

15 Jun 2019



A New RE Eco-system Under Feed-in Tariff (FiT) and RE Certificates Schemes

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Head of Customer Business Development

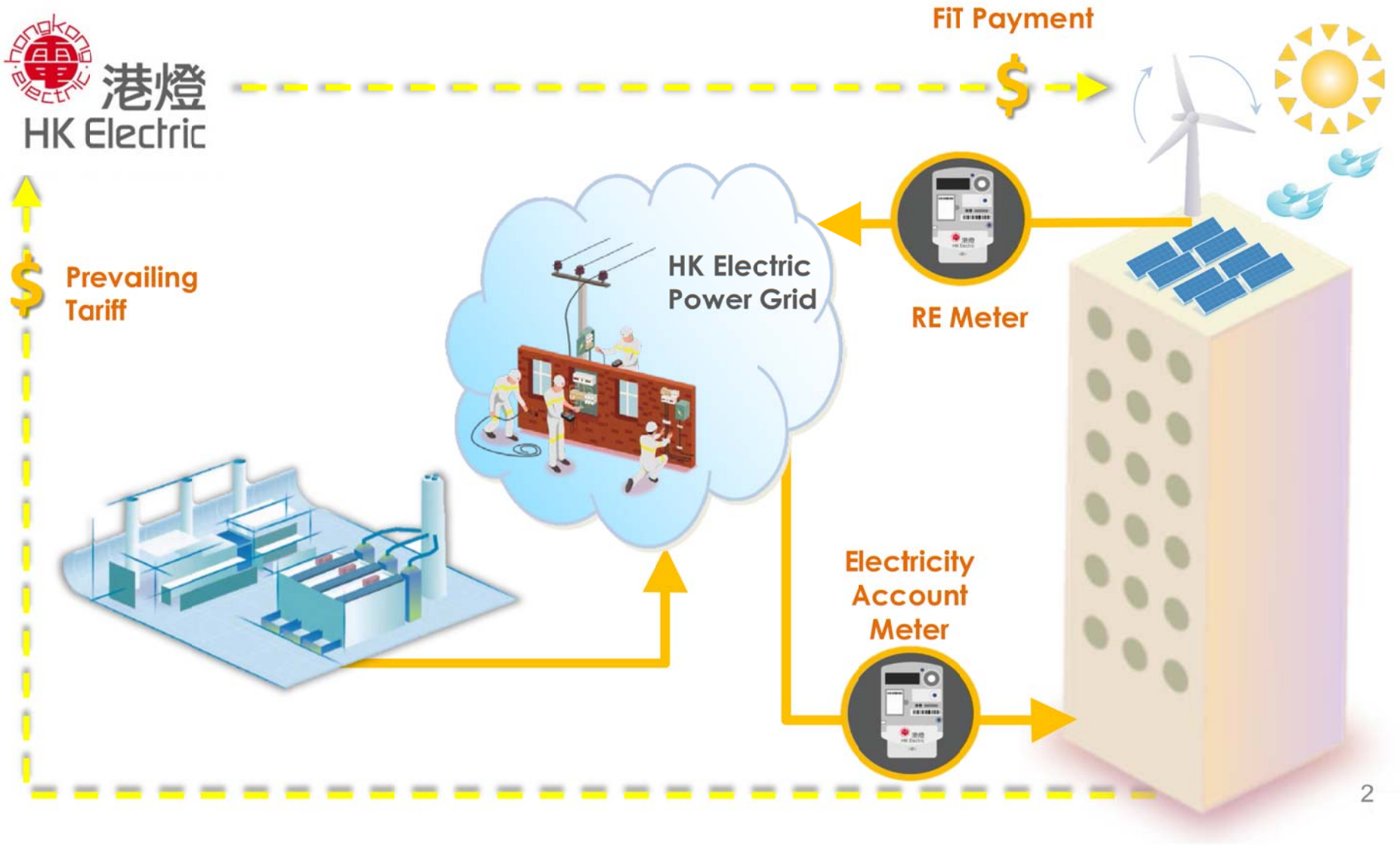


港燈
HK Electric

智惜用電
smart
power
上網電價
FEED-IN
TARIFF

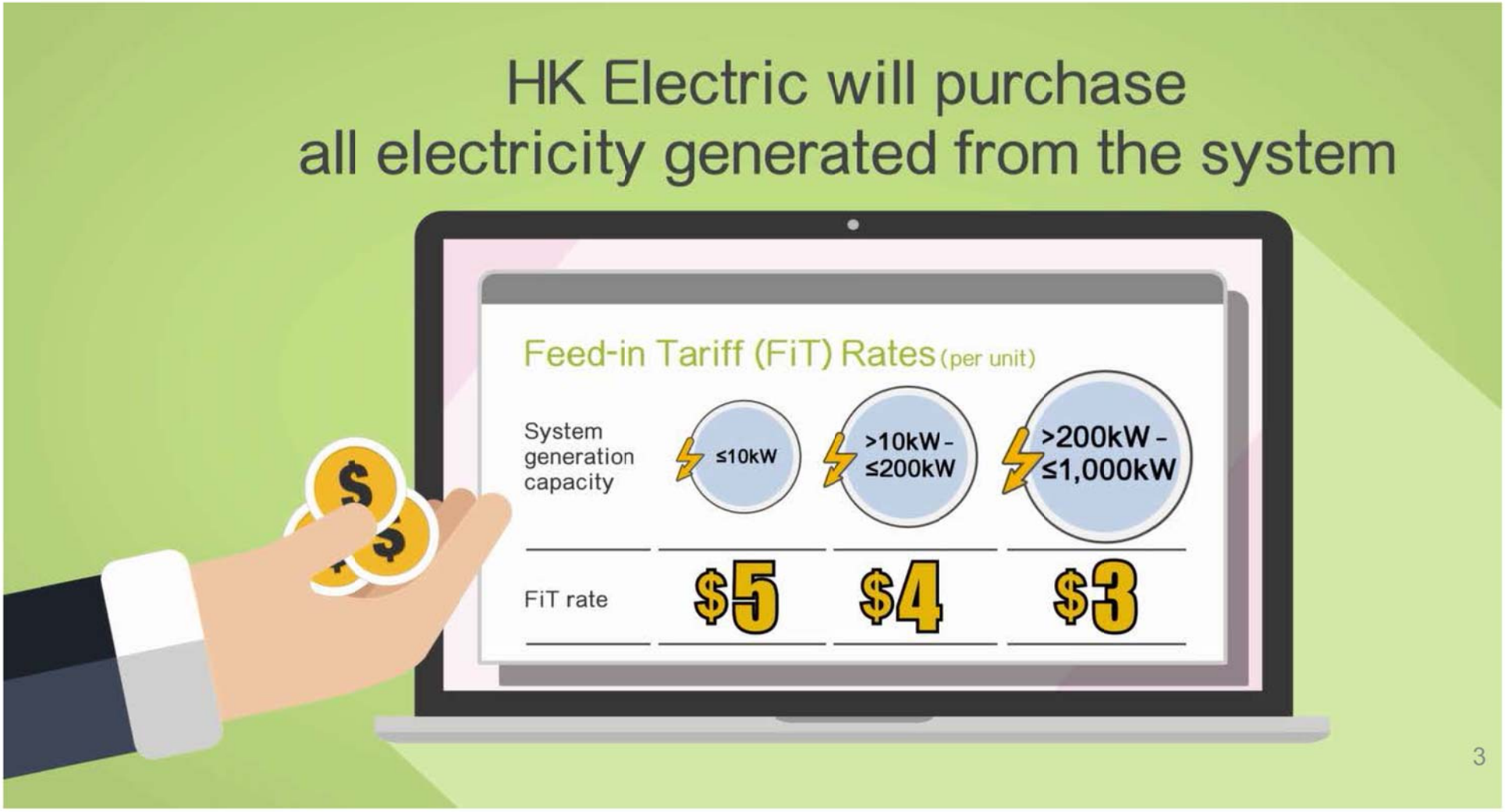
Encourages the installation
and supports the development of renewable energy

Feed-in Tariff (FiT) Scheme



FiT Rates in 2019

- **From start of FiT Agreement throughout the project life of the RE Power System (REPS) or until 31 December 2033 (whichever is earlier)**



Participation in FiT Scheme

1. Submit application form and technical information
2. Install REPS after obtaining HK Electric's consent
3. Perform system tests, submit results and other necessary information
4. HK Electric to connect REPS to power grid and install RE meter upon satisfactory site inspection
5. Receive FiT payment based on metered system output



FiT Scheme
Required Submissions

1



Submit application form and technical information

- Duly completed application form
- Identity Verification Document (e.g. BR copy)
- Technical Drawings
- Single-line Electrical Diagrams
- Major Components Technical Information

(Application with incomplete documents will not be processed)

3



Perform system tests, submit results and other necessary information

- Copy of Commissioning Report* (Sample at website)
- Copy of Operation & Maintenance Manual* (Sample at website)
- Copy of WR1 Work Completion Certificate*
- Project Cost Information

* Signed by REC/REW

Time Limits on Participation in FiT Scheme

T1 **Date of receipt of the Application**: Date of receipt of application form and **all required documents**, on which the **Provisional FiT Rate** is based

T2 **Consent Letter Date**

T3 **FiT Agreement Start Date**: 1 January 2019 or the completion date of installation of RE Meter(s) at the Service Address, whichever is later

Validity Period of Provisional FiT Rate

T1 → Within 3 months → T2

T2 → ≤10 kW : Within 4 months; > 10 kW : Within 12 months → T3

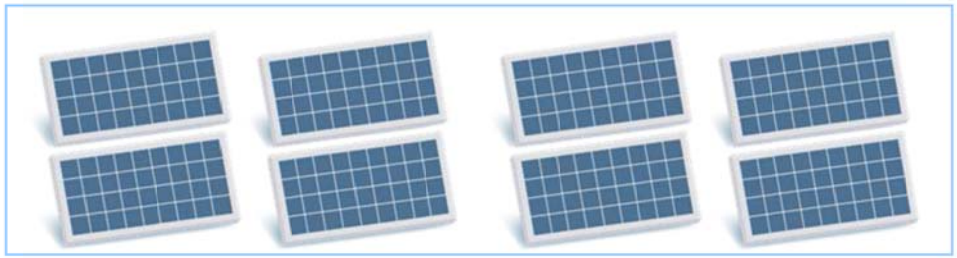
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Max. 18 months

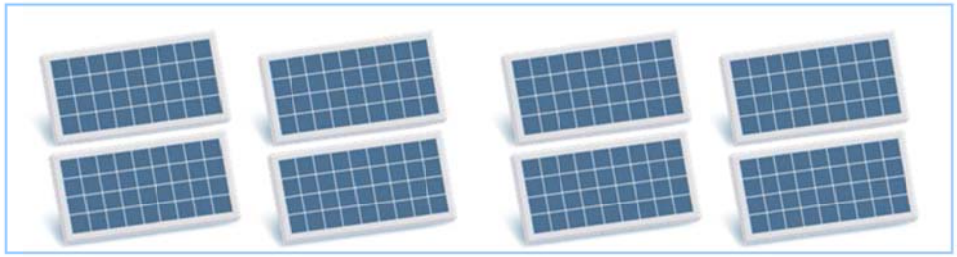
REPS Capacity for FiT Determination

PV array type A (each array rating = A_1)

Inverter type A
(each inverter rating = A_2)



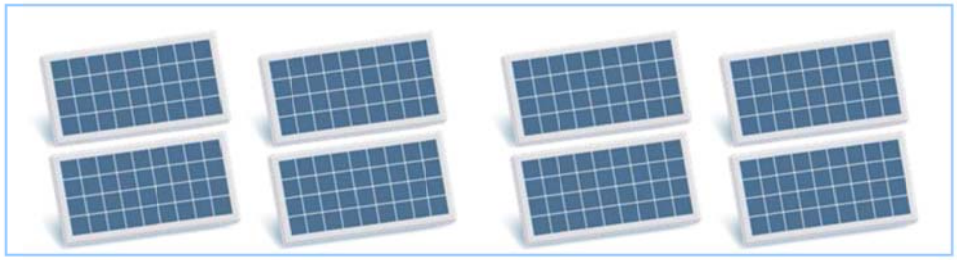




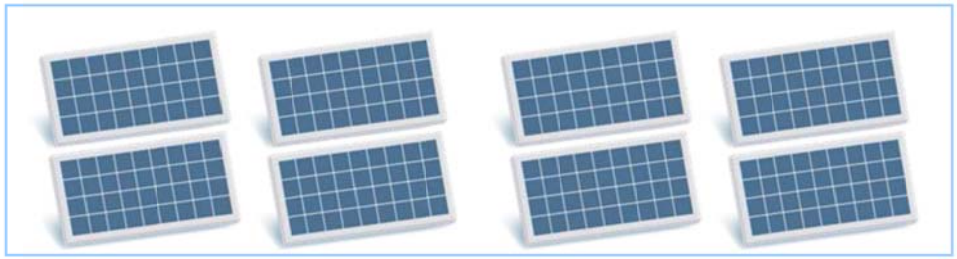


PV array type B (each array rating = B_1)

Inverter type B
(each inverter rating = B_2)





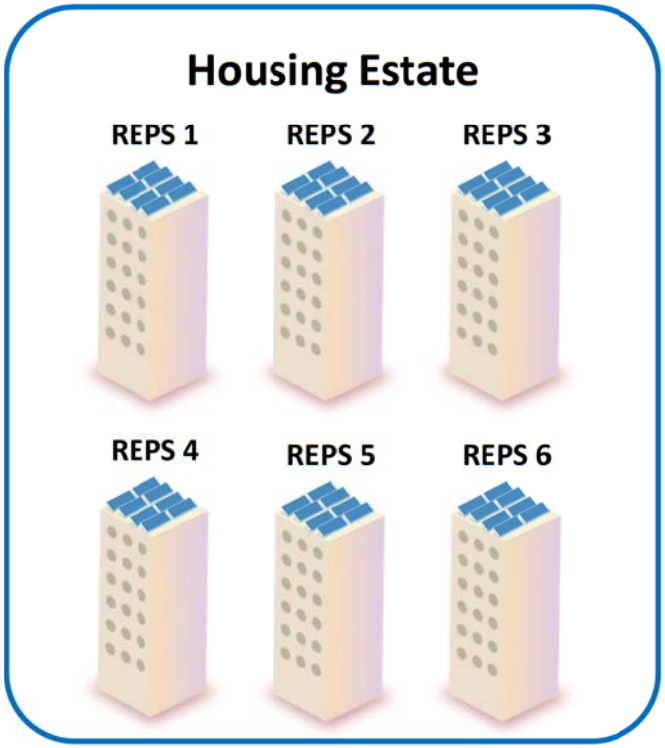




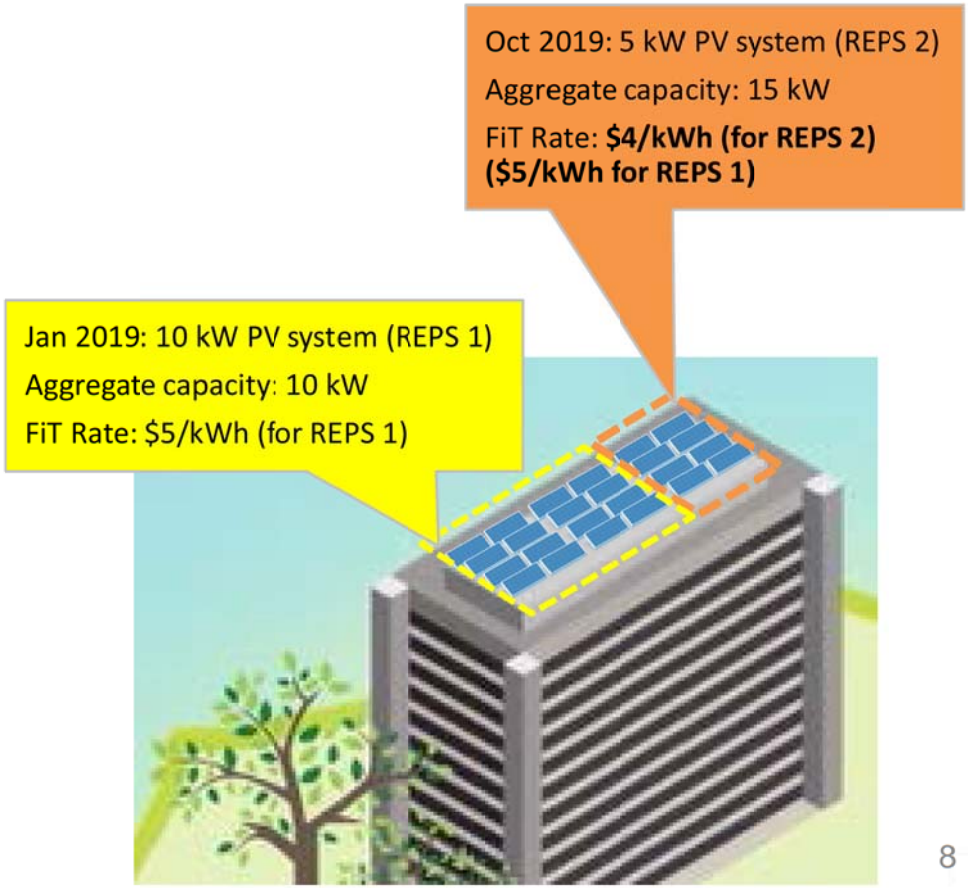
Case	REPS Capacity for FiT Determination
$A_1 > A_2$ $B_1 > B_2$	$2A_2 + 2B_2$
$A_1 > A_2$ $B_1 \leq B_2$	$2A_2 + 2B_1$
$A_1 \leq A_2$ $B_1 > B_2$	$2A_1 + 2B_2$
$A_1 \leq A_2$ $B_1 \leq B_2$	$2A_1 + 2B_1$

