hong Kong Polytechnic study. The three scenarios result in solar PV meeting 1.3%, 3.2% or 6.3% of the total electricity demand by 2028. The last three rows provide an estimate of the annual cost of the feed-in tariff at the three different penetration rates.

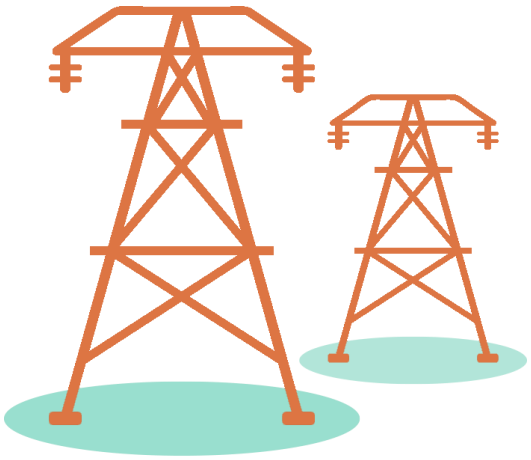


FIGURE 5: FEED-IN TARIFF LEVELS, GROWTH IN GENERATION AND COST OF FEED-IN TARIFF IN SELECTED YEARS FOR DIFFERENT FINAL LEVELS OF PENETRATION

	2019	2020	2022	2024	2026	2028	TOTAL (2019-2028)
Feed-in tariff - initial $4/kWh	4.00	2.17	1.44	0.99	0.84	0.84	
Average feed-in tariff - initial $4/kWh	4.00	3.08	2.29	1.92	1.65	1.49	
PV generation 1.3% penetration (m kWh/yr)	60	110	220	330	440	550	3,050
PV generation 3.2% penetration (m kWh/yr)	140	280	550	830	1110	1390	7,620
PV generation 6.3% penetration (m kWh/yr)	280	550	1110	1660	2220	2770	15,240
Spending: 1.3% penetration ($mil)	190	270	370	440	460	490	3,900
Spending: 3.2% penetration ($mil)	470	690	930	1090	1160	1220	9,740
Spending: 6.3% penetration ($mil)	940	1370	1870	2190	2320	2440	19,480

Figure 5 provides further sensitivity analysis and reports the overall financial impacts of the policy over the first ten years of the SCA period. All the figures are given for the overall period 2019 to 2028. The cost analysis assumes at the FiT scheme will launch in 2019 and offer RE developers an initial feed-in tariff of $4/kWh with a sensitivity analysis of $3/kWhr. The total cost of funding an initially $4/kWh FiT grows steadily over time to finally reach between $336 million and $2,770 million per year in 2028. Since the sales of the two power companies are around $46,000 million per year, the average feed-in-tariff over the ten year period amounts to between 0.5%, for the 10% take-up, $3/kWh initial tariff scenario, and 3.8%, for the 50% take-up, $4/kWh initial tariff scenario. By then solar PV would be supplying 1.3% or 6.3% of electricity need. The cost-effectiveness of the feed-in tariff policy becomes more efficient over time in the sense that over time the expensive early PV installations become a smaller proportion of the overall installed capacity. After 20 years these installations cease to receive a feed-in tariff completely relieving pressures on the feed-in tariff funding scheme.

FIGURE 6: OVERALL COST OF INTRODUCING A FEED-IN TARIFF IN TARIFF IN THE NEXT SCHEME OF CONTROL

Initial feed-in Tariff rate	$3 per kWh			$4 per kWh		
Scenario summary (Uptake rate by 2028)	10% Uptake	25% Uptake	50% Uptake	10% Uptake	25% Uptake	50% Uptake
Solar PV share of electricity demand by 2028	1.3%	3.2%	6.3%	1.3%	3.2%	6.3%
Cumulative costs 2019 - 2028 ($m)	2,460	6,149	12,298	1,847	14,357	15,235
Average annual costs 2019-28 ($m)	224	559	1,118	168	1,436	1,385
Annual costs in final year 2028 ($m)	283	707	1,413	336	2,062	2,770
Average impact of FIT charge as a % of electricity bill over the 2019-28 period	0.5%	1.2%	2.4%	0.8%	1.9%	3.8%

