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7 Nov 2019

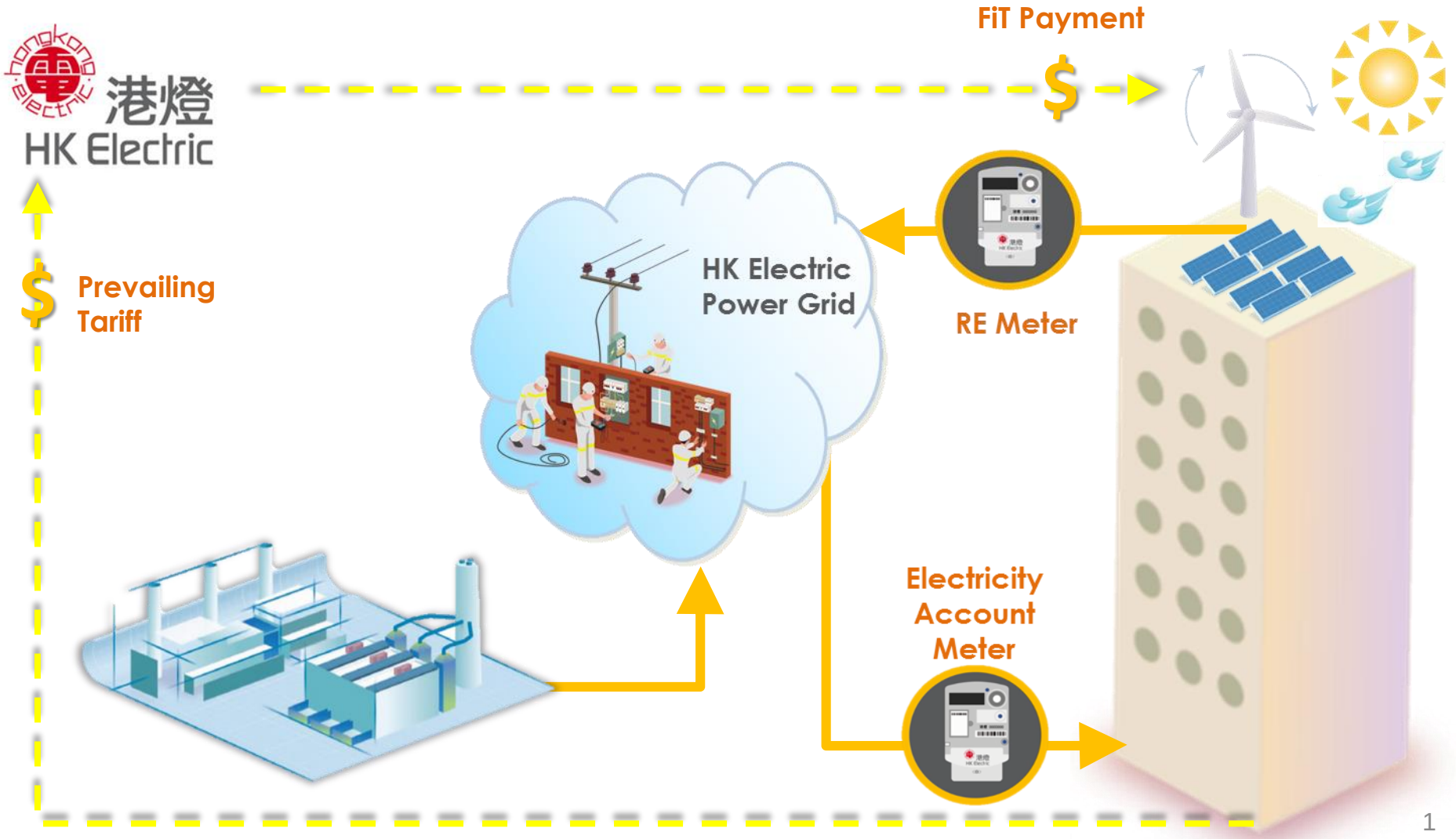
A New RE Eco-system Under Feed-in Tariff (FiT) and RE Certificates Schemes

Ir Kin WK Leung
Head of Customer Business Development

智惜用電 smart power
上網電價 FEED-IN TARIFF

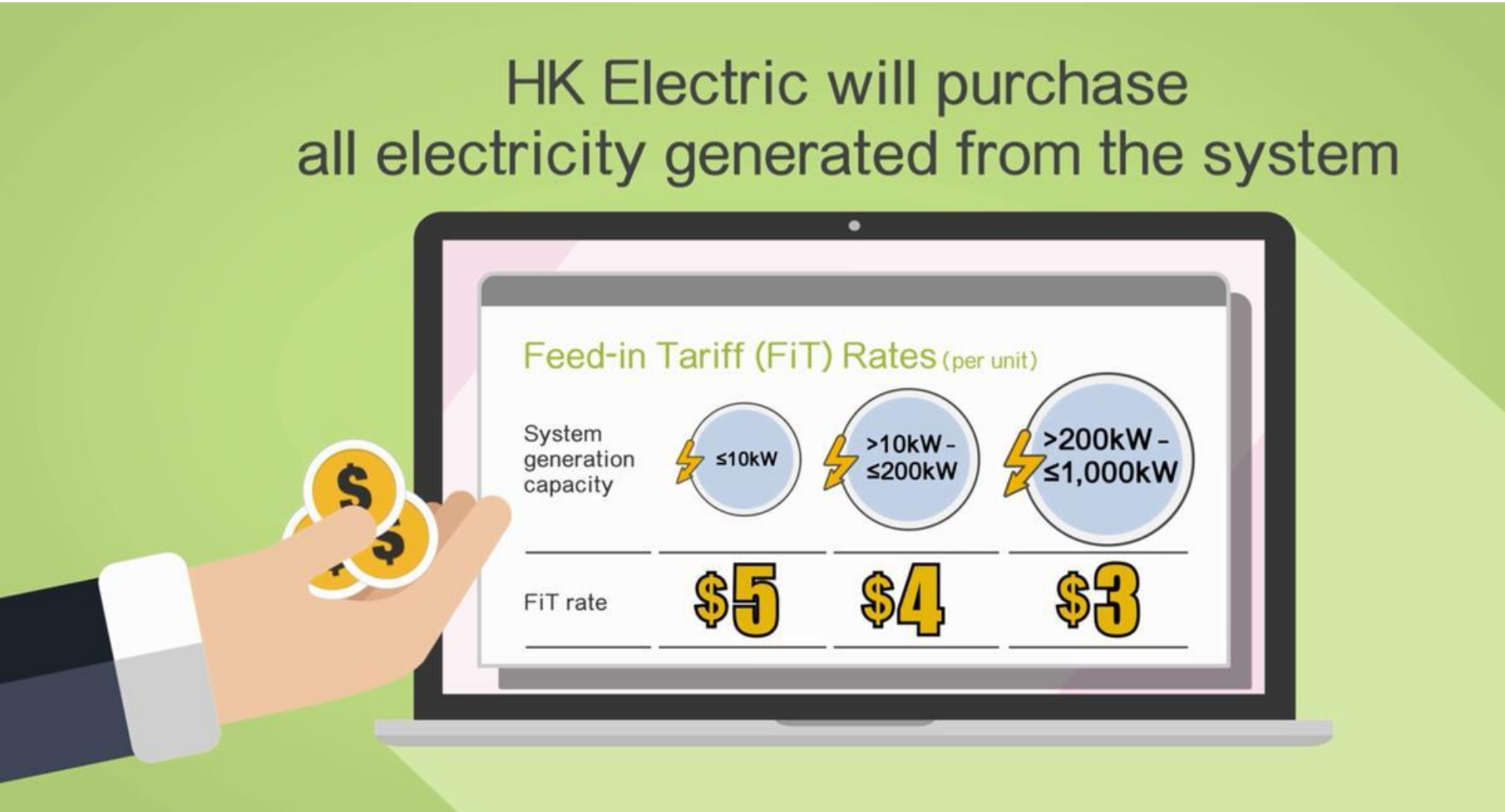
智惜用電 smart power
可再生能源證書 RENEWABLE ENERGY CERTIFICATE