REPS Capacity for FiT Rate Determination

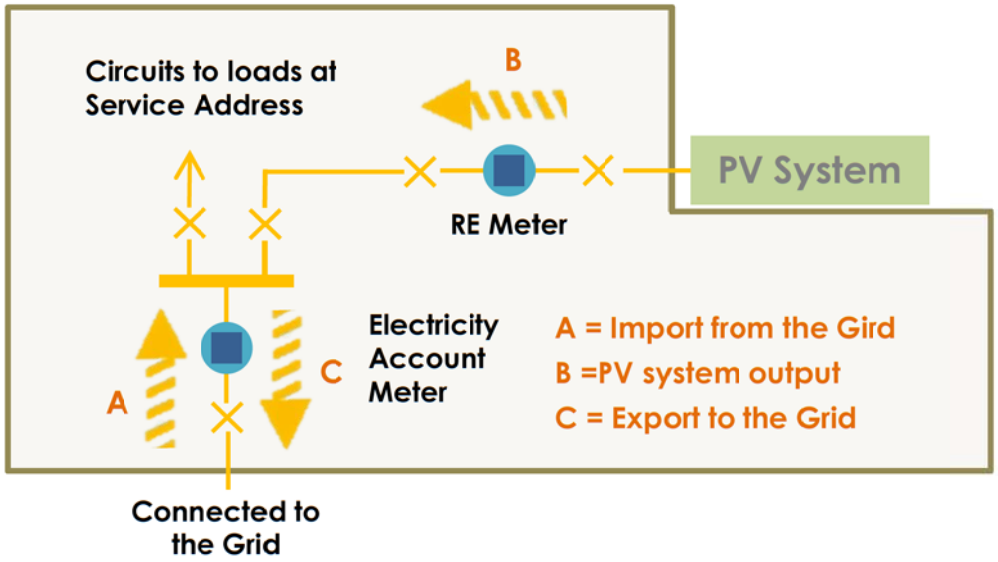
- If a Service Address covers several Premises (e.g. multi-residential blocks), the REPS installed on each Premises (e.g. rooftop of residential block) will generally be treated as a separate REPS



- The FiT rate for the new REPS will be determined based on the aggregate generation capacity of the new REPS and the existing REPS



Metering and Accounting



Payment/Charge	Calculation of Energy (in kWh)
FiT Payment	B x FiT Rate
Charges billed for consumption at Service Address	(A + B - C) x Prevailing Tariff

School Example	Normal Month	Low-usage Month
Import from the Grid	A = 2,000 kWh	A = 0 kWh
PV System output (FiT)	**B = 500 kWh**	**B = 500 kWh**
Export to the Grid	C = 0 kWh	C = 100 kWh
Billed consumption	**A + B - C = 2,500 kWh**	**A + B - C = 400 kWh**

Environmental Consideration





- Environmental attributes (e.g. carbon emission reduction) associated with PV system output are sold to HK Electric under the FiT Scheme
- HK Electric will issue RE Certificates based on RE purchased under the FiT Scheme
- FiT Scheme participants shall not claim:
  - the use of the sold electricity from the PV system; and
  - the associated environmental benefits (e.g. for deducting the GHG Protocol Scope 2 emission by use of RE; for earning credit in green building certification)



港燈
HK Electric

智惜用電
smart
power

可再生能源證書
RENEWABLE
ENERGY
CERTIFICATE

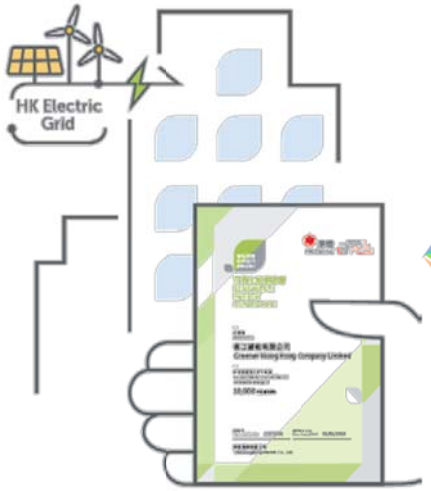
Supports renewable energy in HK

Key Features of RE Certificates (REC)

- REC is a voluntary scheme available for all HK Electric's registered customers
- RE Sources: local wind and solar photovoltaic systems
- RE is either generated by HK Electric or purchased by HK Electric from customers successfully joined the Feed-in Tariff Scheme
- HK$0.5 per kWh (i.e. one unit of electricity) effective 1 January 2019 (a premium on top of normal electricity tariff rate)
- In general, RECs are sold in blocks of 100 kWh (i.e. minimum purchase of $50 for 100 kWh)



Purposes of Purchasing REC



RE 100 THE CLIMATE GROUP CDP

Achieve using 100% RE for business operation by a targeted year



CDP DISCLOSURE INSIGHT ACTION

HKEX 香港交易所

TCFD TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURES

Offset greenhouse gas emissions from purchased/acquired electricity



Earn credit points for green building certification (e.g. LEED)



Show support to local RE development / improve CSR image

Sources: RE100; GHG Protocol Scope 2 Guidance; LEED v4 for Building Design & Construction

Top 10 REC Purchasers



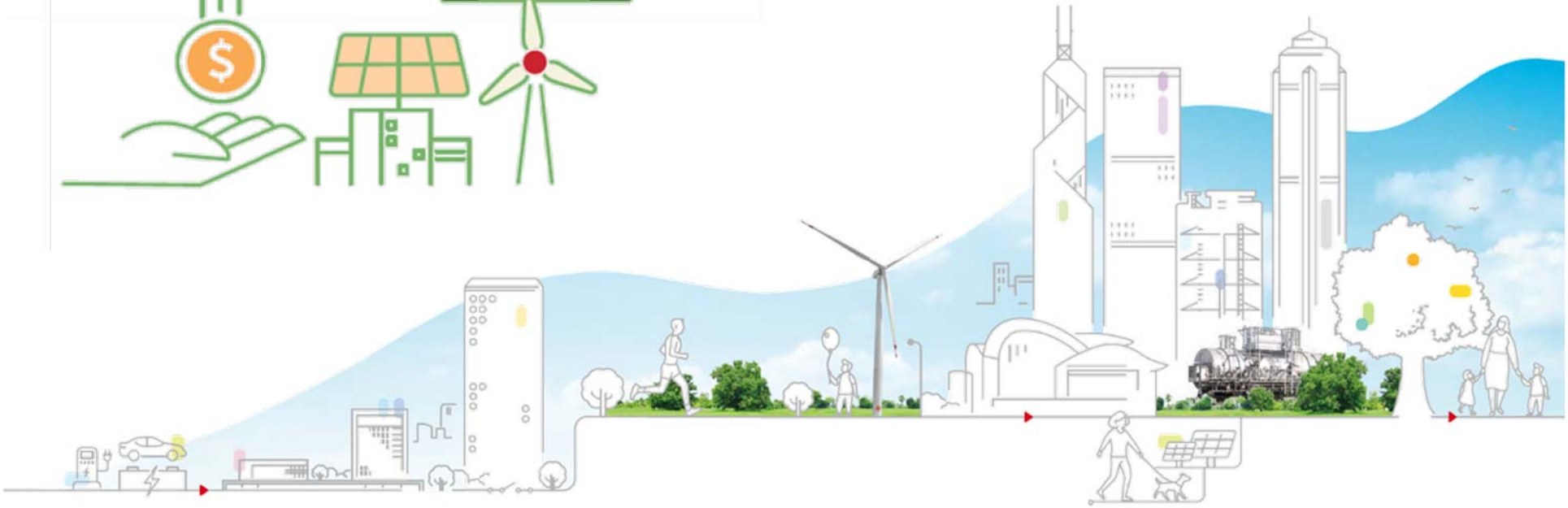
1 HANG SENG BANK LTD	2 CITIBANK N A	3 FUNG HIU FAI KENNETH
120000 kWh	100000 kWh	5100 kWh
Certificate No. 100047	Certificate No. 100043	Certificate No. 100062
Date of Issue 14/05/2019	Date of Issue 07/05/2019	Date of Issue 30/05/2019

Rank #	Registered Customer Name	Units Purchased	Certificate No.	Date of Issue
4	SONY CORPORATION OF HONG KONG LTD	5100 kWh	100053	24/05/2019
5	SUN CHUNG PROPERTY MANAGEMENT CO LTD	5100 kWh	100048	15/05/2019
6	L'HOTEL CAUSEWAY BAY HARBOUR VIEW	5100 kWh	100034	11/04/2019
7	YAKINIKU (CB) LIMITED	5100 kWh	100030	27/03/2019
8	L'HOTEL ISLAND SOUTH O/B WING WONG CO LTD	5000 kWh	100033	11/04/2019
9	URBAN PARKING LIMITED	2000 kWh	100057	29/05/2019
10	LAMMAR OFFSET PRINTING LTD	2000 kWh	100052	22/05/2019

Last updated on 11/06/2019.
The above list shows the most recent top 10 purchasers who have agreed to disclose his/her names as a purchaser of the REC.
The list is ranked according to purchase quantity, certificate issue date and application order.

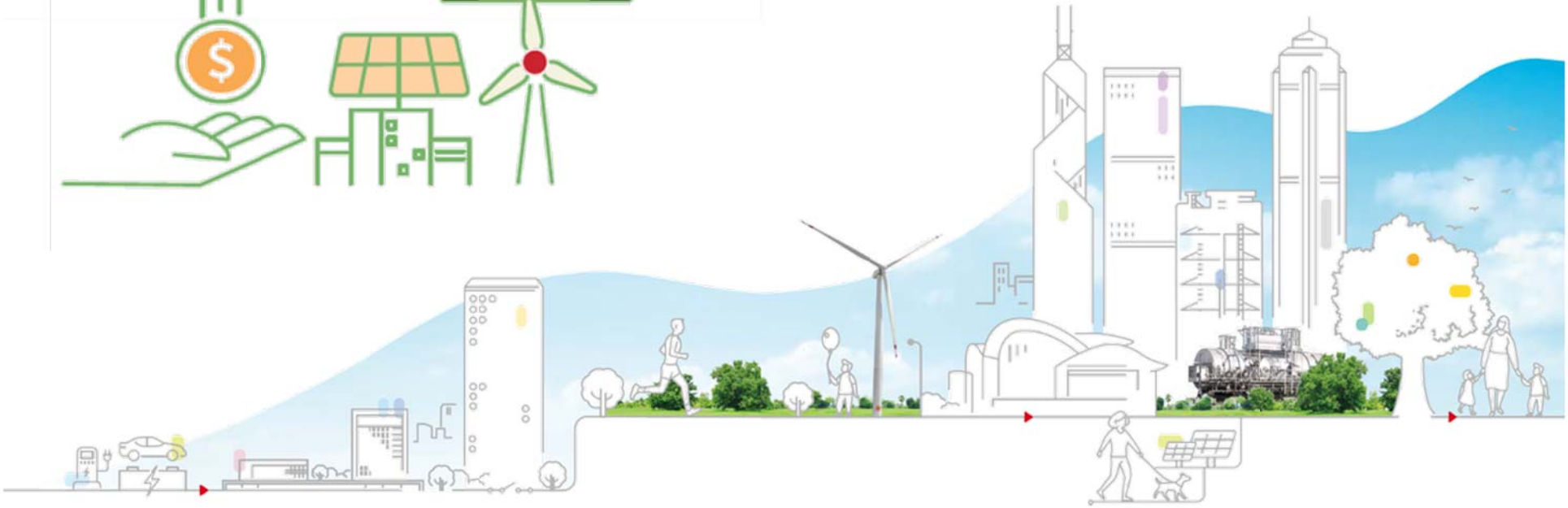


A New Renewable Energy Eco-system

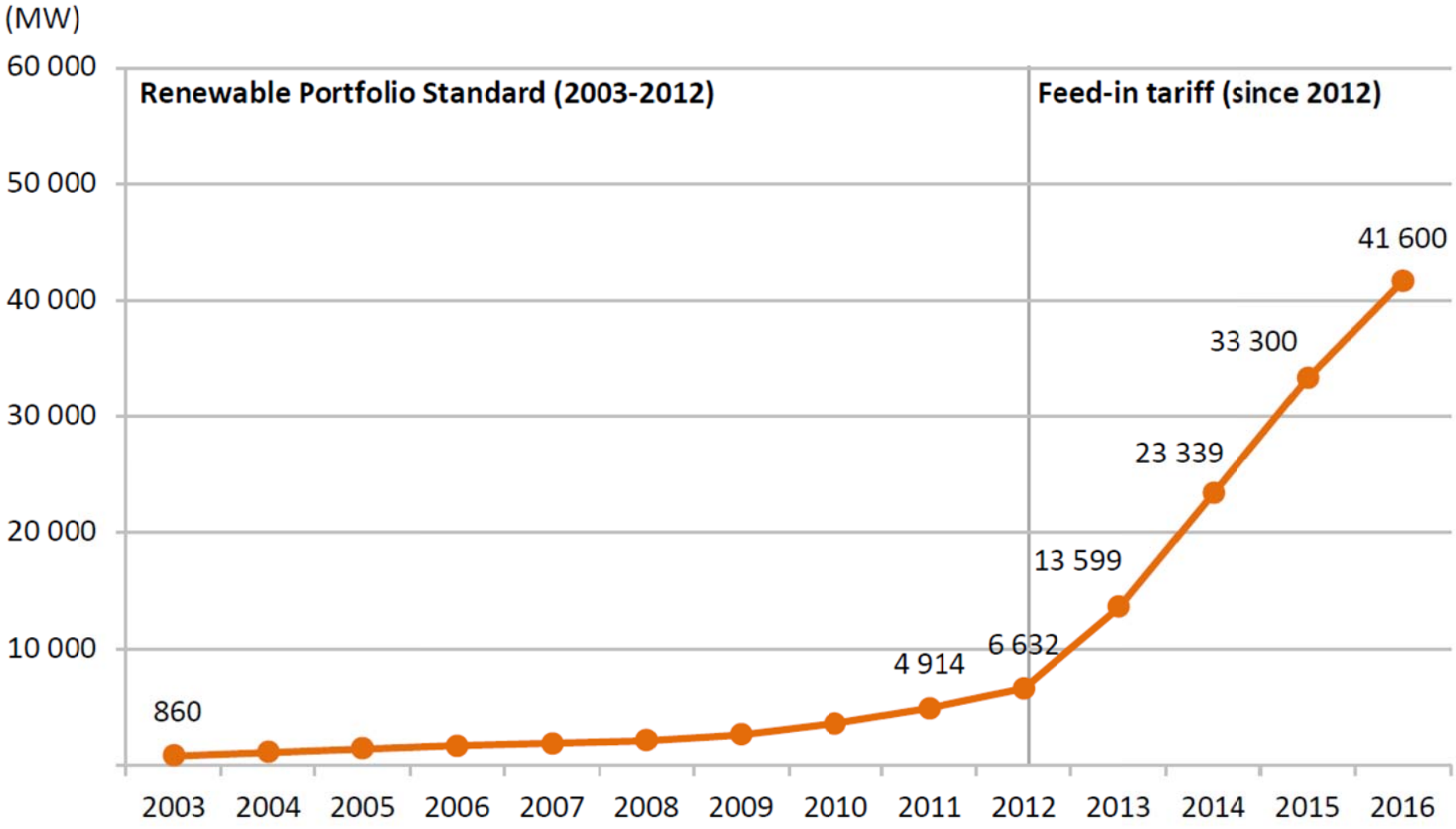



Policy Driver
Life-cycle Management
Community Knowledge
Eco-system
Technology
Industry Knowhow