UTILITIES MEETING THE COST OF THE FEED-IN TARIFFS

One option is for shareholders to fund the cost of the feed-in tariff through accepting a reduction in the rate of return (ROR) on the fixed asset base. At present the power companies receive a 9.99% return on their fixed asset base. This allowed ROR was based on an assessment made of the appropriate return on assets in the private sector when the last SCA was negotiated. Since then interest rates and global rates of return on capital have fallen dramatically as a result of measures like quantitative easing in Europe and USA. Government has considered reducing the RoR to between 6% and 8% to reflect changes in the global rates of return. The new Scheme of Control settled at the top of this range at 8%. Figure 6 below shows that if the Government reduces the ROR to 8% the savings to consumers will be $3.6 billion relative to now and if the rate had been reduced to 6% the annual saving is $7.2 billion.

FIGURE 7: ANNUAL REDUCTION IN ELECTRICITY BILLS IF THE RATE OF RETURN (ROR) IS REDUCED FROM THE CURRENT 9.99%

		Hong Kong Electric	CLP	TOTAL
Assumed Fixed assets (Dec 2018)	$mil	55,990	125,284	181,274
Return on fixed assets at current ROR 9.99%	$mil	5,593	12,516	18,109
Annual reduction in bills new ROR 8%	$mil	1,114	2,493	3,607
Annual reduction in bills new ROR 6%	$mil	2,234	4,999	7,233
Annual reduction in bills new ROR 5%	$mil	2,794	6,252	9,046

Source: Data on the fixed assets in 2018 is based on the power companies 2014-2018 development plans as presented to LegCo added to their most recently reported asset base in their annual reports. The depreciation of existing assets is based on the power company's most recent annual reports

Over the first ten year period of 2019-2028 the reduction in energy bills from reducing RoR to 8% will be $36 billion. This is far in excess of the $19,480 million upper bound estimate of the cost of the solar PV FiT shown in Figures 4&5. WWF is also in favour of FiT support for wind and energy from biomass and biogas combustion. This paper does not attempt to develop costs for these, but energy from waste facilities have typically required low levels of support in other countries as the technology is mature and will be easily financed in Hong Kong because of the abundance of public sector capital.

The analysis above suggests that a suitable feed-in tariff could be offered for solar PV and other RE technologies from the savings in energy bills arising from reducing the SCA's required rate of return.

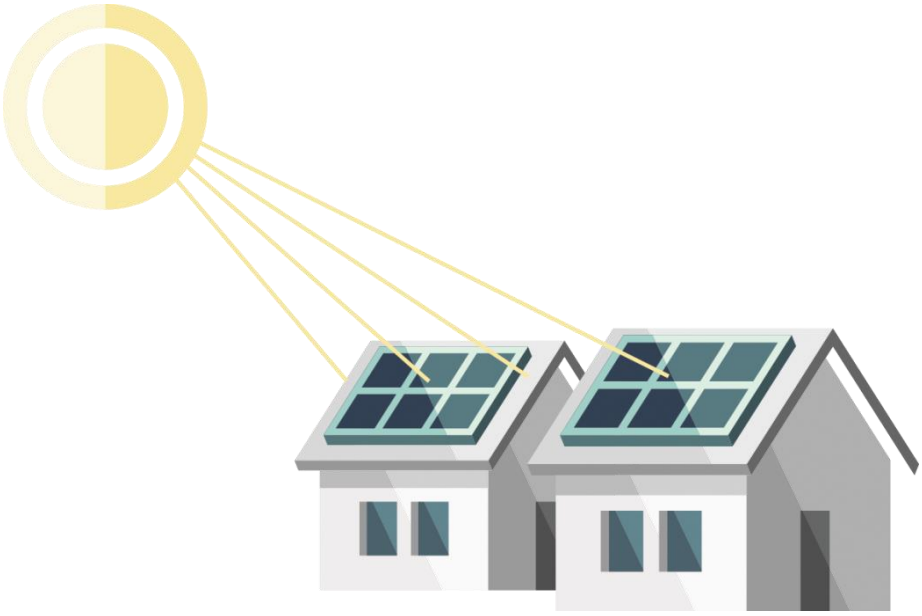
GOVERNMENT'S ROLE IN ENSURING RE IS ENJOYED BY ALL, NOT JUST THE WELL-OFF

Incentivising solar PV through a FiT is sometimes criticised as being elitist – only better off people who *individually* own roofs are able to access the support. The criticism made by some is that people living in apartments cross-subsidise those living in houses. It is not inevitable that solar PV should only be enjoyed by the well-off. In the first round of its SolarNova programme[13] Singapore's Government issued tenders inviting installers to fit 32 MW of solar PV to 900 social housing blocks. It is worth reflecting on this. Singapore's first round effort to install social housing with PV resulted in a greater amount installed than has been achieved in Hong Kong to date. Singapore in a single tender has streamlined procedures and used economies of scale to ensure a large scale deployment of solar PV so that the man in the street can enjoy clean solar PV.