Feed-in Tariff (FiT) Scheme

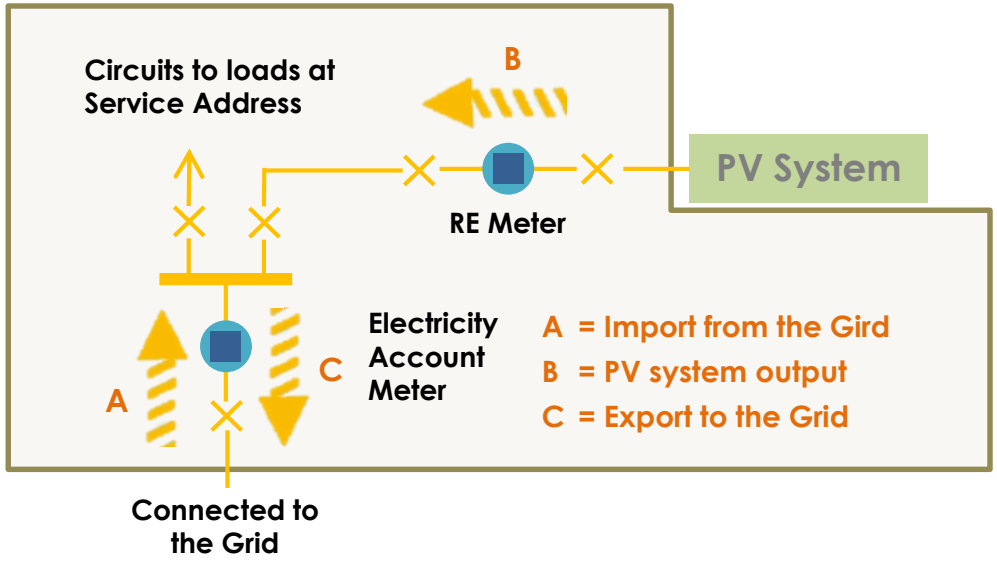


FiT Rates in 2019

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



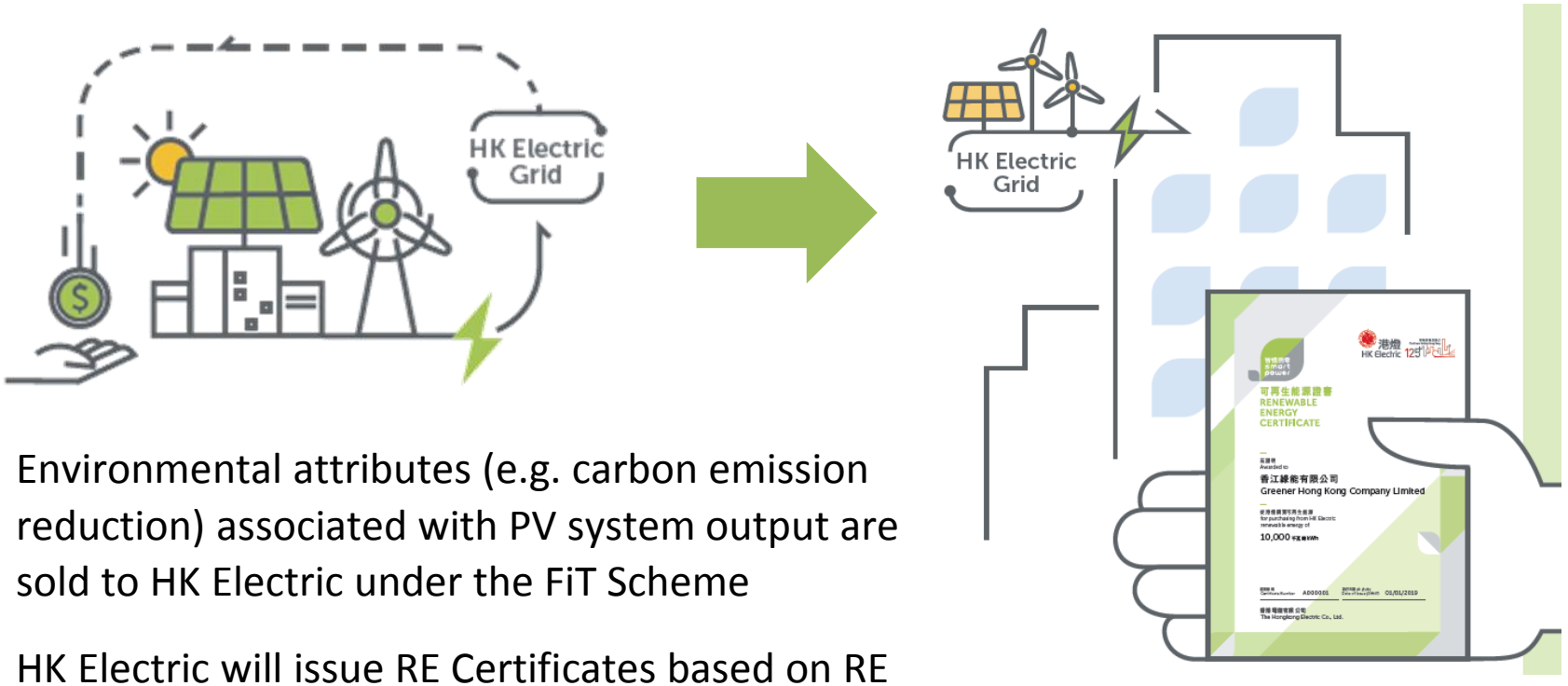
Metering and Accounting



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 Attributes



- 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)

Key Features of RE Certificates (REC)

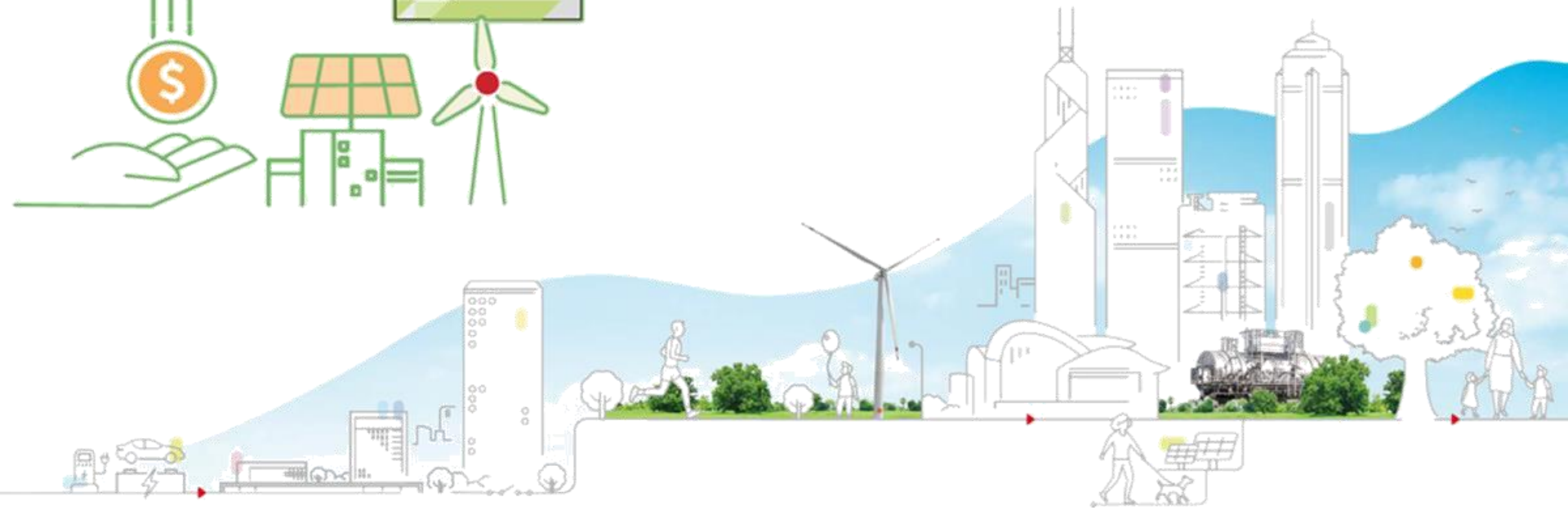
- REC is a voluntary scheme available for all HK Electric's registered customers
- RE is either generated by HK Electric or purchased by HK Electric from customers successfully joined the Feed-in Tariff Scheme
- HK$0.5 per kWh (i.e. one unit of electricity) effective 1 January 2019 (a premium on top 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