Policy Driver

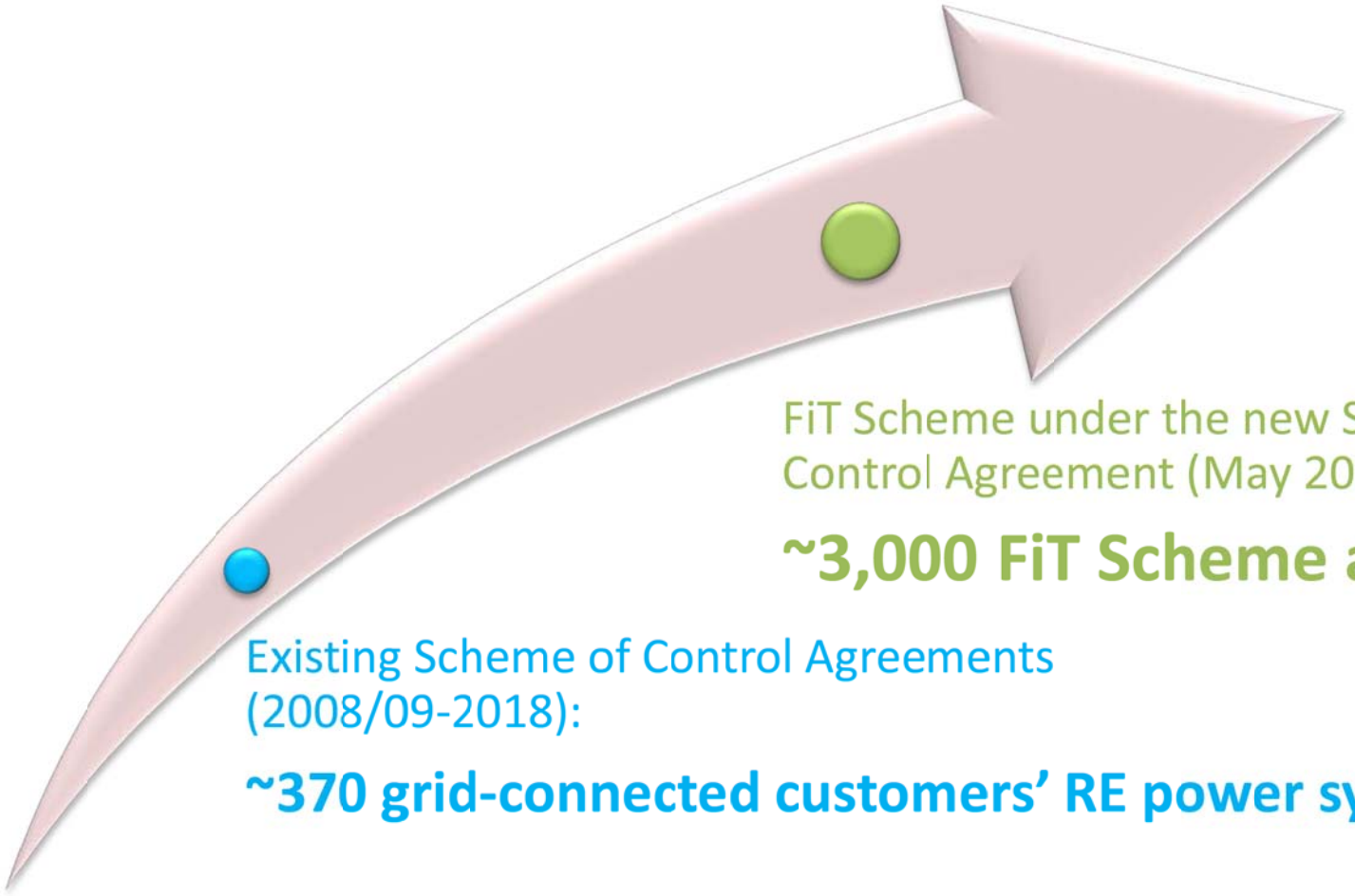


Capacity of Solar PV system in Japan (2003-2016)



Source: IRENA
Image credit: Feed-in tariff for solar power in selected places (Jan 2018), Research Office, LegCo Secretariat

Response to FiT Scheme in HK



FiT Scheme under the new Scheme of Control Agreement (May 2018-May 2019):

~3,000 FiT Scheme applications

Existing Scheme of Control Agreements (2008/09-2018):

~370 grid-connected customers' RE power systems

Sources:

1. LC Paper No. CB(1)840/17-18(01) (23 Apr 2018), LegCo
2. LCQ3: Combating climate change and protecting biodiversity, HKSARG Press Release of 29 May 2019

A Vibrant Market



EMSD's Survey Returns:

- ~80 RE equipment suppliers
- ~30 RE installation contractors

Sources: HK RE Net, EMSD, HKSARG

FiT Rates for Solar PV System in Other Jurisdictions

Jurisdictions	Year of first launch	Type of Payment	At the year of first launch		
			Initial FiT rate per kWh	Residential Tariff per kWh	Ratio of Initial FiT rate to Residential Tariff
Germany	1991	Gross	EUR 8.5 (~HK$ 0.8)	EUR 9.4	~1
Australia	2010	Gross	AUD 60 (~HK$ 4.3)	AUD 21.55	~3
Taiwan	2010	Gross	NTD 11.8 (~HK$ 2.9)	NTD 2.61	~4.5
UK	2010	Gross	GBP 0.427 (~HK$ 5.1)	GBP 0.1086	~4
Japan	2012	Gross	JPY 39 (~HK$ 3.8)	JPY 22.01	~2

Source: "Study on the Feed-in Tariff Rates for Renewable Energy in Hong Kong Final Report" dated April 2018 to EMSD by Atkins

Ratio of FiT Rate to Residential Tariff
First Launch vs Current

Jurisdictions	Year of first launch	Technology	Ratio of initial FiT rate to residential tariff at the year of first launch	Latest available FiT rate / current residential tariff rate
UK	2010	PV	~4	~0.2
		Wind	~1	~0.7
		CHP (gas)	~3.5	~1.2
Germany	1991	PV	~1	~1
		Wind	~1	~0.5
		CHP (biogas)	~1	~1
Taiwan	2010	PV	~4.5	~2
		Wind	~2	~3.5
Japan	2012	PV	~2	~1
		Wind	~2	~2
		Biomass	~2	~1.5
Australia	2010	PV	~3	~0.3

Image credit: "Study on the Feed-in Tariff Rates for Renewable Energy in Hong Kong Final Report" dated April 2018 to EMSD by Atkins

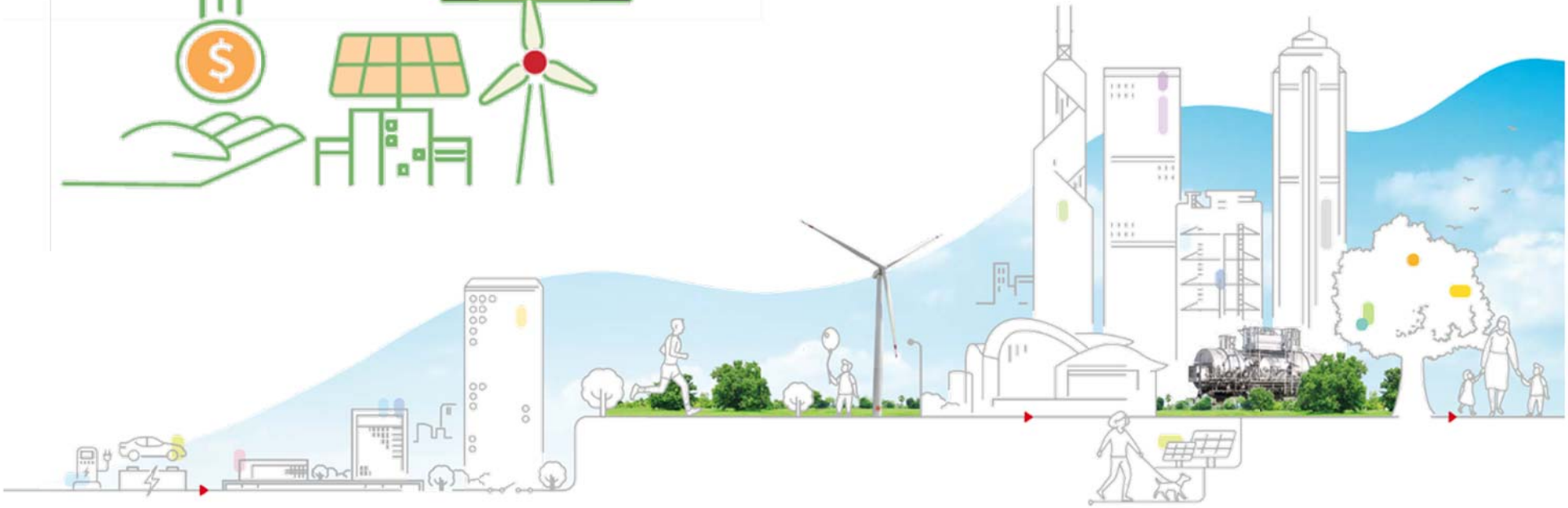
FiT Rates of Japan
(Financial Year 2013 – 2019)

Purchase Prices [JPY/kWh] (tax excl)							
	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019
Less than 10kW	38	37	33	31	29	27	25
Less than 10kW (+energy storage system)	31	30	35	33	26	26	25
10kW or more	36	32	29	24	21	-	-

Image credit: "Study on the Feed-in Tariff Rates for Renewable Energy in Hong Kong Final Report" dated April 2018 to EMSD by Atkins



Community Knowledge

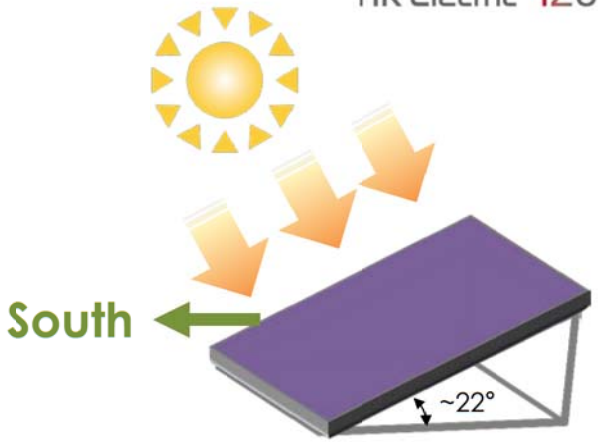


Installation Locations



- Rooftop (village houses, private buildings), idle land
- Ownership - Owner or occupant
- Uses - Leisure purpose (BBQ, gardening, etc.)

PV System Layout Considerations (1/2)



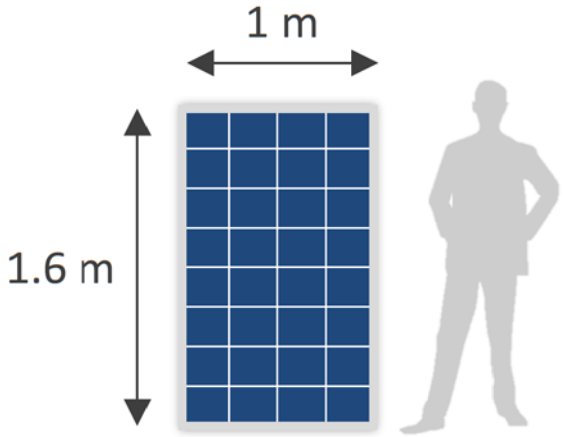
- Hong Kong lies at
  - Latitude: 22°08' ~ 22°35' N
  - Optimum orientation and tilt angle

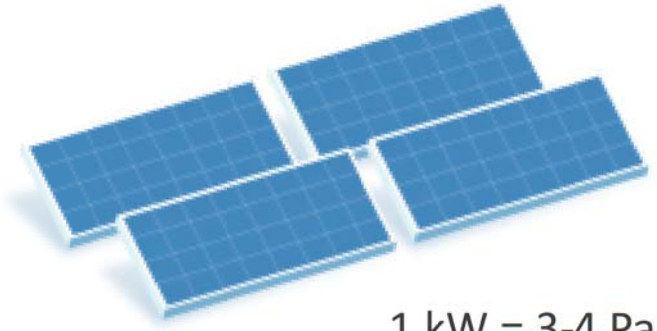
- Glint and glare



Image credit: 將軍澳醫院天台光害擾民, 17 Aug 2013, Orient Daily

Quick Metrics for PV System in HK





1 kW = 3-4 Panels

For a Typical 1 kW Solar PV System (about 3 - 4 PV panels) (Note 1)	
Footprint required	~ 7-10 m^2 or 70-100 ft^2
Annual electricity generation	~ 1,000 units
Construction cost	~ HK$30,000 - 50,000 (US$ 4,000 – 6,500)
Payback period	~ 6-10 years (Note 2)

Note:
1. Actual figures will be subject to site conditions and design of the PV system
2. Based on a FiT rate at HK$5 per unit, operation & maintenance costs are assumed minimal

Business Models

Self-Owned

- Roof Owner (as a HK Electric customer) installs a REPS, participated in FiT Scheme



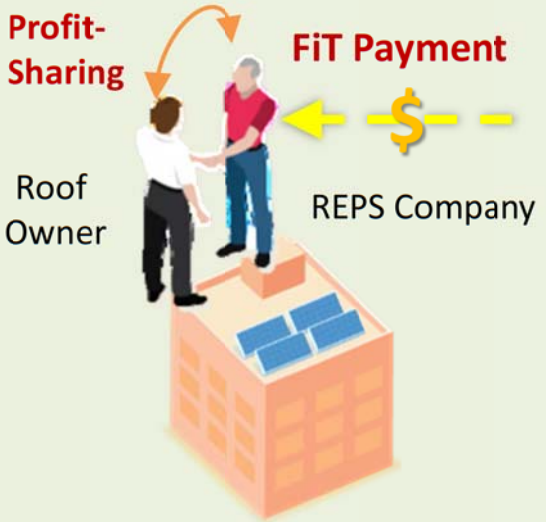
Roof Leasing

- Roof Owner charges a fixed rent
- Tenant such as REPS Company (as a HK Electric customer) pays the rent, the cost of REPS system, and participates in FiT Scheme



Solar Leasing (profit-sharing)

- REPS Company owns/shares the cost with Roof Owner for REPS system
- Roof Owner/Company (as a HK Electric customer), participates in FiT Scheme Profit-sharing of FiT Payment



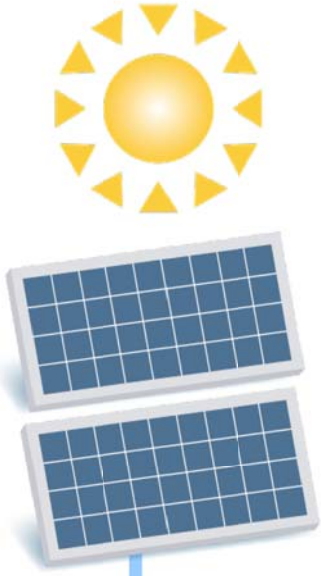
PV System Configuration

上網電價
FEED-IN
TARIFF

Battery System?

- HK Electric purchases all output - no surplus energy to store
- Battery cost
- Charging/discharging efficiency loss
- Battery life







DC Current

AC Current



Isolation Transformer



RE Meter

HK Electric's Power Grid

Requirements on Solar PV System

- PV system owner shall ensure REPS design, installation, operation and maintenance comply with all applicable laws, regulations, codes of practice, guidelines, safety and technical requirements including:
  - Technical Guidelines on Grid Connection of Renewable Energy Power System
  - Registration of Generating Facility in accordance with the Electricity Ordinance
  - **EMSD Guidance Notes for Solar Photovoltaic (PV) System Installation**
  - Minor Works Control System
  - HK Electric Technical & Interface Requirements

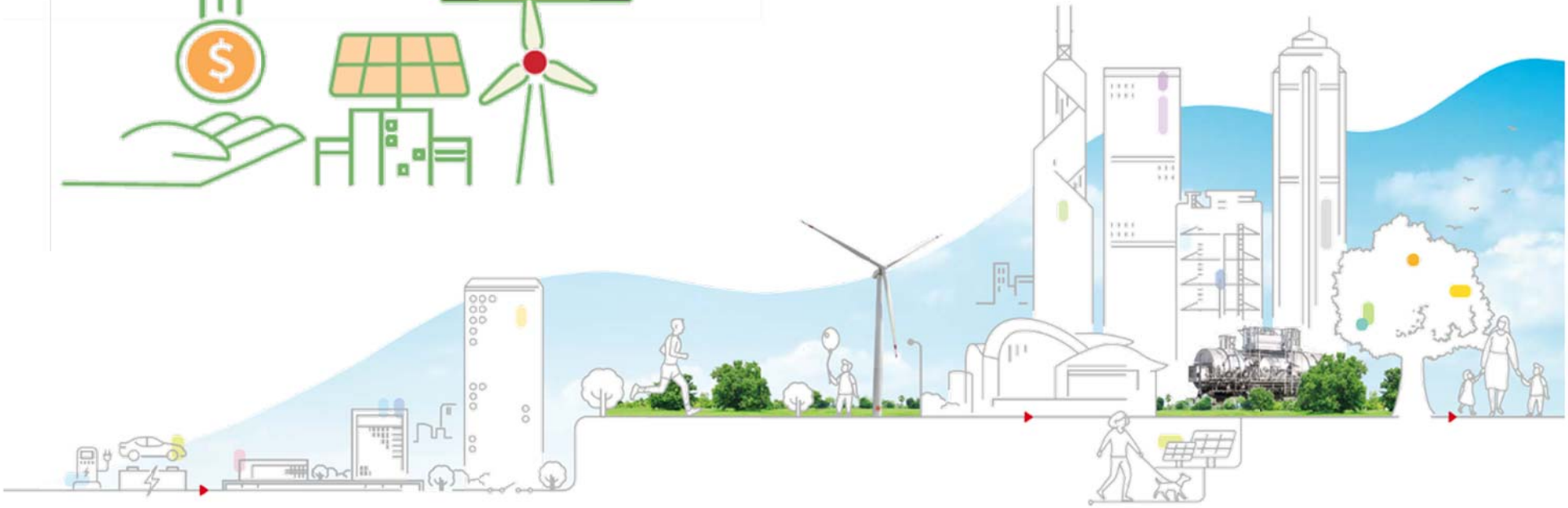


- PV system owner shall engage qualified service provider (e.g. Registered Electrical Contractor) to design and install solar PV system
  - Lists of RE equipment suppliers and contractors are published on EMSD website re.emsd.gov.hk (EMSD hotline: 6395 2930)