Most people in Hong Kong live and work in high-rise buildings. Roofs on Hong Kong buildings, unlike buildings in Europe and North America, have shared ownership. HK Baptist University carried out research for WWF and Greenpeace which revealed a number of administrative and legal blockages that prevent people from installing solar PV. These include restrictive management rules applied by a housing development, well-intentioned rules to guard against typhoon hazard, planning ordinance, confusion under Building Ordinance.

As a result of this thicket of rules and regulations, there is significant complexity and ambiguity about who makes the decisions, who finances and who receives the proceeds from the solar FiT in high rise apartments and offices. WWF believes Government should support the development of an *inclusive* RE market. One means of achieving this would be to co-finance a small number of early installations on different building types: Housing Authority blocks, offices, shops, village homes, private residential blocks. The goal of this funding programme will be to develop, demonstrate and then promulgate behavioural norms and contractual forms that govern how decisions should be made, costs and benefits shared.

WWF believes that Government should financially support the first 120 installations and assist in simplifying the rules to encourage tenants, buildings owners and property management companies to develop suitable legal agreements, and to share the costs and proceeds from participating in decentralised electricity generation. The policy should be: "*Energy for all, energy from all.*"



LET'S NOT FORGET ENERGY EFFICIENCY

As well as funding RE utilities and Government could also fund electricity users to invest in improving their buildings' energy efficiency and overcome the well-known market failures that prevent tenants from benefitting from cost-effective investments that owners or building managers could make. Programmes like the Buildings Energy Efficiency Funding Scheme (BEEFS) which the Hong Kong Government operated between 2009 and 2012 are highly cost-effective at reducing energy use. This programme subsidised half the cost of energy audits and capital costs of fitting energy efficiency measures subject to ceilings of $650,000 per building. In an evaluation by EMSD[14] the measures funded by the scheme yielded savings with pay-back periods of on average just 5.9 years.

The table below shows the savings achieved from the capital projects that were evaluated by EMSD by the sort of project. Of the approved schemed 604 (60%) were for residential blocks suggesting that benefits were widely distributed to households. On average the schemes reduced electricity use by the device by around 20%.

FIGURE 8: RESULTS FROM EVALUATION OF ENERGY EFFICIENCY PROJECTS FUNDED BY GOVERNMENT 2009-12

Categories of project	No. of projects	Energy saving original estimate (kWh/yr)	Funded Amount (million HK$)	Measured saving upon completion (kWh/Yr)	Saving %	Est. payback (yr)
Lighting	139	37,219,513	42.2	33,508,491	19.20%	3.2
Air-conditioning	4	488,561	0.9	584,492	12.80%	4.4
Lift & Escalator	20	1,810,869	14.3	1,737,201	28.90%	33.7
Electrical	6	1,574,048	3.7	932,366	24.40%	3.1
Multi-installation	18	4,666,442	5.3	9,749,239	23.20%	4
Total	**187**	**45,759,433**	**66.4**	**46,511,789**	**20.80%**	**5.9**

Source: Szeto W. S. (undated) "The Building Energy Efficiency Funding Schemes – A preliminary technical analysis" EMSD

The programme had a budget of $450 million over three years and it succeeded in reducing electricity usage by 180 million kWh/year saving 126,000 tonnes of CO2. If the $3,330 million released when the SCA's RoR was reduced from 9.99% to 8% were invested in this programme it could reduce energy consumption by 3% per year!

In theory the power companies could use the Eco-Building Fund mentioned in the Scheme of Control to bring about this sort of radical reduction in energy use. This would involve the Fund being set ambitious energy efficiency target either offering incentives or installing capital items in their customers' homes and offices to reduce their use of electricity. But to make this work it is important the target is expressed in terms of actual or modelled energy savings, and that there are meaningful sanctions on the utilities for failing to achieve these targets. The new SCA only offers incentives to encourage effective deployment of the fund but no sanction if the fund is not used, or used badly. Previous SCAs have included weak energy efficiency packages (Demand Side Agreement 2000-2003[15] and Energy Efficiency Schedule 6[16], 2008-2018) which did not have an impact commensurate with the size of the challenge. It is important this opportunity is not missed again.