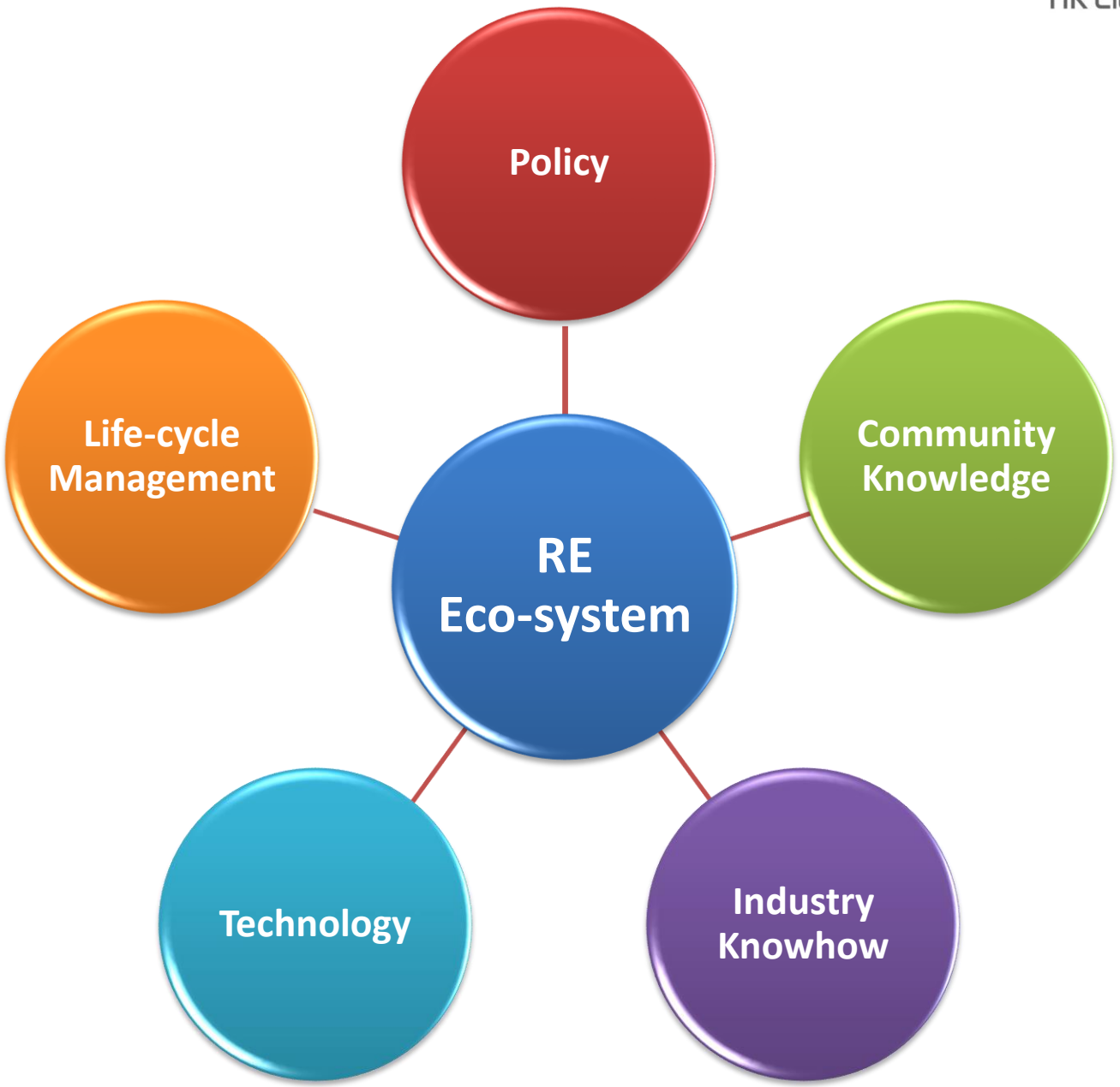
IKEA	3M Science. Applied to Life.™	Adobe	AEON
2020	2050	2035	2050
Bloomberg	citi	DECATHLON	facebook
2025	2020	2026	2020
Goldman Sachs	H&M	HSBC	ING
2020	2030	2030	2020
Morgan Stanley	PRUDENTIAL	Life Is On Schneider Electric	SONY
2022	2025	2030	2040

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

A New Renewable Energy Eco-system



What have been evolving?



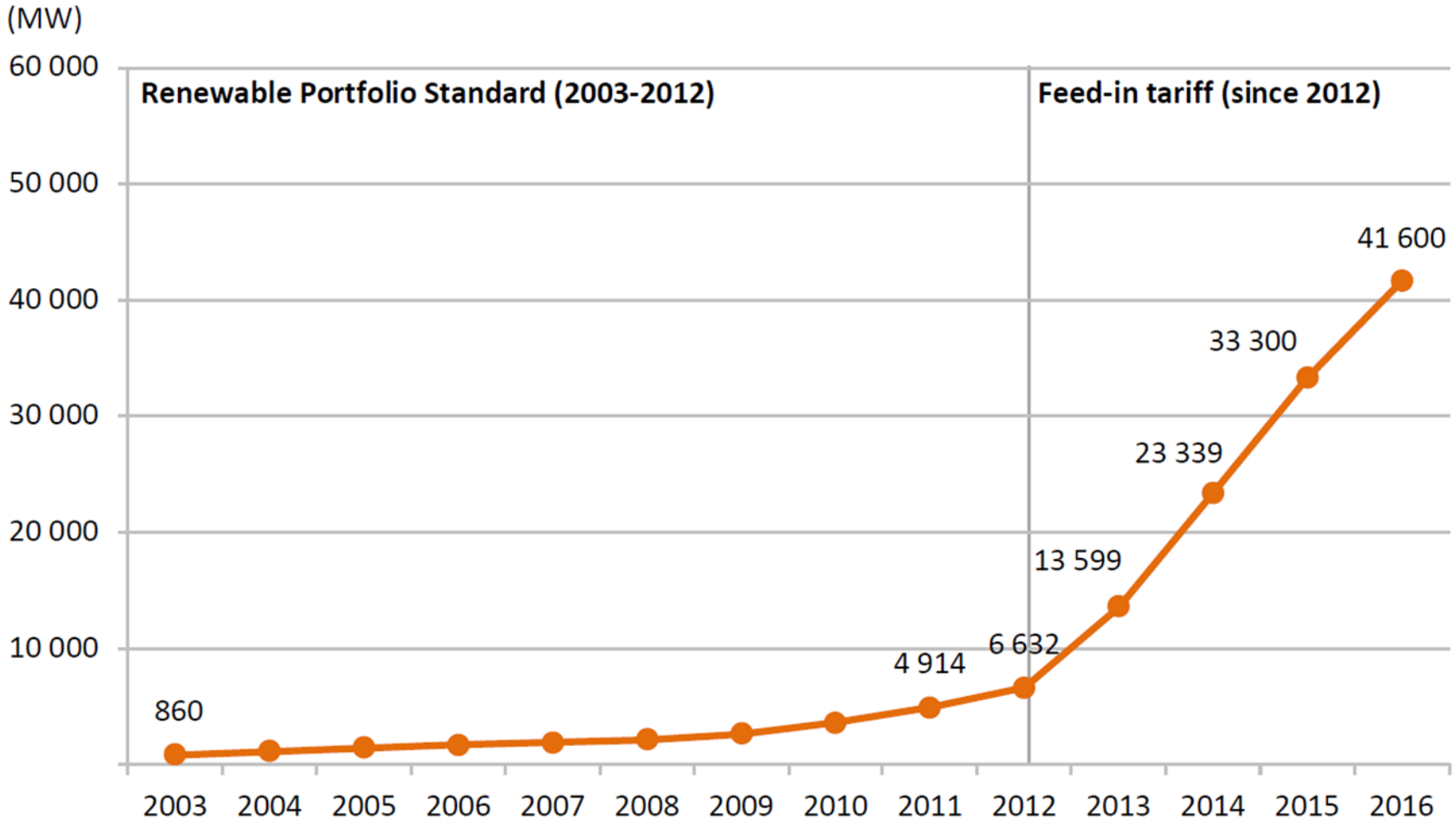
Policy

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 0.085 (~HK$ 0.8)	EUR 0.094	~1
Australia	2010	Gross	AUD 0.6 (~HK$ 4.3)	AUD 0.2155	~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