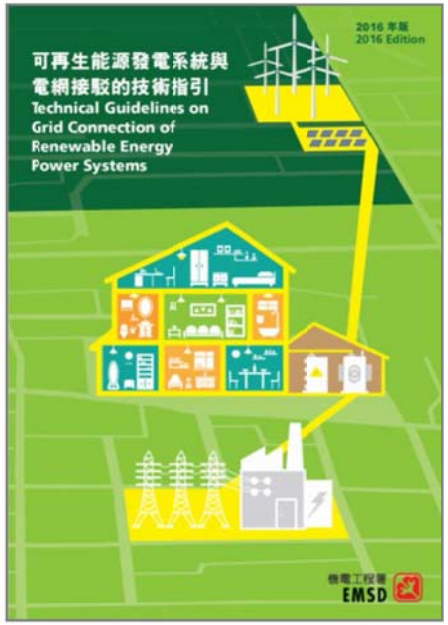
Source: EMSD, HKSARG



Industry Knowhow



Industry Knowhow



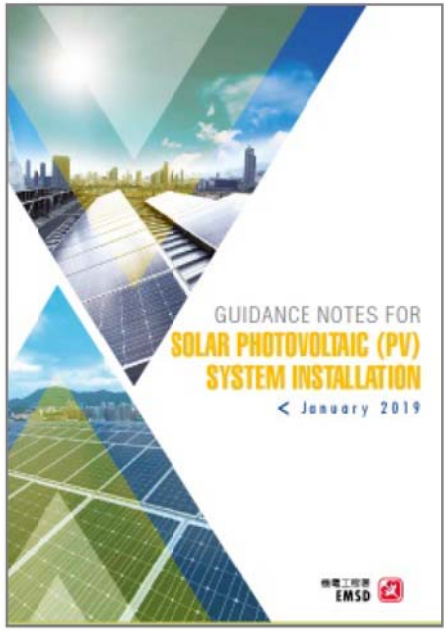


Image credit: EMSD, HKSARG

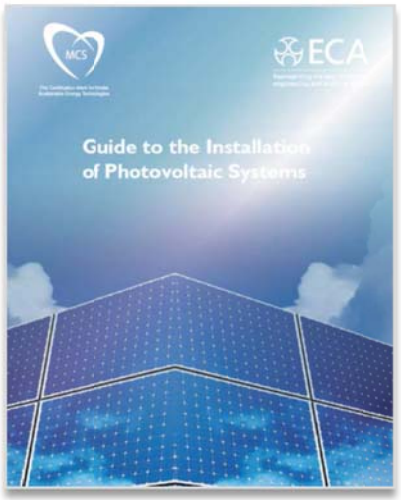


Image credit: Guide to the Installation of Photovoltaic Systems, Microgeneration Certification Scheme (MCS), the UK

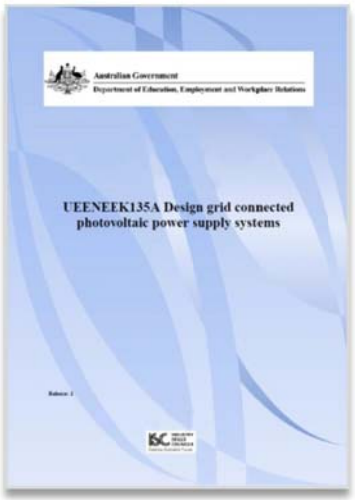


Image credit: UEENEEK135A Design grid connected photovoltaic power supply systems, Australian Government

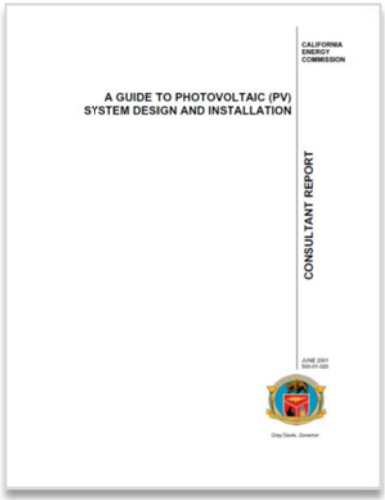


Image credit: A Guide to Photovoltaic (PV) System Design and Installation, California Energy Commission

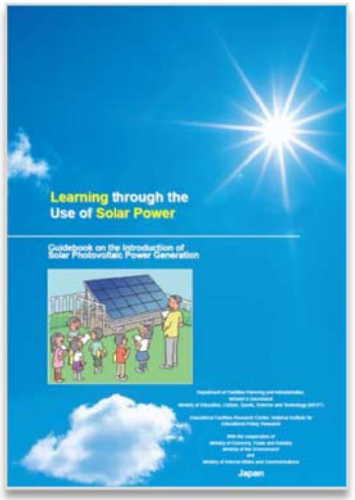


Image credit: Guidebook on the Introduction of Solar Photovoltaic Power Generation, Japanese Government

Typical PV Panels

Monocrystalline	Polycrystalline	Thin-Film (TF)
		
• Highest efficiency, ~20% or above • High Cost • ~11 kg/m^2 • Energy PayBack Time (EPBT): ~ 3 years	• High efficiency, similar to monocrystalline cells • High cost but lower than monocrystalline • ~11 kg/m^2 • Energy PayBack Time (EPBT): ~ 2 years	• Low efficiency, around half of crystalline cells • Lowest Cost • ~3 kg/m^2, flexible model available for curved surface • Energy PayBack Time (EPBT): ~ 1.5 years

- Warranty, degradation, etc.

Niche PV Panels



Image credit: EG Energy Management

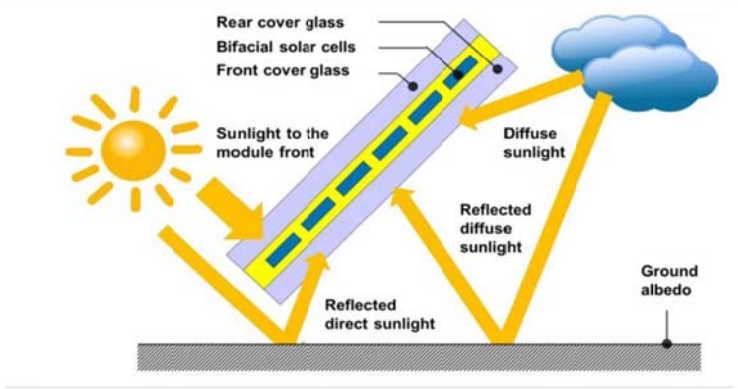


Image credit: TÜV Rheinland Energy



Image credit: Time Magazine



Image credit: ABC

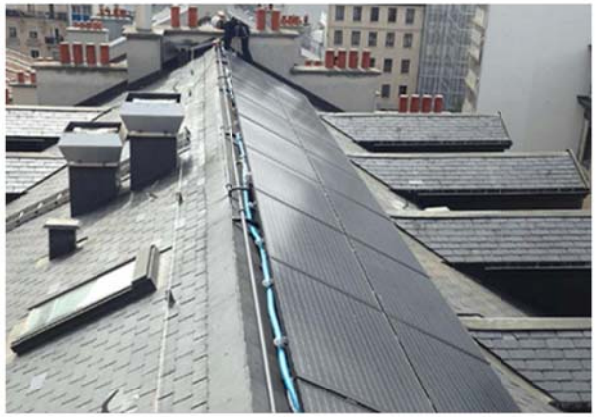


Image credit: Dual Sun



PV Panel Inclination

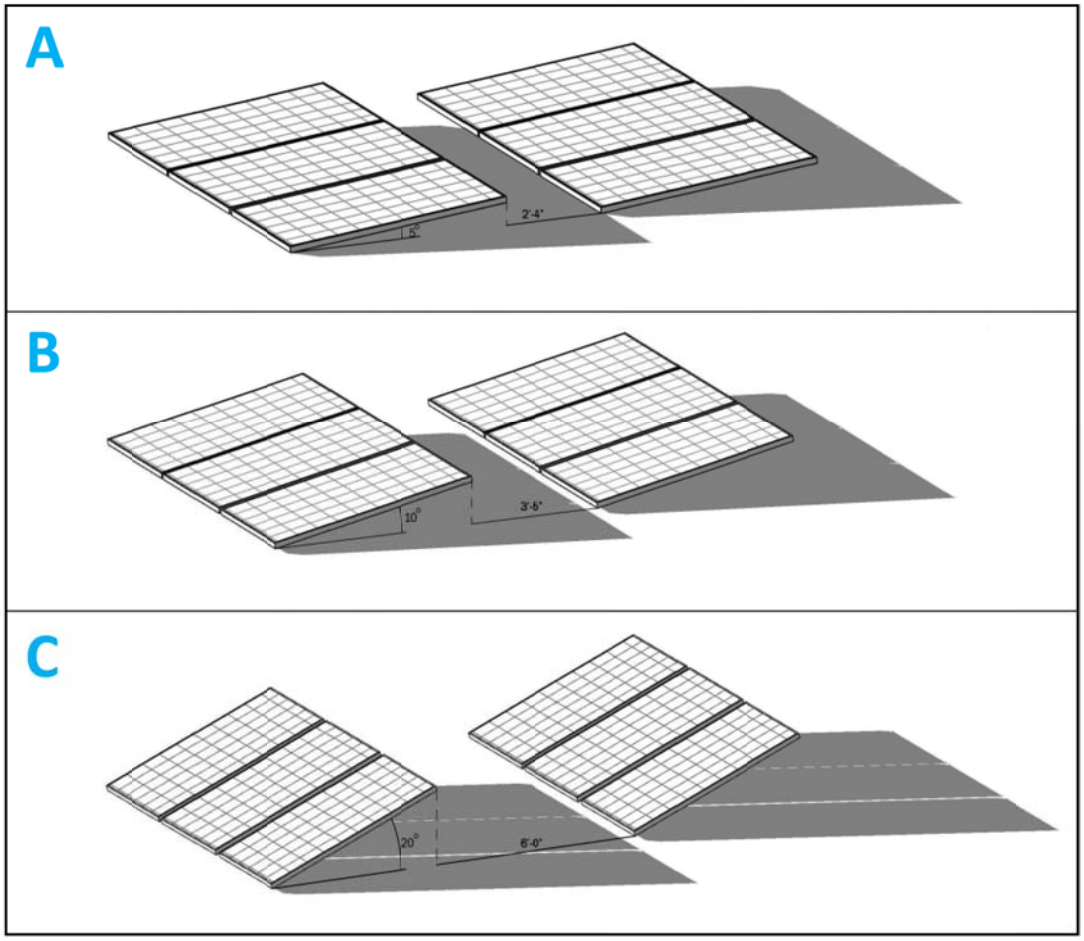
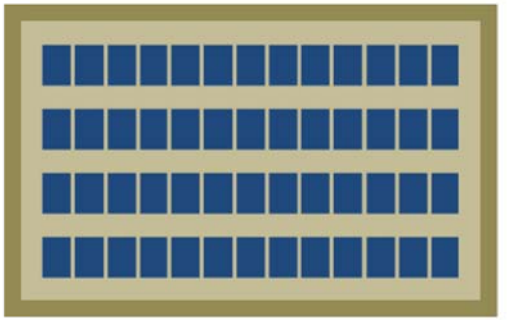
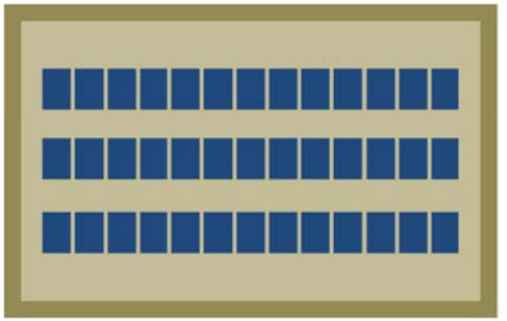


Image credit: The American Institute of Architects

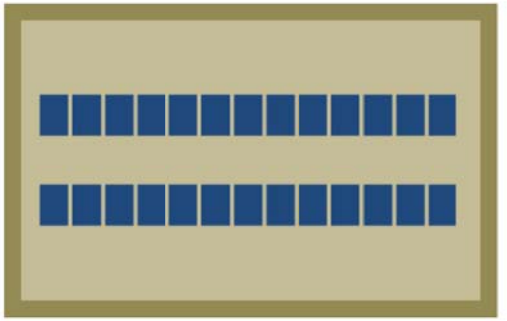
A
4 arrays



B
3 arrays



C
2 arrays



PV Panel Orientation
South vs East-West



Image credit: METALOUMIN SA (East-west PV in Greece)



Image credit: Neoen (300MW project in Cestas, France, developed by Neoen with east-west orientation for maximum land efficiency)



Image credit: Neighbour Power Inc. (Canada)

Benefits of East-west PV Installation (1/2)

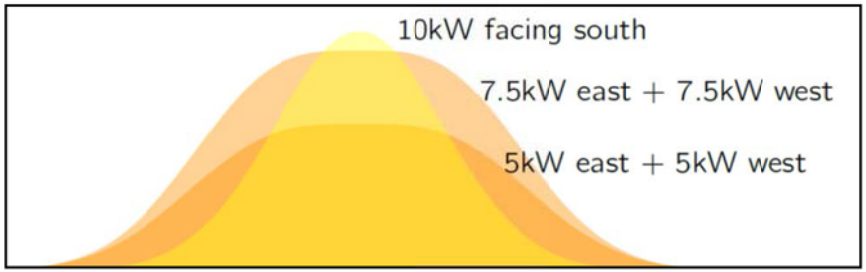


Image credit: Neighbour Power Inc. (Canada)

Lower system peak output

→ inverters can be over-panelled without any change to the inverter/balance of plant

→ more energy output per inverter kW

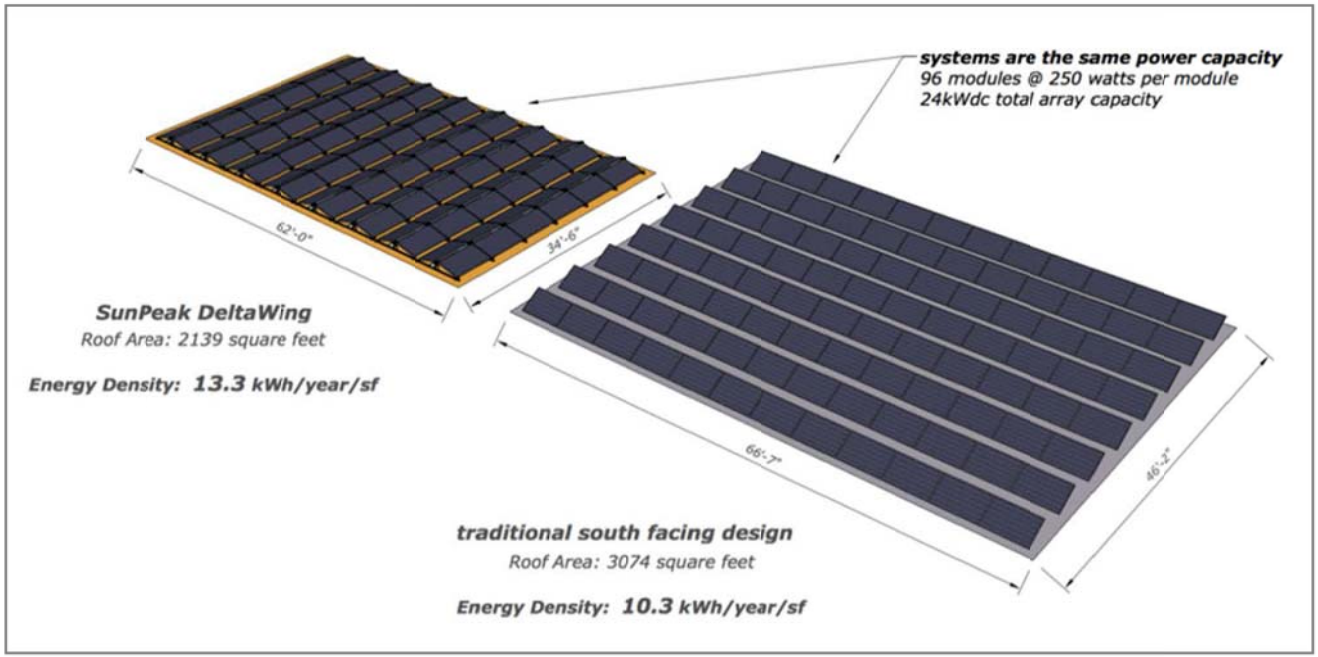


Image credit: SunPeak

Higher panel density

→ higher yield per square feet

Benefits of East-west PV Installation (2/2)