The Eco-Building Fund must have a rigorous and independent procedure to ensure that there is a high quality of pipeline of projects eligible for support, that no undue restrictions are placed on projects for instance limits on eligibility or size, and that there are genuine carbon savings, additional to what would have occurred in the absence of the programme. In other countries evaluation of the programme is often undertaken by independent Government or not-for profit agencies. Such a programme might need a degree of independence from the power companies, that might be difficult to achieve from the current "contractual SCA" and might need a move a regulatory model used elsewhere in the world.

6. CONCLUSIONS & RECOMMENDATIONS

This briefing paper argues that solar PV could contribute as much as a tenth of Hong Kong's electricity needs if a high proportion of reservoirs, roofs and open-land are installed with modern PV panels. This rate of take-up needs the correct policy environment. Looking across the range of incentive mechanisms used around the world – the feed-in tariff seems particularly appropriate to Hong Kong. In countries like Taiwan, Germany and UK take-up of the technology has been rapid.

Solar PV is sometimes criticised as being an expensive means of generating electricity. This view is out of date. The global price of PV modules has dramatically fallen. However, a high feed-in tariff is needed for a few years to subsidise the transition to low carbon technology. This short duration subsidy is needed to allow the development of the installer industry and for site owners and the industry to gain familiarity with the technologies and regulations. Feed-in tariffs in many countries are now below the retail price of electricity.

The current reliance on expanding Hong Kong's fleet of CCGT is not helpful in achieving long-term climate goals, nor is it even the *cheaper* option. WWF modelling suggests that suitably located solar PV has the potential to be cheaper than new CCGT because of the high costs of gas in Asia and the relative abundance of sunlight at our latitude. Our modelling suggests that if gas prices continue at the levels experienced last year, the cost of generating power from newly built efficiently run CCGT plant will be $0.71/kWhr. Once the cost of transmission, distribution and billing is included it will be far more expensive than the prices Hong Kong consumers have come to expect. Such plant will have active lives of 25 plus years by when Hong Kong will have to made reductions in its carbon much deeper than can be achieved through CCGT.

Our modelling suggests that introducing FiT can be done without increasing consumer bills. The cost of a solar PV FiT could be easily funded from the savings released by reducing the scheme of control's RoR to from 9.99% to 8%. The costs of the solar PV FiT policy over the ten-year scheme of control period is estimated as being a maximum (under different scenarios) of $19.5 billion far less than the $36 billion saving over the ten years. The saving could also be used to finance FiT schemes for other RE technologies, like off-shore wind and energy from biological waste combustion, and also the Eco-Building Fund mentioned in the new SCA.

It is important that solar PV be widely deployed. To ensure this WWF recommends that Government provide a small number of targeted grants that allow early adopters in different housing types to overcome the current obstacles that prevent the uptake of solar PV in the different building types found in Hong Kong, especially buildings where there are many different parties involved in decision making.

Inspired by the success in other countries WWF recommends the feed-in tariff and energy efficiency measures to be introduced to Hong Kong incorporating the following features:

- Government to set a target for Hong Kong to reach at least 5% RE by 2030 which the WWF believes can easily be met,
- SCA to introduce a FiT for households' and private companies' RE with an introductory level of $4/kWh for solar PV,
- Clear and simple set of codes to allow small generators to connect, an obligation on power companies to connect suitably certified small generation and a guaranteed grid access,
- This could be funded by the reduction in RoR agreed in the Scheme of Control. This means there is no increase in consumer bills as a result of the new FiT policy,
- Government to facilitate an inclusive solar PV deployment available to residents in all sorts of different building. This will require generous grants for 120 pioneering installations to trial solar PV on their buildings, and
- Government and power companies should make maximum use of the new Eco-Building Fund to finance cost-effective energy efficiency solutions in buildings along the lines of those were supported by the Building Energy Efficiency Fund operated by the Hong Kong Government between 2009-2012.

Together these policies could go a long way to help Hong Kong set and achieve the sort of renewables target that have been adopted in most other developed economies in the world and will allow Hong Kong to catch-up in RE deployment with other countries in Europe, North America and Asia.