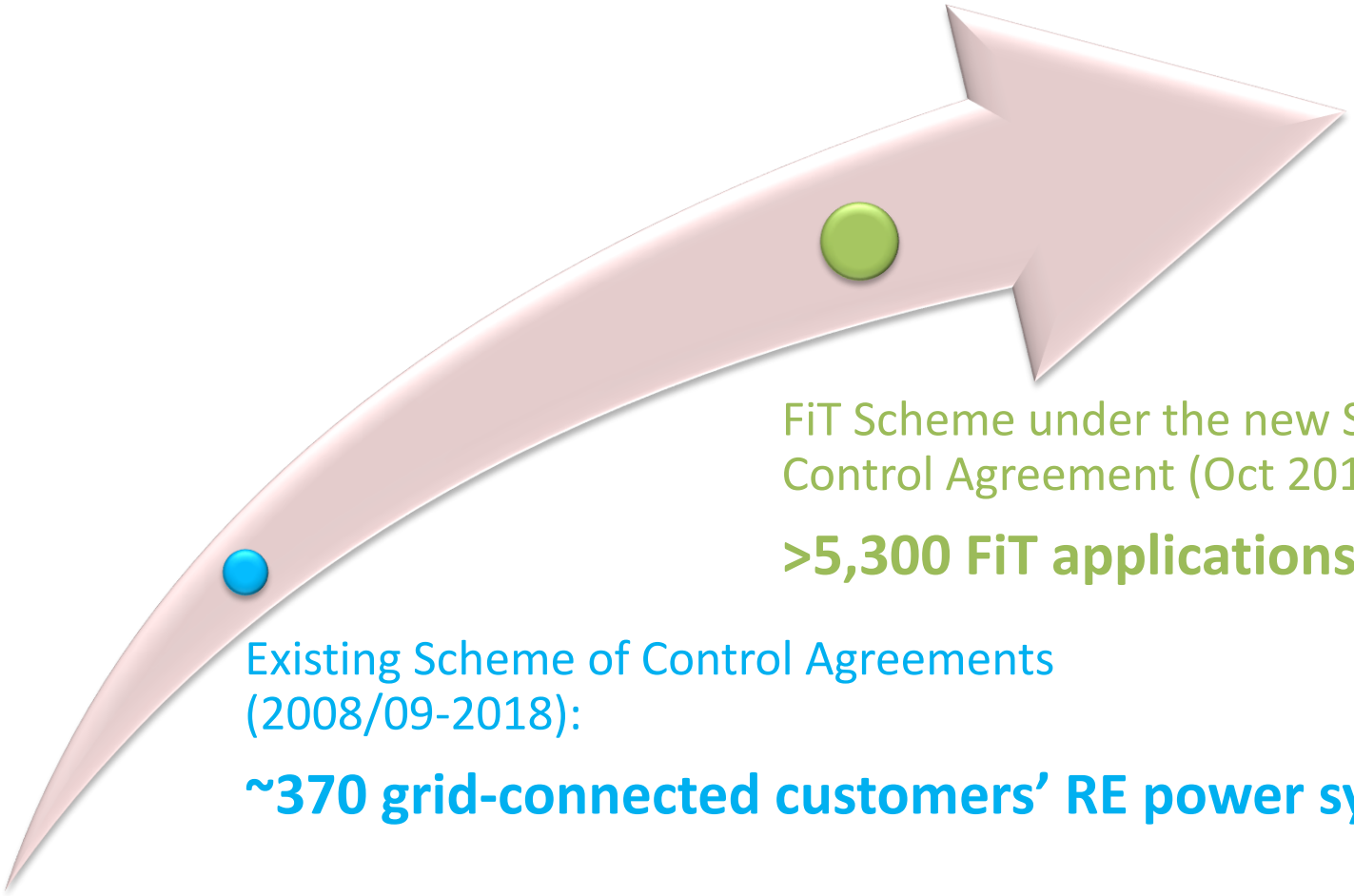
Capacity of Solar PV system in Japan (2003-2016)



Data source: IRENA

Image source: 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 (Oct 2018-Oct 2019):

>5,300 FiT applications approved

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

~370 grid-connected customers' RE power systems

Sources:

1. Press Releases LCQ21: Renewable energy (23 Oct 2019), LegCo
2. 2019 Policy Address – Policy Initiatives of Environment Bureau: Environmental Protection (28 Oct 2019) LegCo EA Panel

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

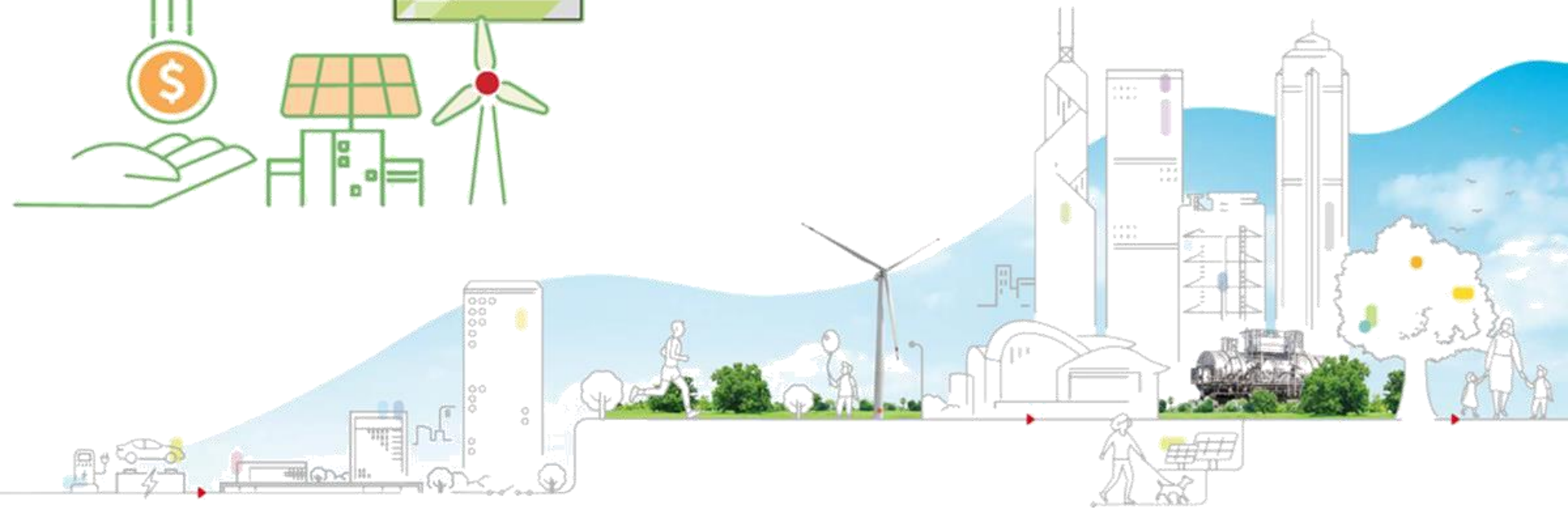
Source: “Study on the Feed-in Tariff Rates for Renewable Energy in Hong Kong Final Report” dated April 2018 to EMSD by Atkins