Image credit: ALTEC SYSTEMTECHNIK AG

Lower mounting/supporting materials

→ Lower cost

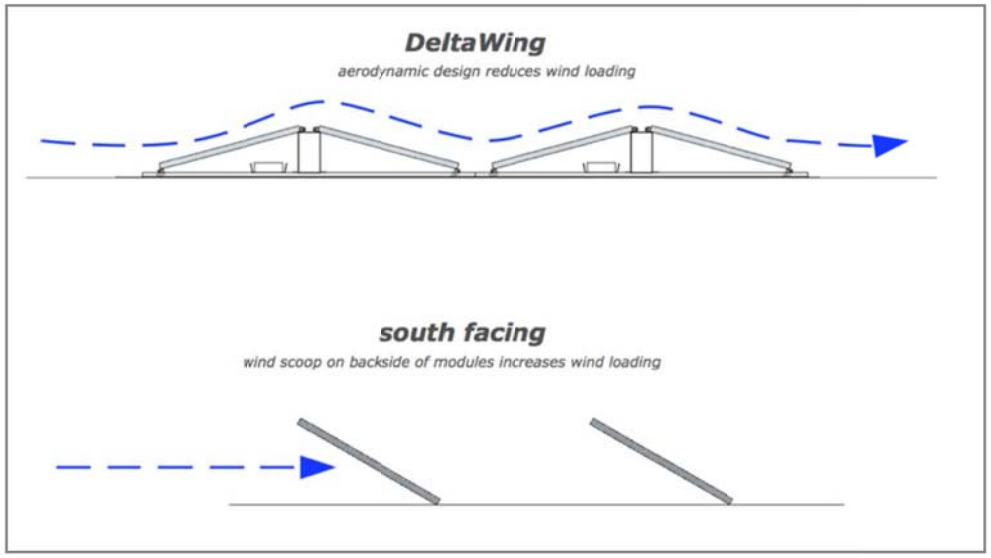


Image credit: SunPeak

More aerodynamic / lower wind load

→ Less vulnerable to strong winds (e.g. during typhoon season)

Building/Structural Requirements
Wind Effect

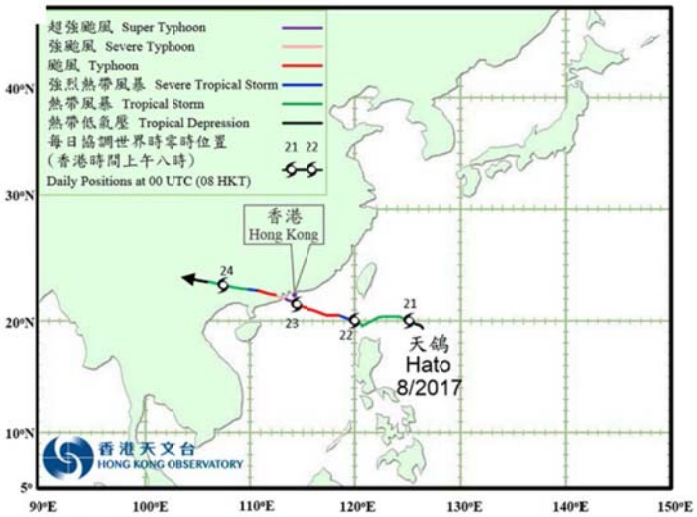
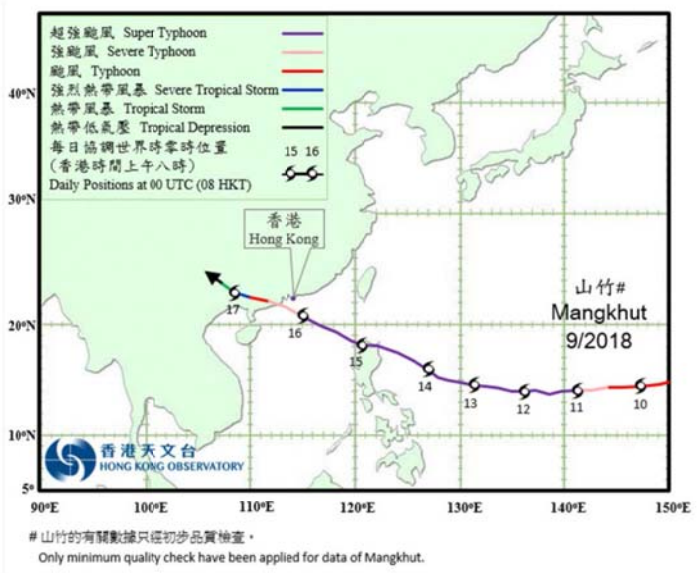
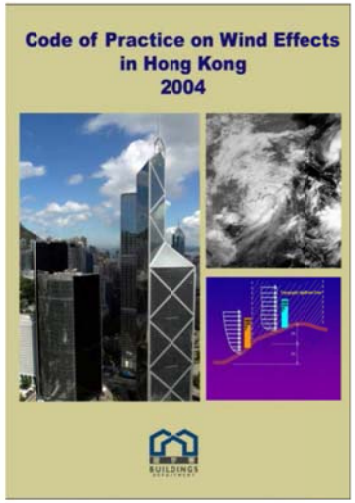


Image credit: HK Observatory





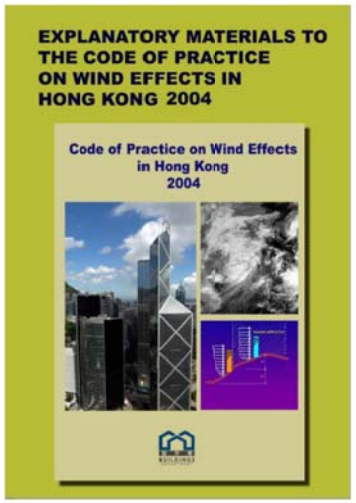


Image credit: Code of Practice on Wind Effects in Hong Kong 2004 (BD); Explanatory Materials to The Code of Practice on Wind Effects in Hong Kong 2004 (BD)



Image credit: 耐17級風攏是假 國小太陽能板9級風就垮了, 28 Sep 2016, Taiwan Apple Daily

Vertical Bifacial PV Installation

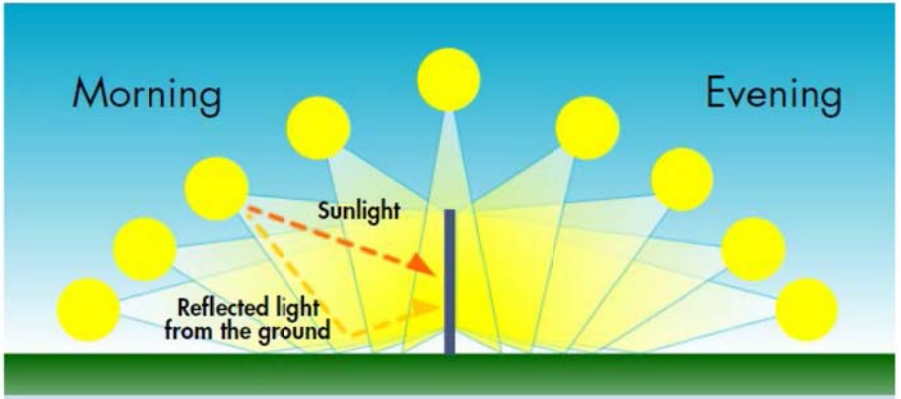


Figure 8. Rear collection power gain of a vertically mounted bifacial PV module
Source: Natural Energy Yasukawa

Image credit: EPRI



Image credit: EPRI (One of the first commercial applications of bifacial PV modules: noise barriers along roadways in Switzerland); source: TNC Consulting AG



Image credit: Solar Energy Application Centre (SEAC) (Bifacial modules will be installed on highways noise barriers as part of the Solar Highways initiative in Netherlands)

Vertical Bifacial PV Installation – Better Land Use





Image credit: Next2Sun (A farm in Dirmingen, Saarland (south-west Germany)

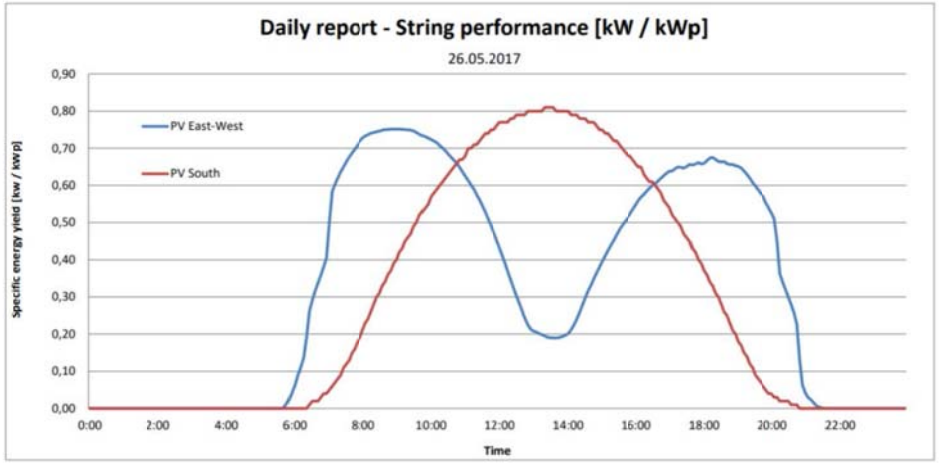
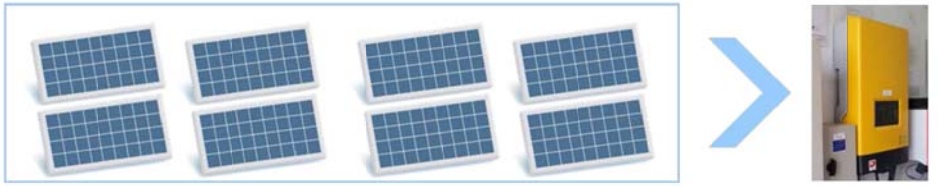


Image credit: Next2Sun

Over-panelling/Oversizing

- Irradiation values are not achieved (e.g., in the winter months)
- Ambient temperatures are too high (temperature de-rating effect)
- Pollution of the modules
- Suboptimal orientation of the modules
- Module degradation
- Other system losses (e.g. cable losses)



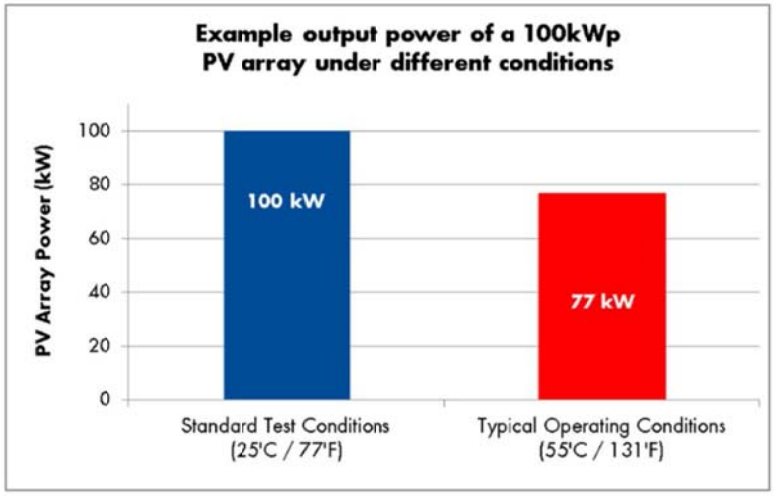


Image credit: SMA

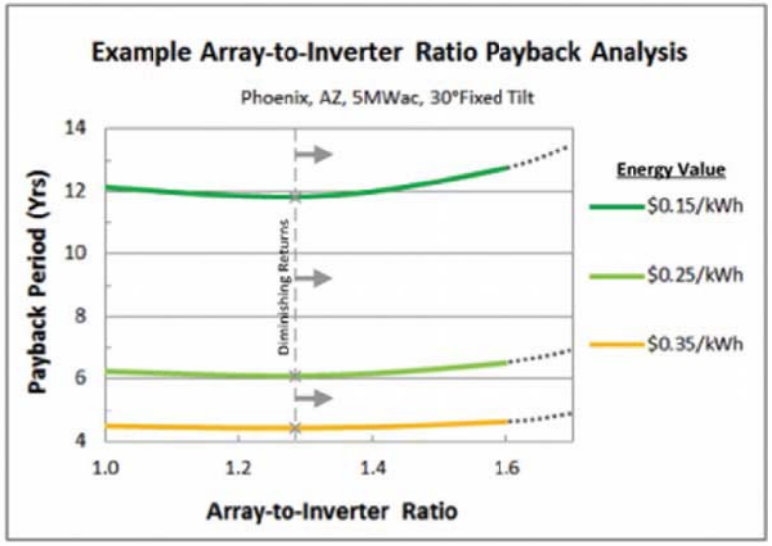
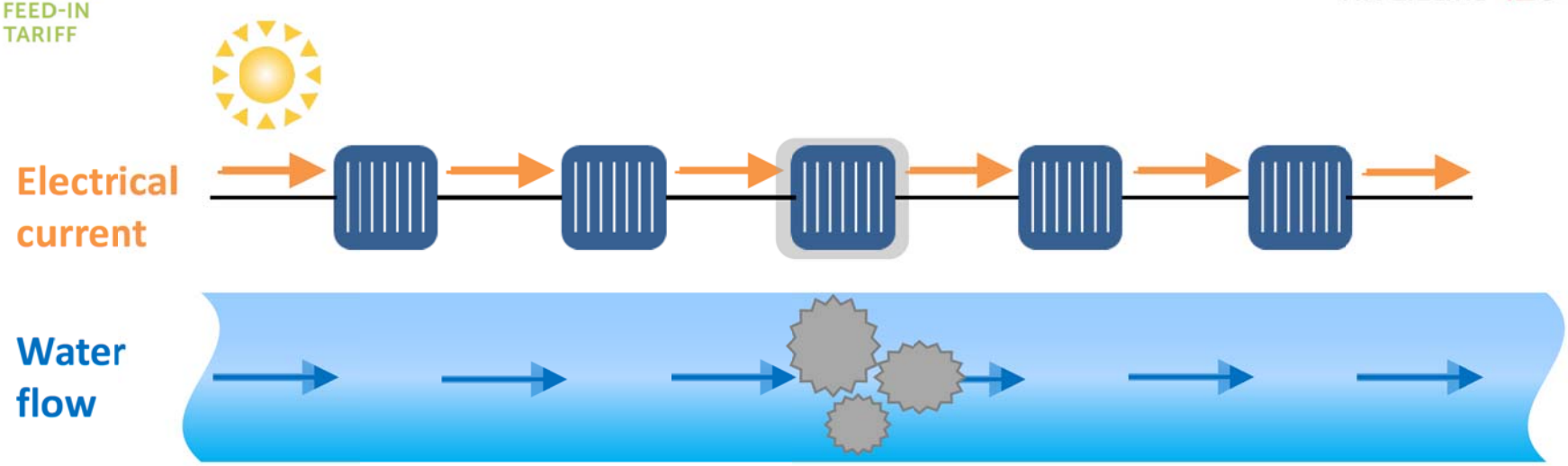