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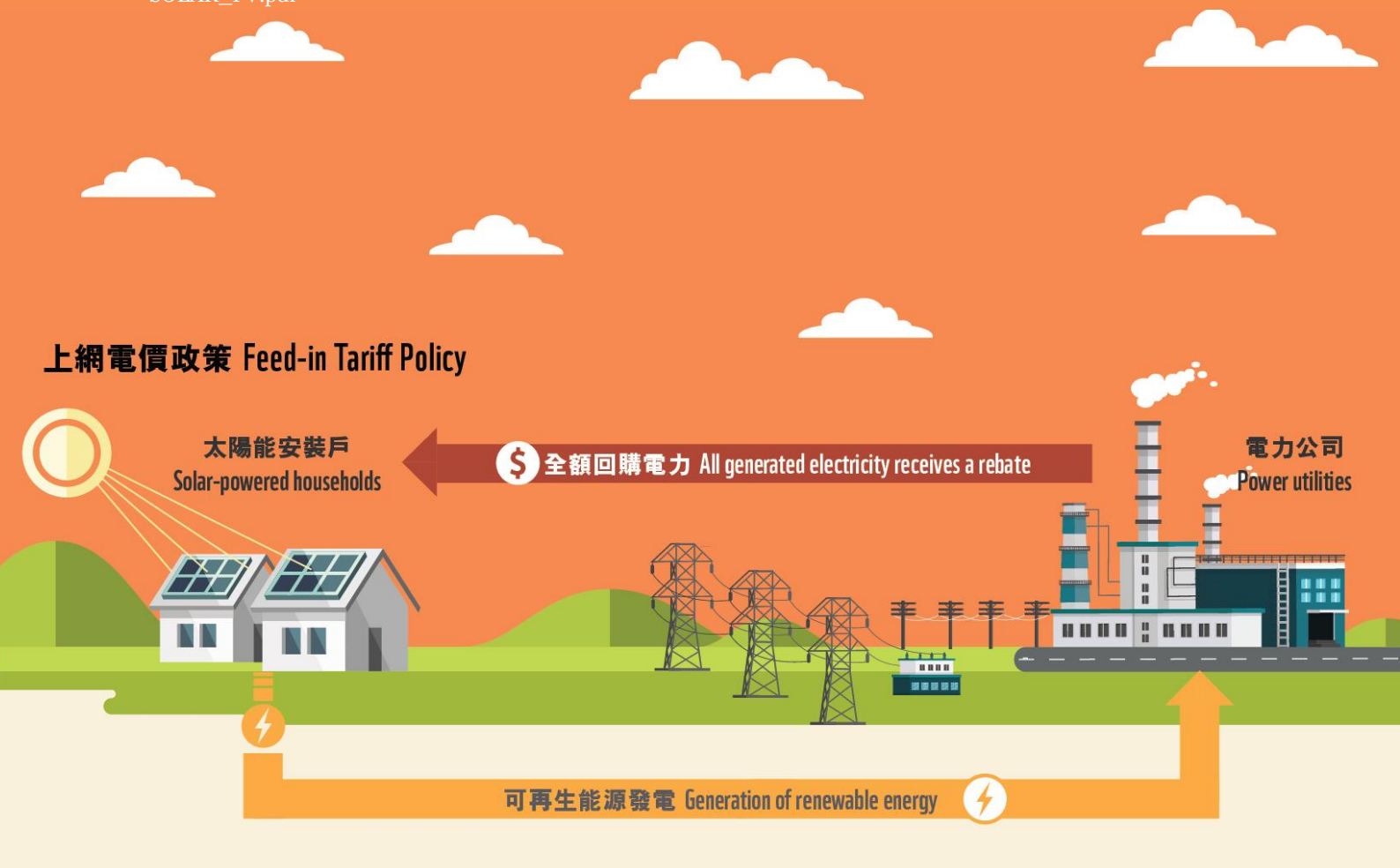

WWF-Hong Kong numbers

242,279

people supported WWF's conservation initiatives this year

27,572

704 volunteers, interns and mentees donated a total of 27,572 service hours in FY16.

110

This year Island House Conservation Studies Centre celebrated its 110th anniversary, inviting over 800 people to its Open Days held in January 2016

378

corporations and organizations supported WWF this year

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