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	-	-

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

Community Knowledge



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

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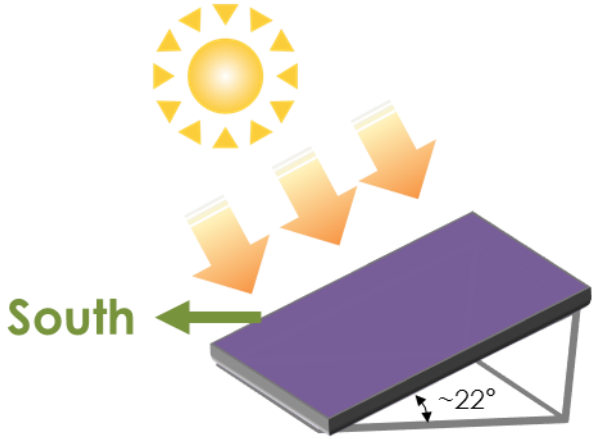
Considerations (1/2)

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

Image: Google Map

Considerations (2/2)

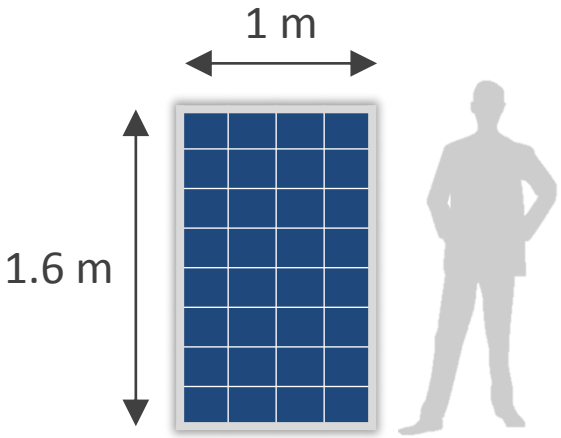
- Hong Kong lies at
  - Latitude: 22°08' ~ 22°35' N
  - Optimum orientation and tilt angle

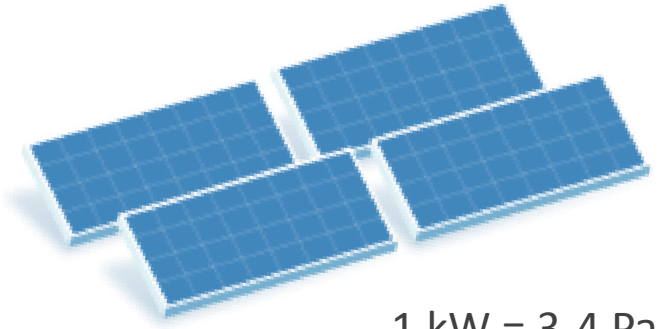


- Glint and glare

Source: 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

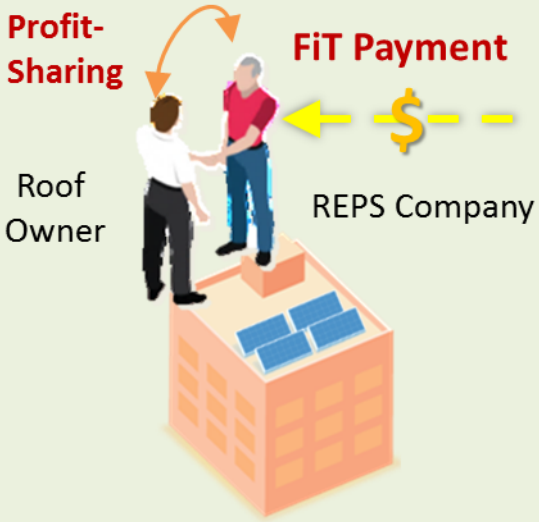
- Roof Owner (as a HK Electric customer) installs a REPS, participated in FiT Scheme

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

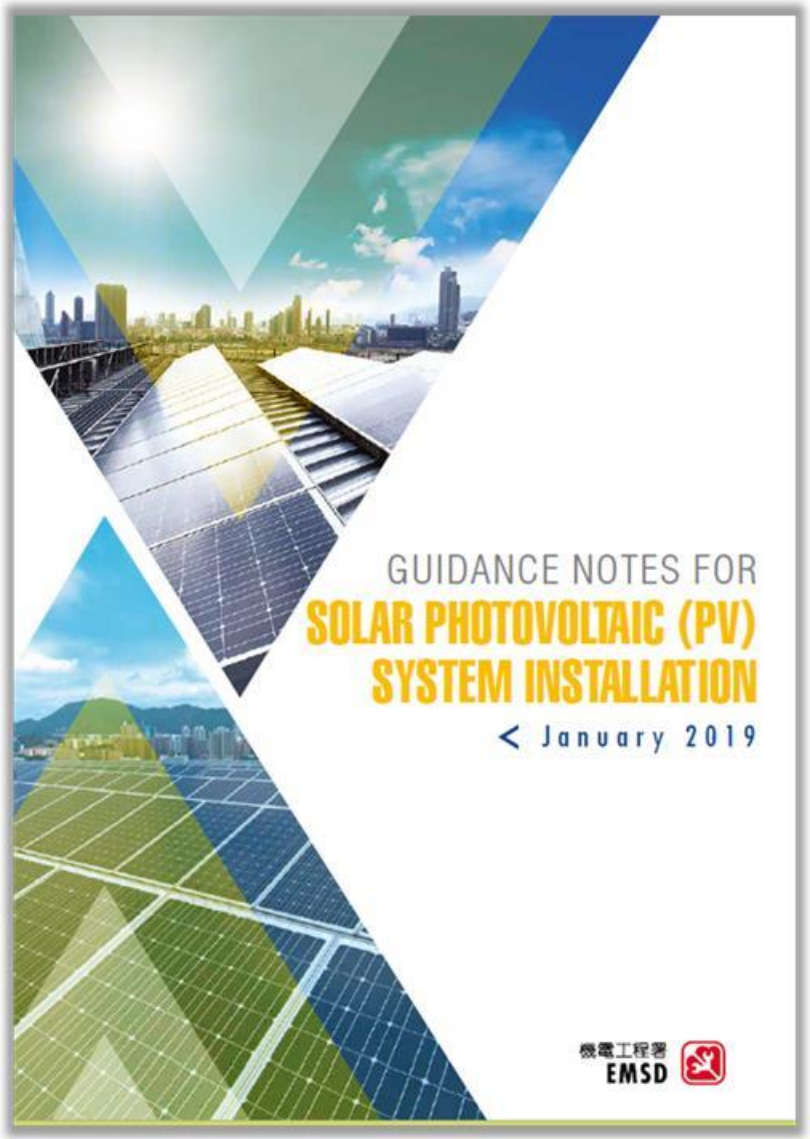
Solar Leasing (profit-sharing)