Image credit: Solectria Renewables

Shading Effect on PV Panel



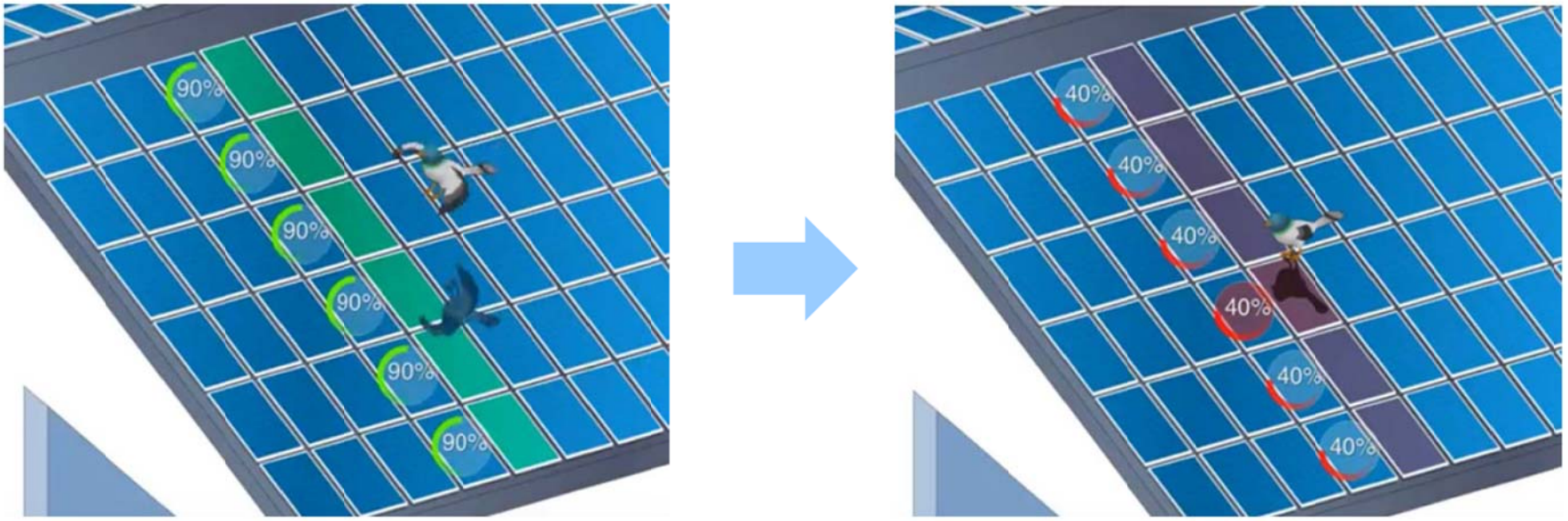


Image credit: Sunlit Future

Tackling Shading Effect

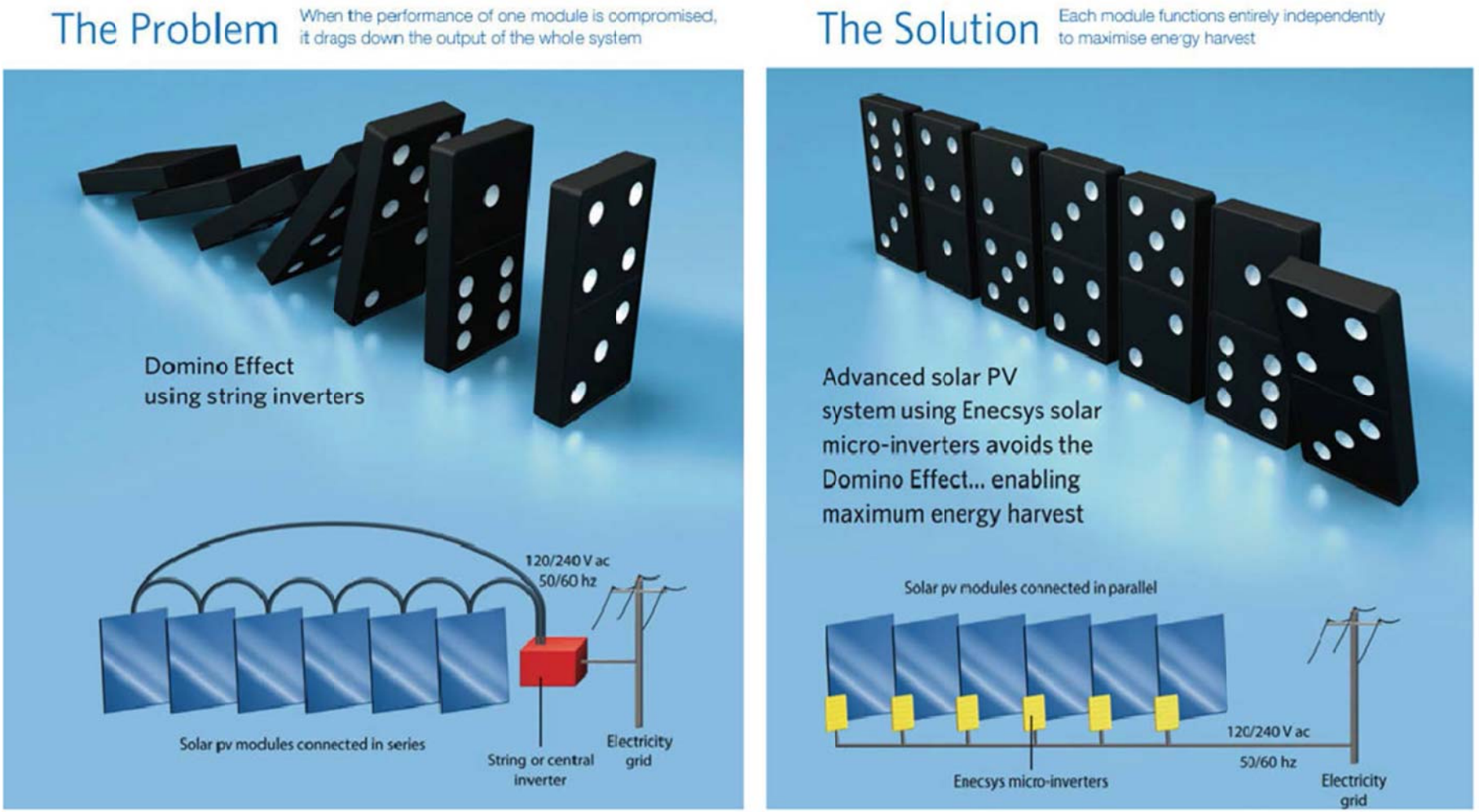
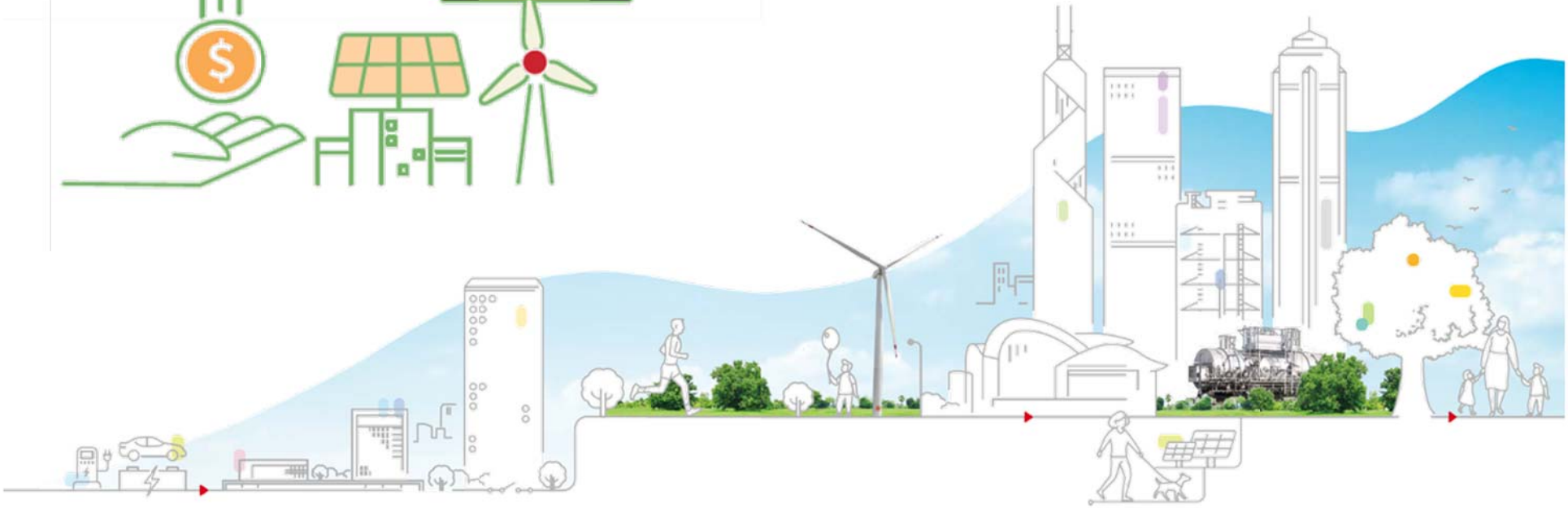


Image credit: Texas Solar Energy Primer (Enecsys solar micro-inverters)


Technology



PV Technologies

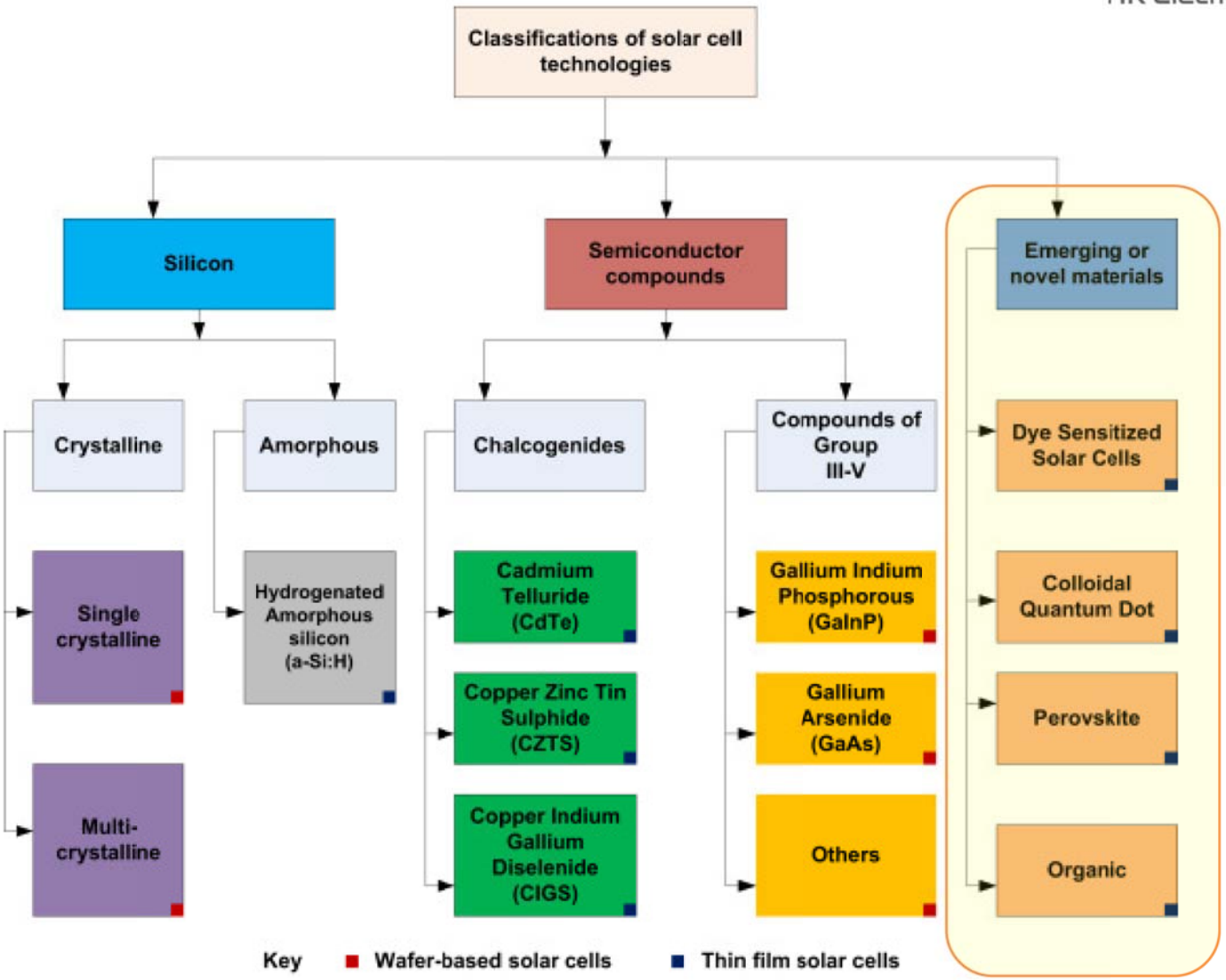


Image credit: T.Ibn-Mohammed, S.C.L.Koh, I.M.Reaney, A.Acquaye, G.Schileo, K.B.Mustapha, R.Greenough. Perovskite solar cells: An integrated hybrid lifecycle assessment and review in comparison with other photovoltaic technologies. Volume 80, December 2017, Pages 1321-1344

Cell Efficiencies

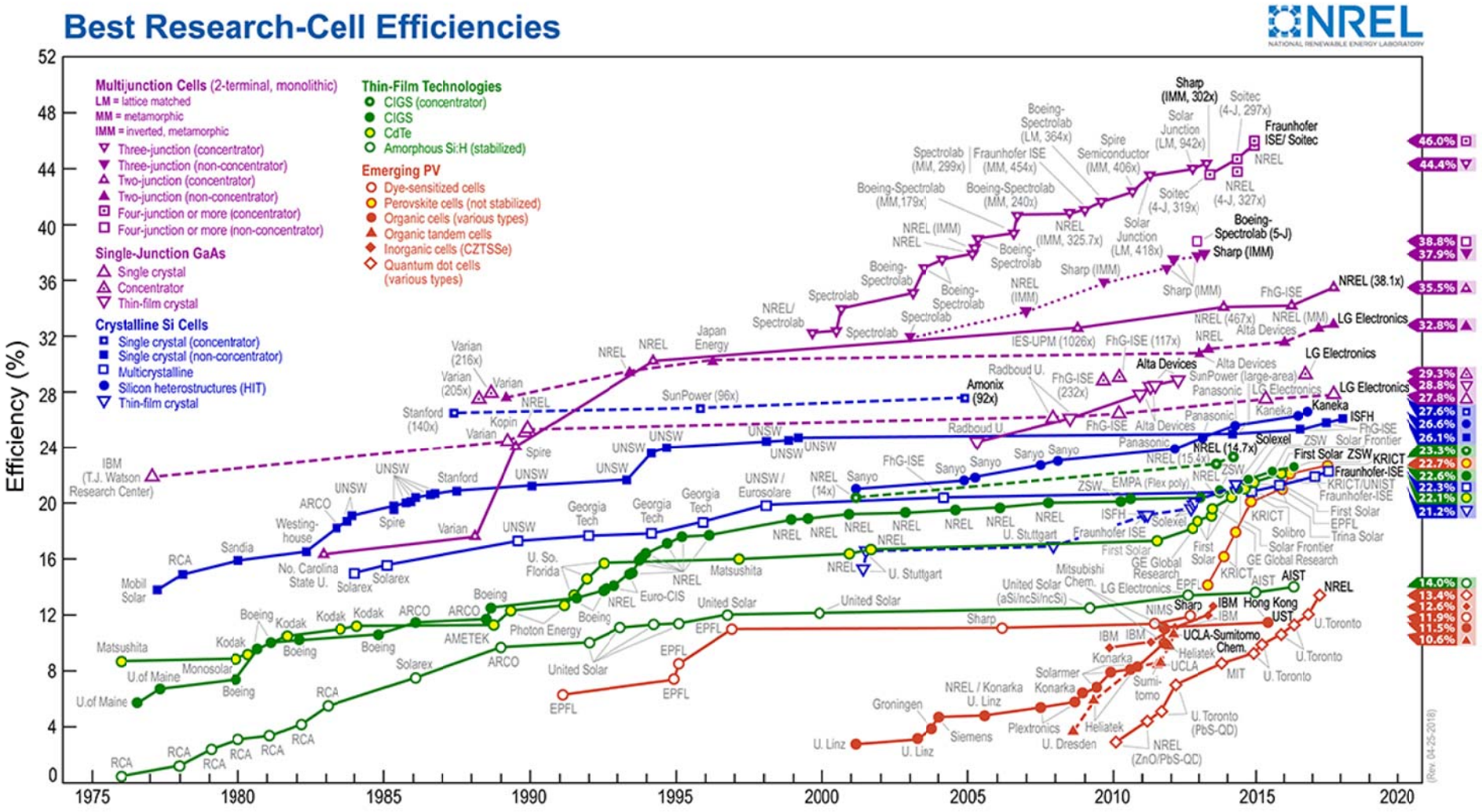


Image credit: NREL

3rd Generation Solar Cells

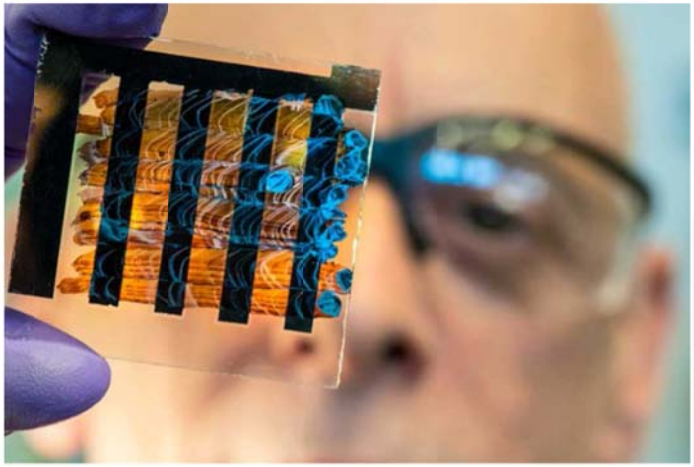


Image credit: Dennis Schroeder, NREL (NREL researcher David Moore holds a perovskite solar cell painted with a special ink he developed)

- Organic
- Non-toxic
- Abundant
- Transparent
- Flexible
- Low cost
- High efficiency

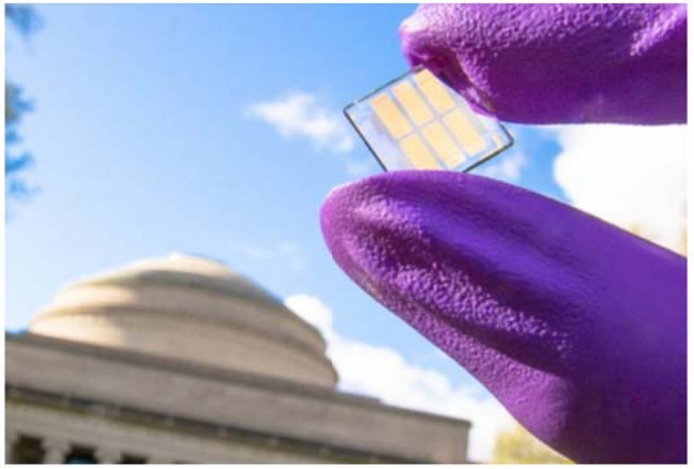


Image credit: Chia-Hao Chuang (Researcher displays a sample of the record-setting new solar cell on the MIT campus)



Image credit: Richard Lunt/Michigan State University (See-through solar-harvesting applications, such as this module pioneered at Michigan State University, have the potential of supplying 40 percent of U.S. electricity demand)