- 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



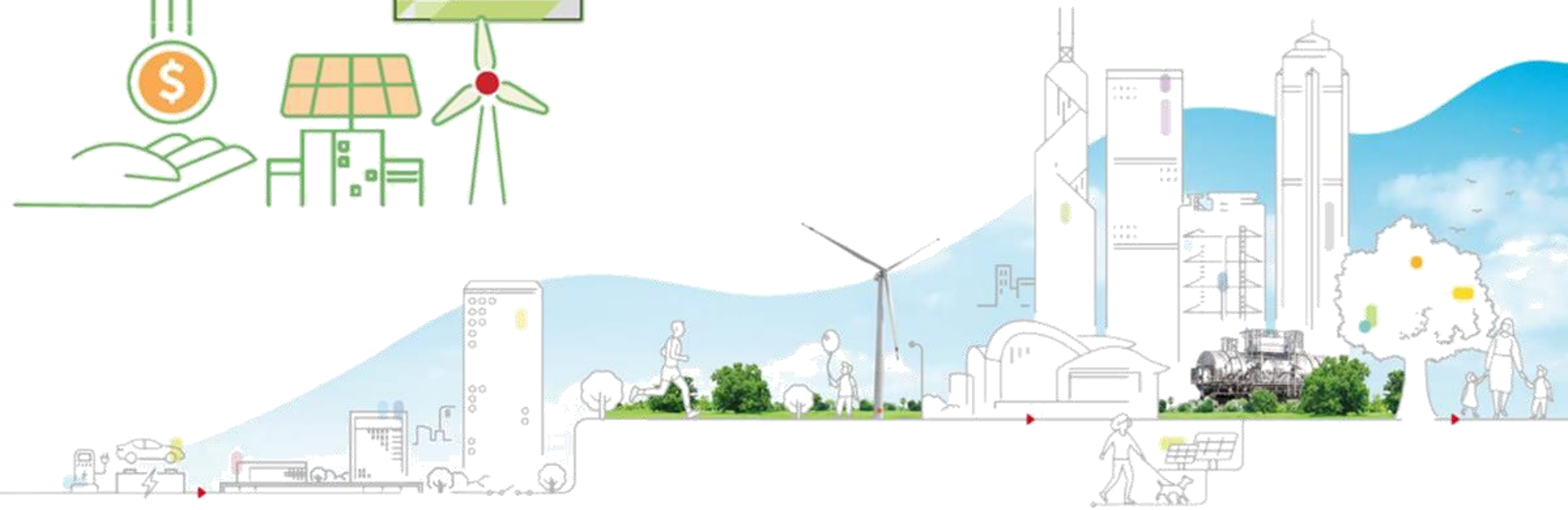
Requirements on Solar PV System

- PV system owner sh ion and maintenance comply with all appl guidelines, safety and technical requireme
  - Technical Guidelin of Renewable Ener
  - Registration of Ger accordance with th
  - **EMSD Guidance N Photovoltaic (PV)**
  - Minor Works Cont
  - HK Electric Technic Requirements
- PV system owner sh Registered Electrical Contractor) to desig
  - RE installation con d.gov.hk (EMSD hotline: 6395 2930)

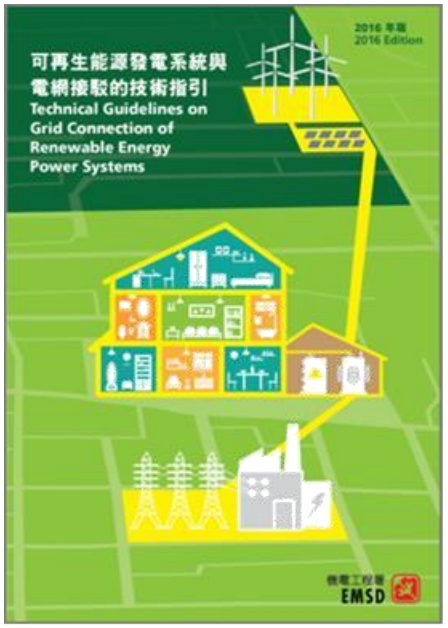


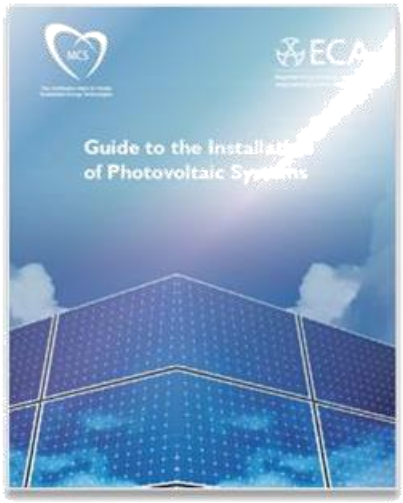
Source: EMSD, HKSARG

Industry Knowhow



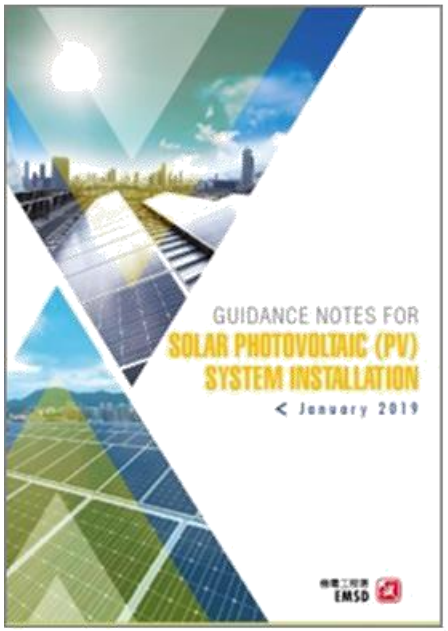
Industry Knowhow



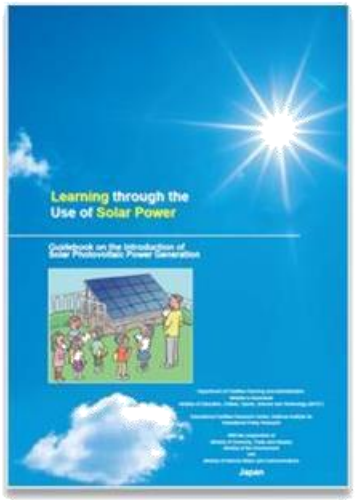


Guide to the Installation of Photovoltaic Systems, Microgeneration Certification Scheme (MCS), the UK

UEENEEK135A Design grid connected photovoltaic power supply systems, Australian Government



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



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

Typical PV Panels

Monocrystalline	Polycrystalline	Thin-Film (TF)
		 
• 11 kg/m²	• 11 kg/m²	• 3 kg/m², flexible model available for curved surface
• Energy PayBack Time (EPBT): ~ 3 years	• Energy PayBack Time (EPBT): ~ 2 years	• Energy PayBack Time (EPBT): ~ 1.5 years

- Warranty, degradation, etc.