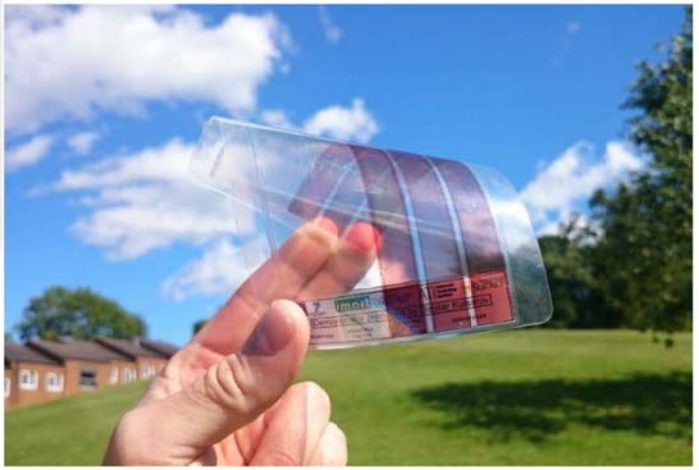
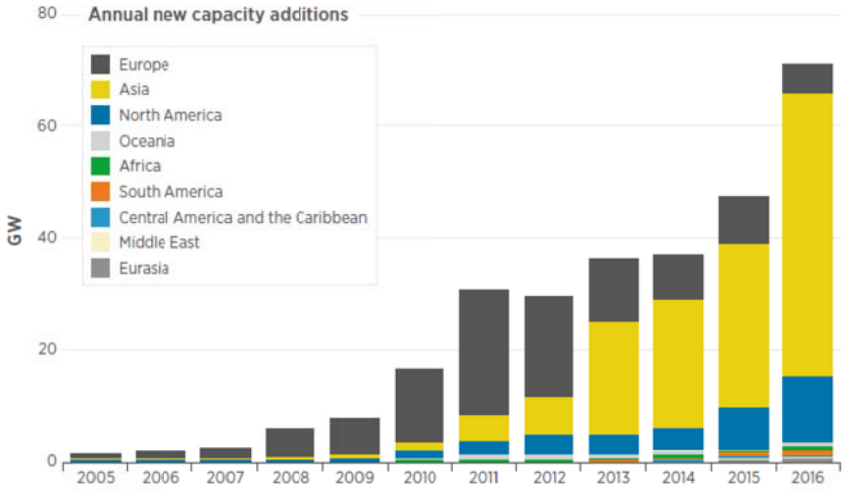
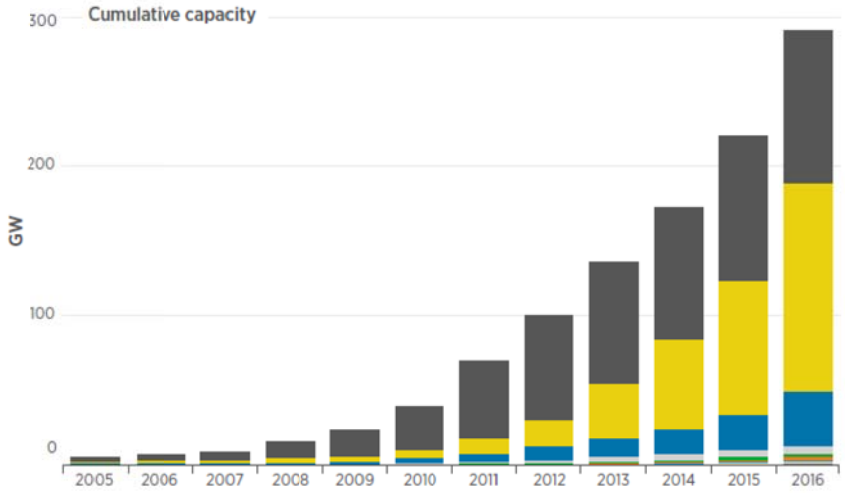
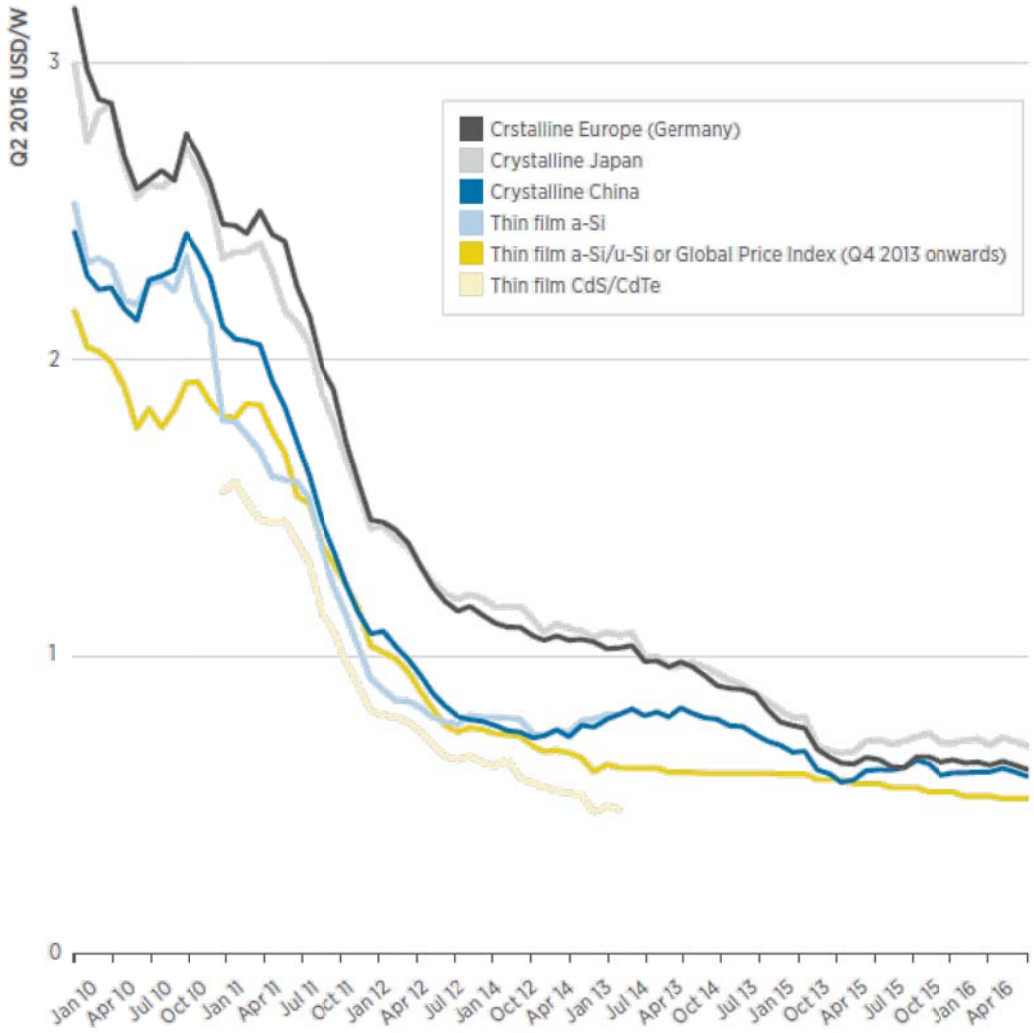


Image credit: University of Surrey (Researchers studied the eyes of moths to create sheets of graphene they claim to be the most light-absorbent material ever created)

Declining PV Module Price





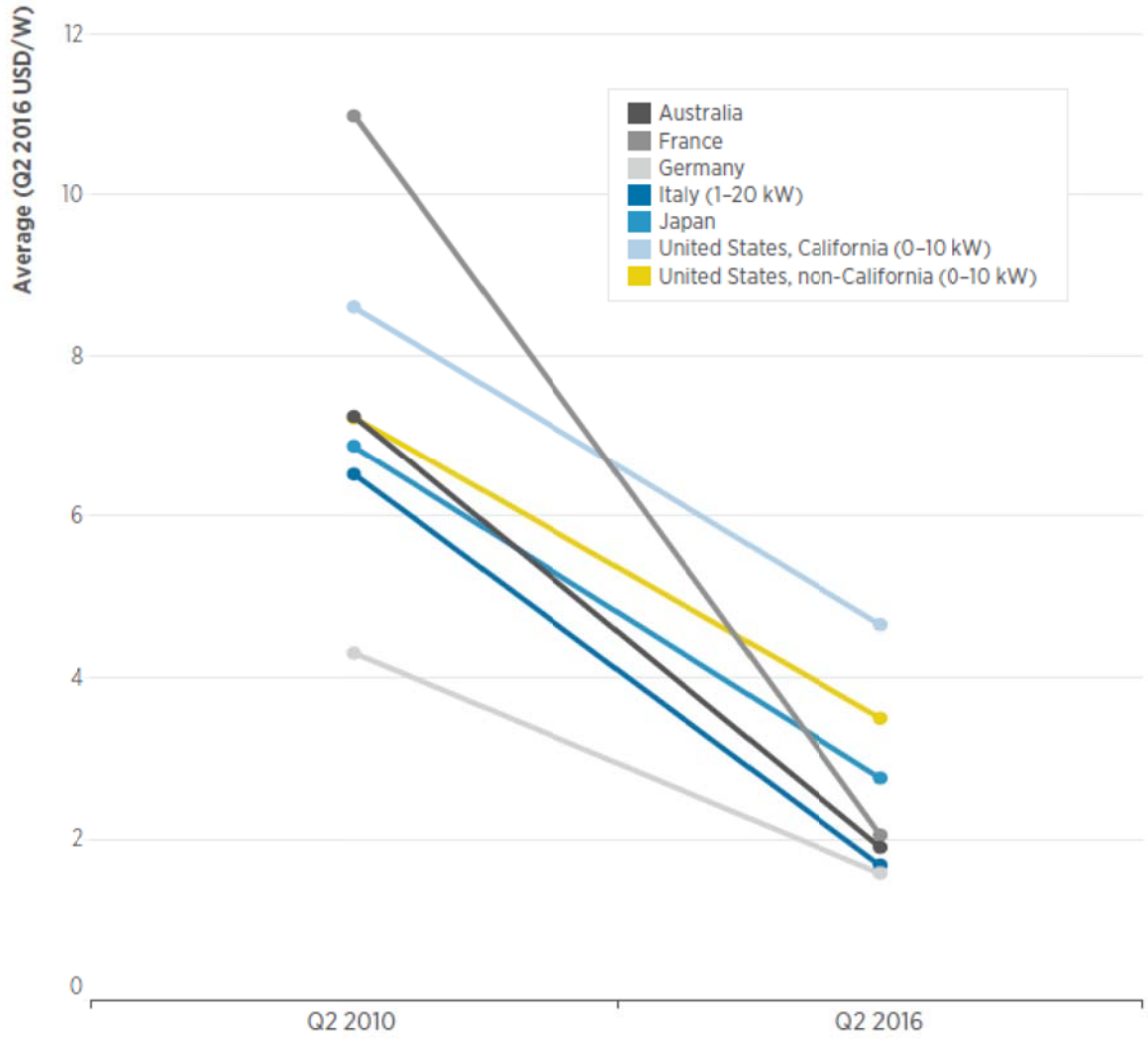


Source: GlobalData, 2015; pvXchange, 2016.

Note: Values displayed in real Q2 2016 USD/W.

Image credit: IRENA Cost and Competitiveness Indicators (Rooftop Solar PV (Dec 2017), IRENA

Average Total Installed Cost of Residential Solar PV Systems



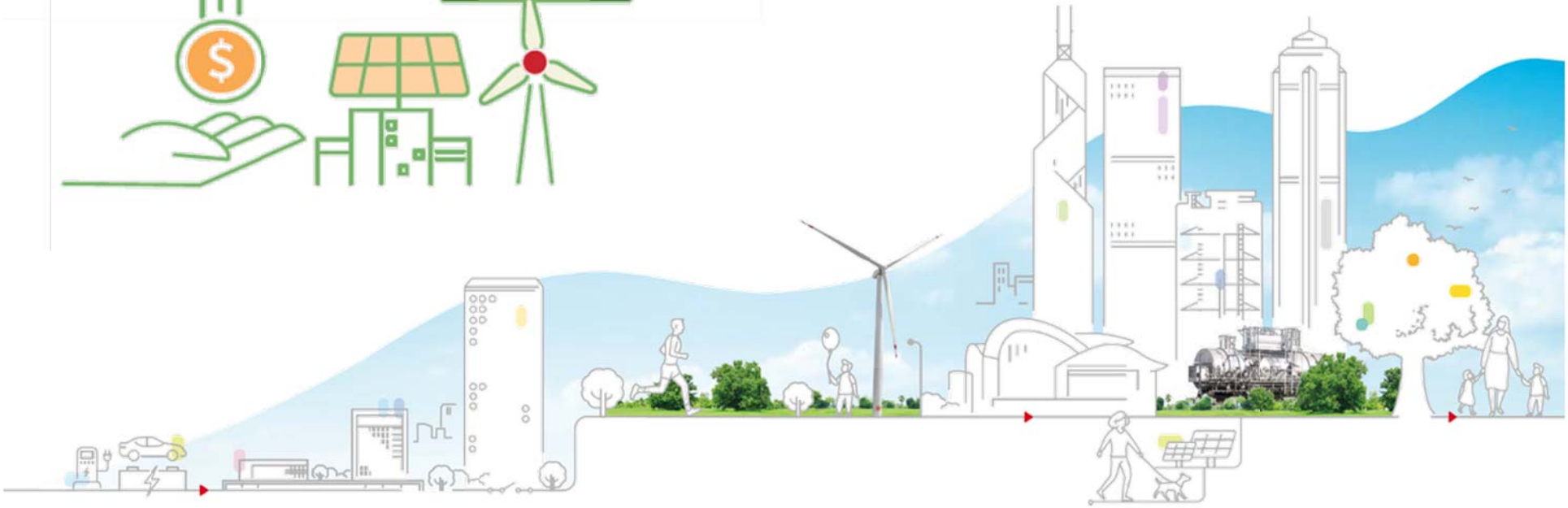
% Decline 2010–2016	
Australia	–74%
France	–81%
Germany	–63%
Italy (1–20 kW)	–74%
Japan	–60%
United States, California (0–10 kW)	–46%
United States, non-California (0–10 kW)	–52%

Source: IRENA Renewable Cost Database, 2017; Solar Choice, 2016; Photon Consulting, 2016; EuPD Research, 2017a.

Image credit: IRENA Cost and Competitiveness Indicators (Rooftop Solar PV (Dec 2017), IRENA



Life-cycle Management



PV Panel Waste Projection



Overview of global PV panel waste projections, 2016-2050

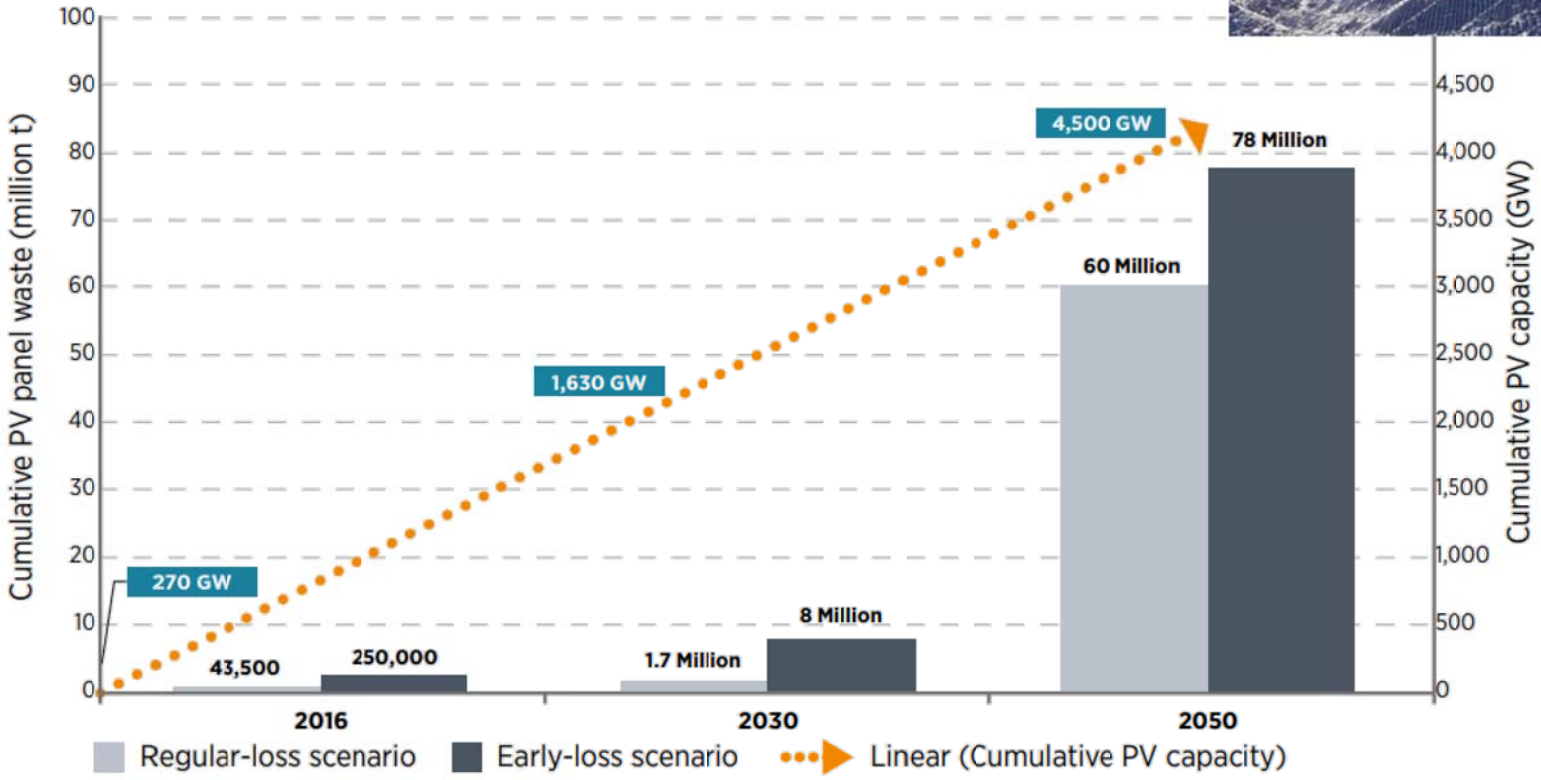


Image credit: End-of-Life Management Solar Photovoltaic Panels ((Jun 2016), IRENA

Cumulative Waste Volumes of End-of-life PV panels in 2050

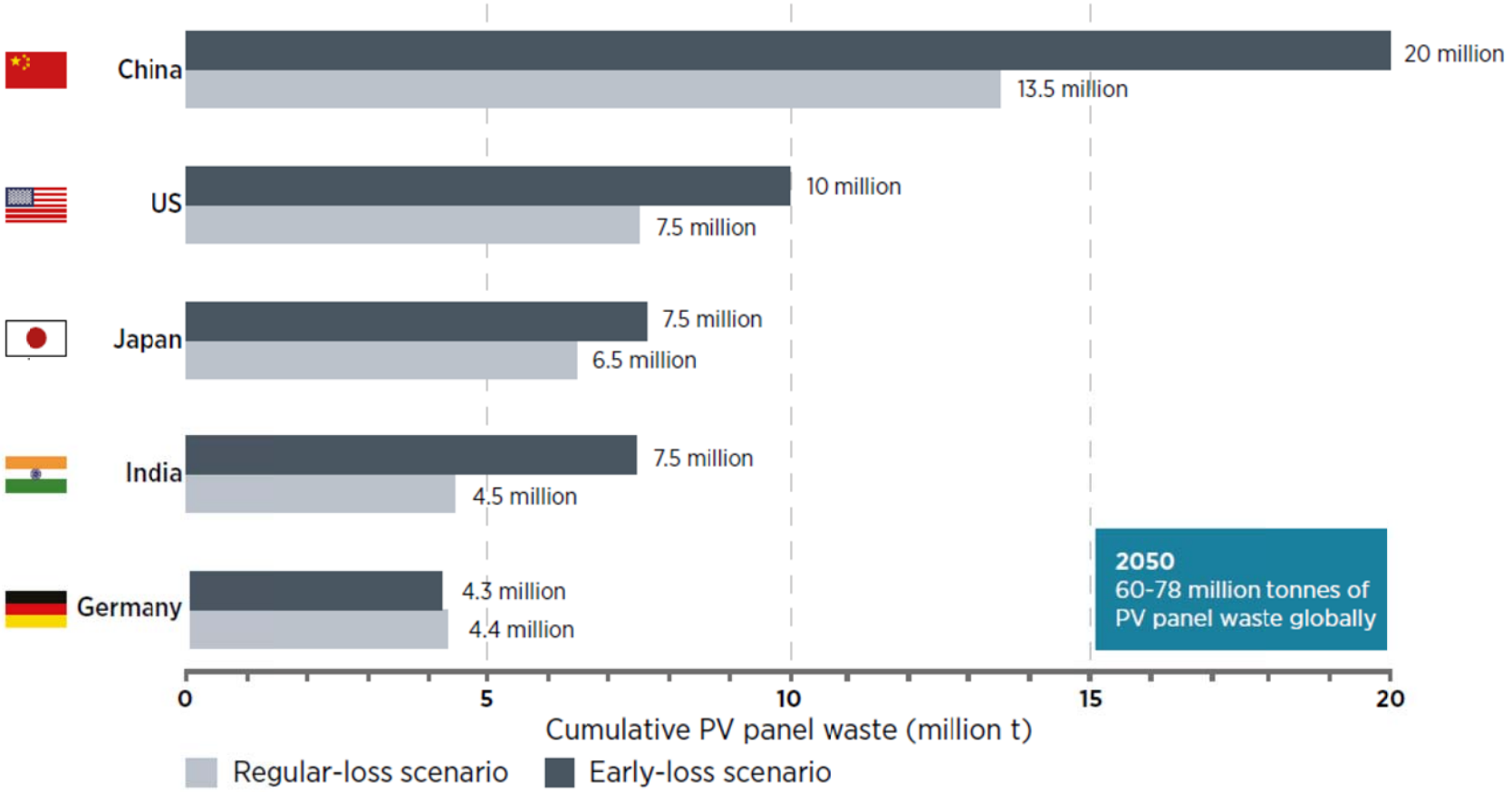
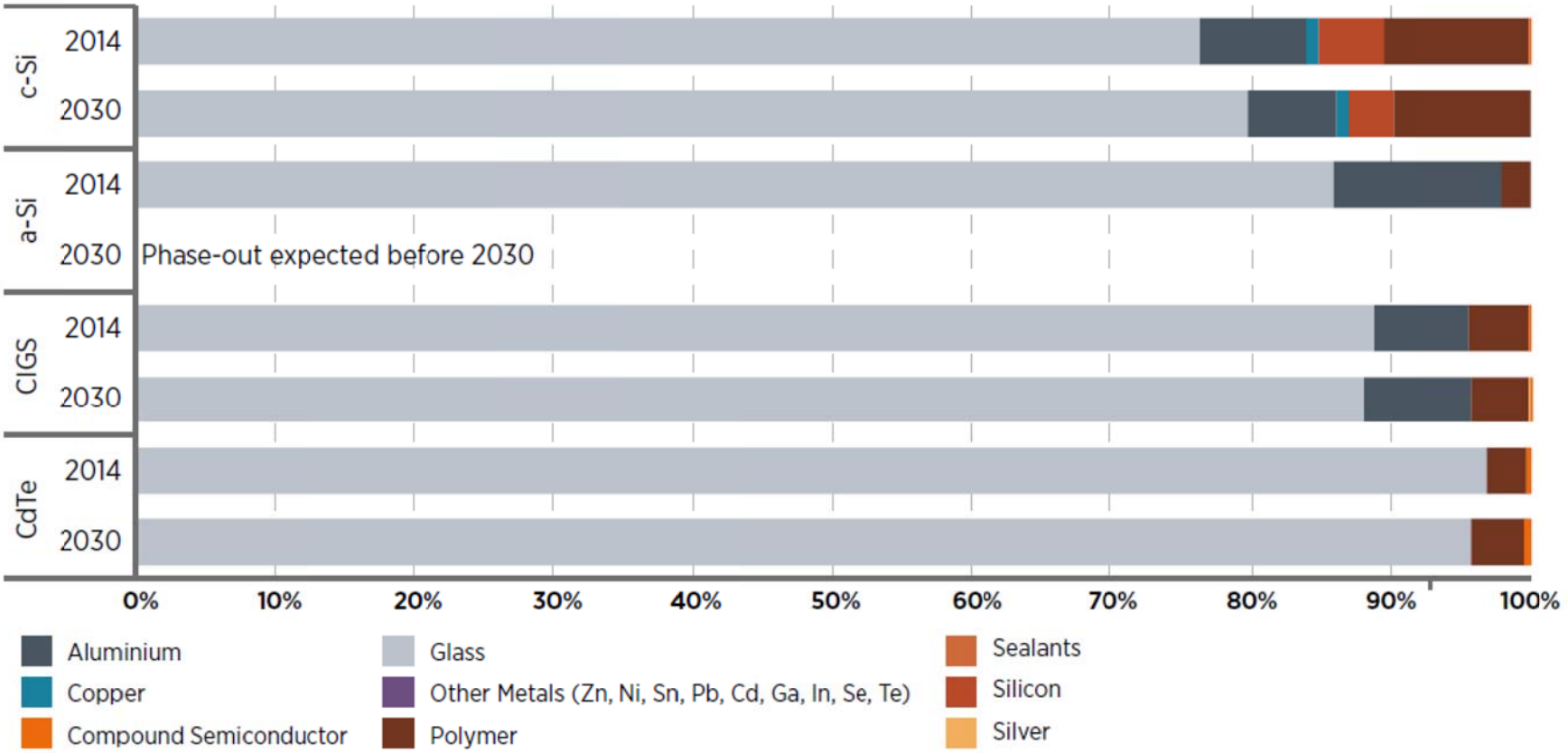


Image credit: End-of-Life Management Solar Photovoltaic Panels ((Jun 2016), IRENA

Materials Used for Different PV Panel Technologies (% of Total Panel Mass)



Based on Marini et al., (2014); Pearce (2014); Raithel (2014); Bekkelund (2013); NREL (2011) and Sander et al., (2007)

Image credit: End-of-Life Management Solar Photovoltaic Panels ((Jun 2016), IRENA

PV Panel Recycling

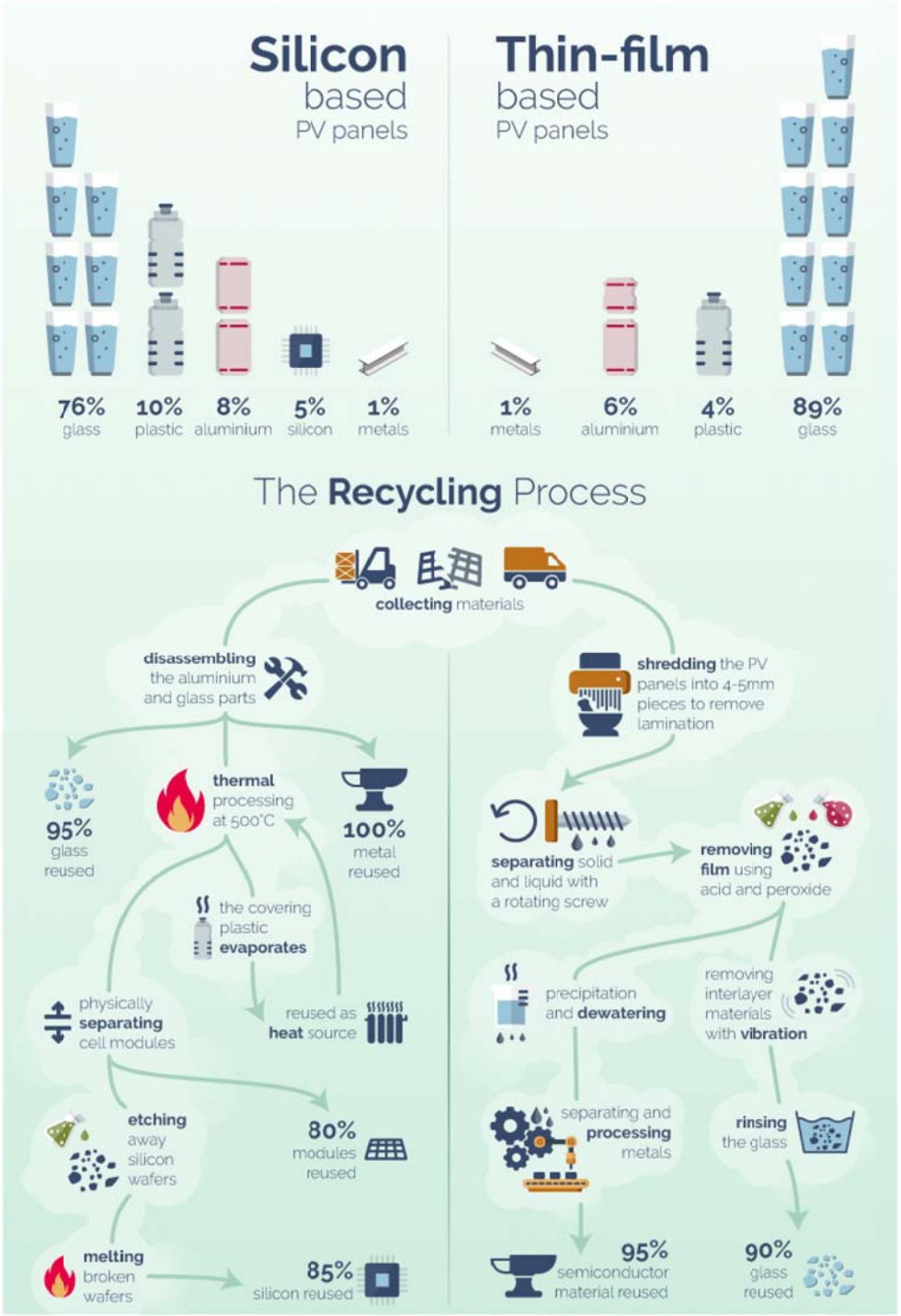


Image credit:
The Opportunities of Solar Panel Recycling, Greenmatch.co.uk

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PV Waste Management

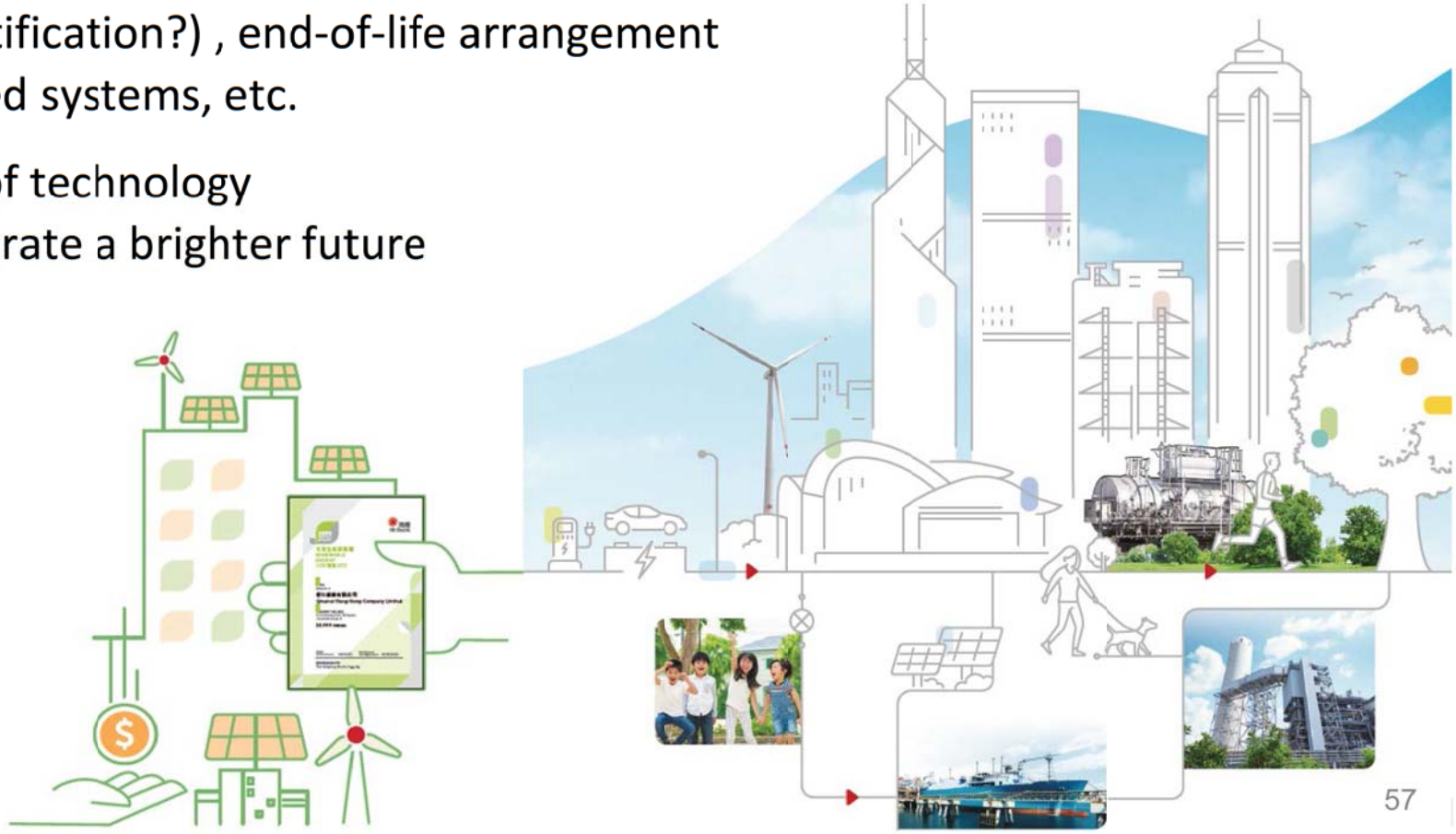
- **At present, only the European Union (EU) has adopted PV-specific waste regulations**
- **The EU started to promote sustainable PV life cycle management in 2000s**
  - Example: PV CYCLE initiative established in 2007 by leading PV manufacturers, which is fully financed by its member companies so that end-users can return member companies' defective panels at over 300 collection points around Europe
- **EU Waste Electrical and Electronic Equipment (WEEE) Directive** requires all producers supplying PV panels to the EU market (wherever they may be based) to finance the costs of collecting and recycling end-of-life PV panels
- **Most jurisdictions classify PV panels as general or industrial waste**



Image credit/source: End-of-Life Management Solar Photovoltaic Panels ((Jun 2016), IRENA

Concluding Remarks

- Positive market response to Hong Kong first-ever FiT Scheme
- FiT is a strong catalyst for local RE market development
- Regulatory shaping forces – FiT rate, practitioner training (and certification?) , end-of-life arrangement for retired systems, etc.
- Advent of technology will generate a brighter future



Thank You



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Enquiry/Application



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