Niche PV Panels

Image: EG Energy Management

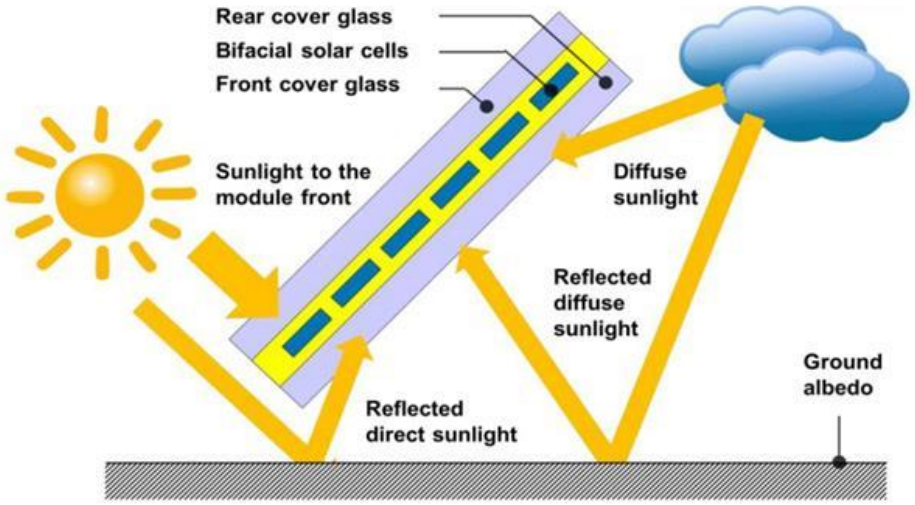
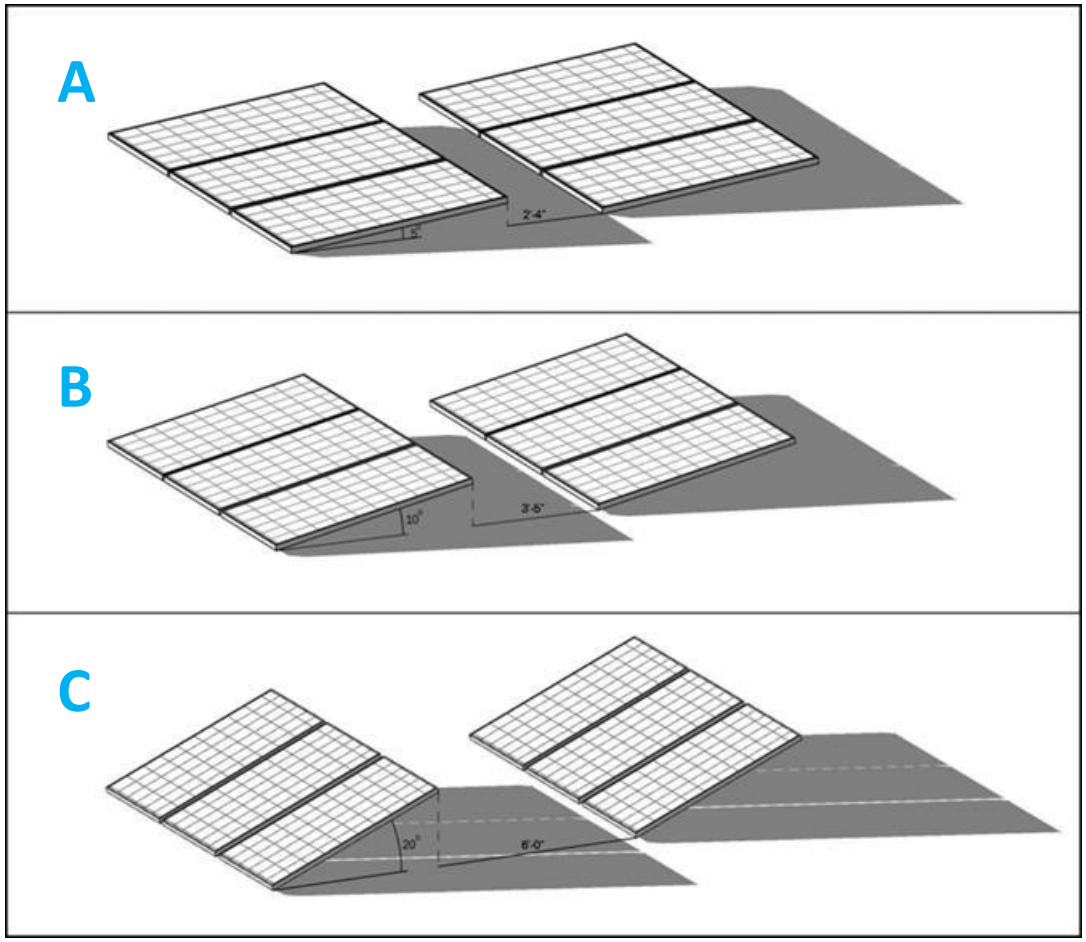


Image: TÜV Rheinland Energy

PV Panel Inclination



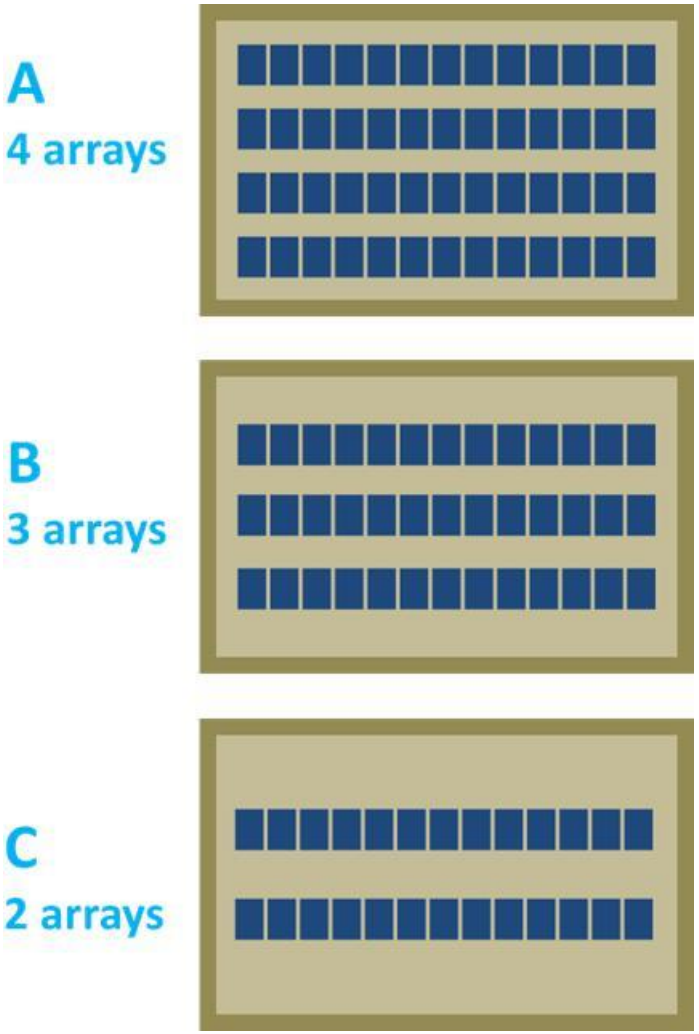


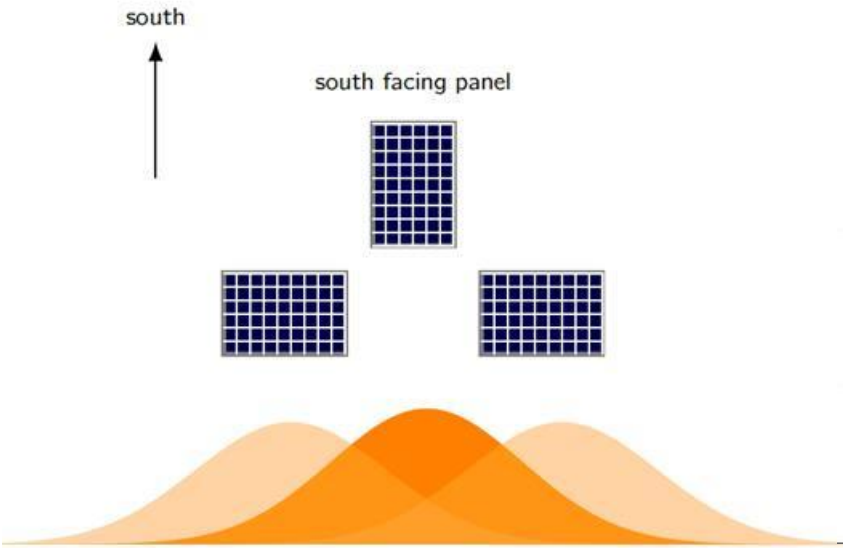
Image: The American Institute of Architects

Ocean Park

PV Panel Orientation
South vs East-West

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

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



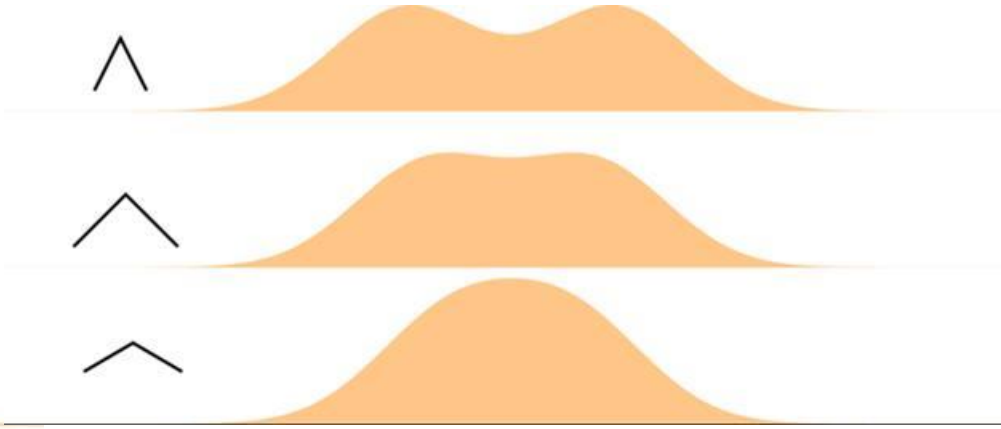


Image: Neighbour Power Inc. (Canada)

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

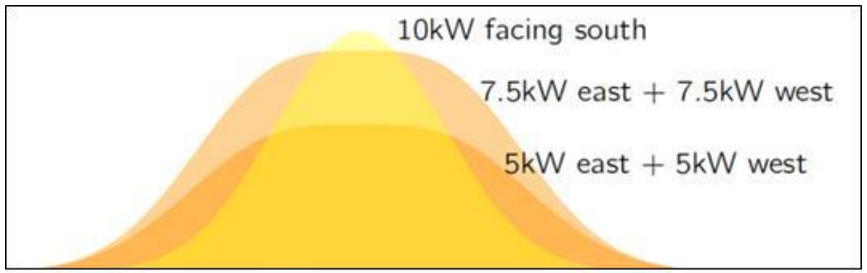


Image: Neighbour Power Inc. (Canada)

Lower system peak output

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

→ more energy output per inverter kW

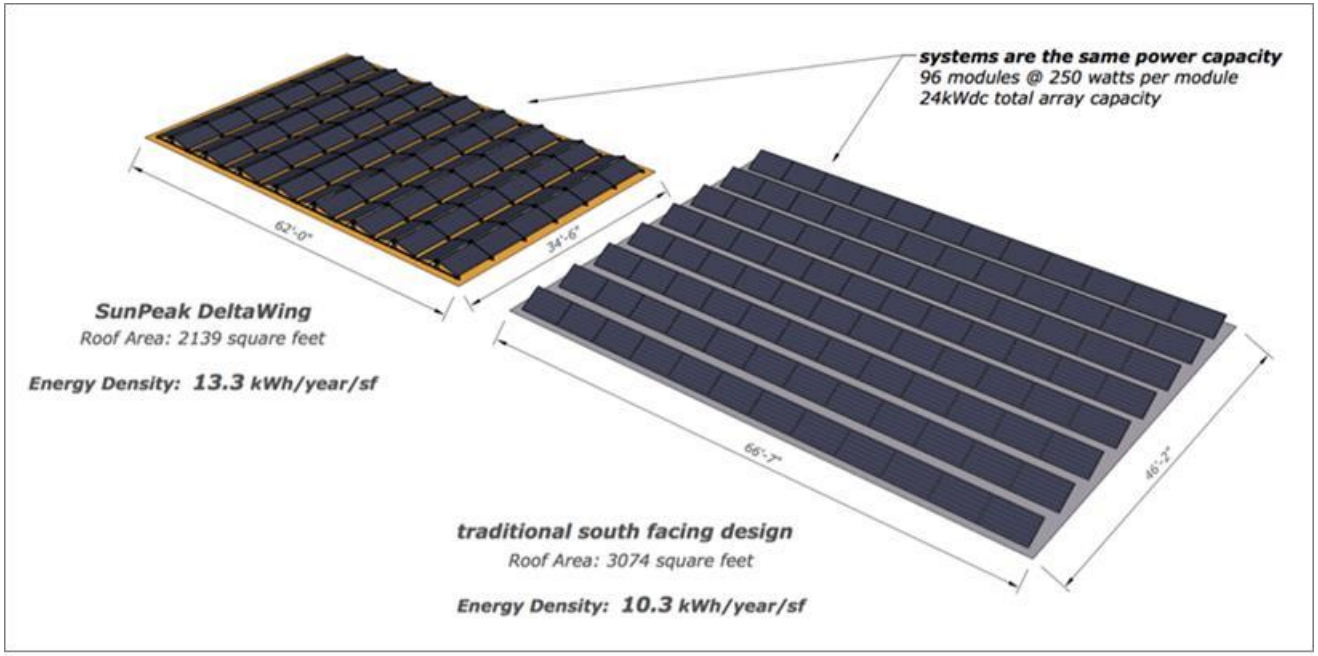


Image: SunPeak

Higher panel density

→ higher yield per square feet

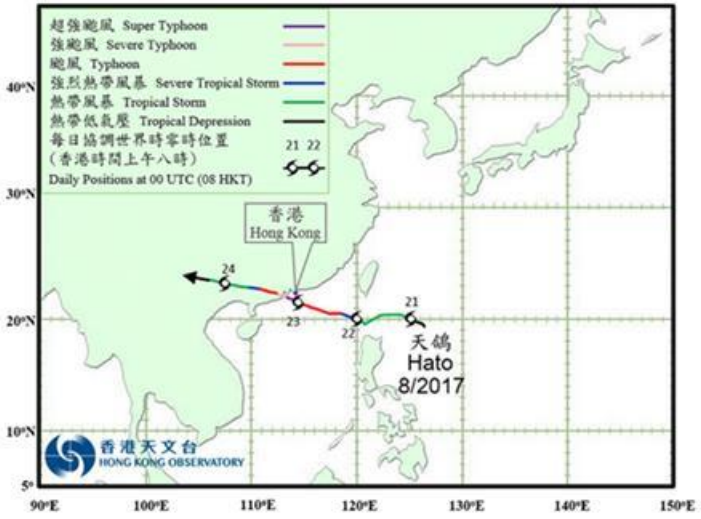
Benefits of East-west PV Installation (2/2)

Image: ALTEC SYSTEMTECHNIK AG

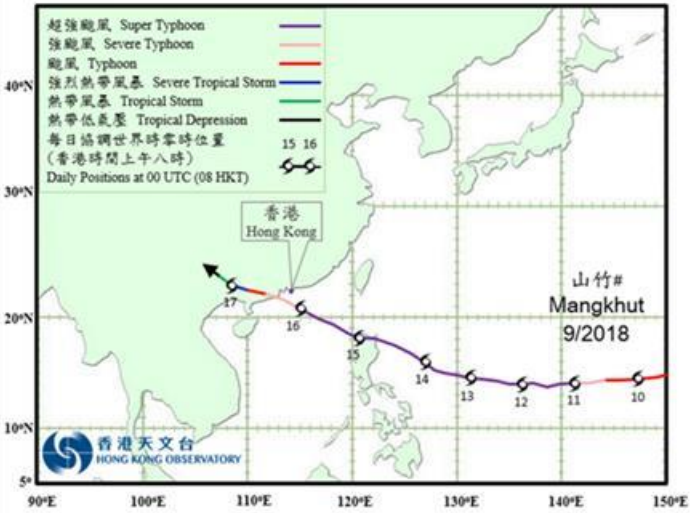
Lower mounting/supporting materials

→ Lower cost

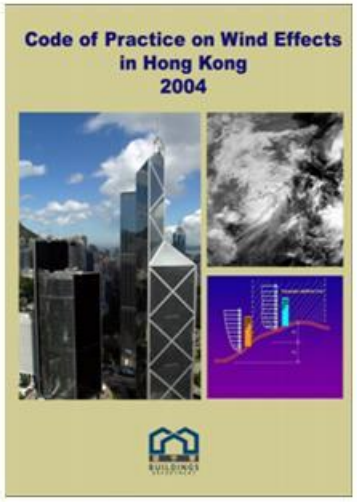
Building/Structural Requirements
Wind Effect

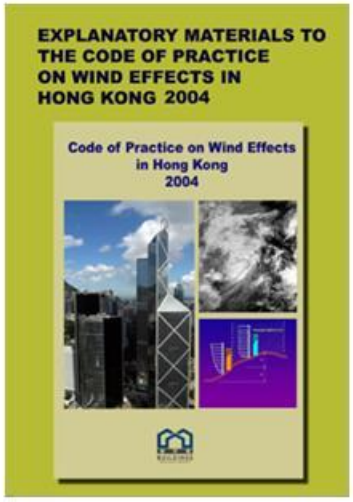


Source: HK Observatory



山竹的有關數據只經初步品質檢查。
Only minimum quality check have been applied for data of Mangkhut.





Source: 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

Sources: 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)

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

Image: ALTEC SYSTEMTECHNIK AG

Lower mounting/supporting materials

→ Lower cost

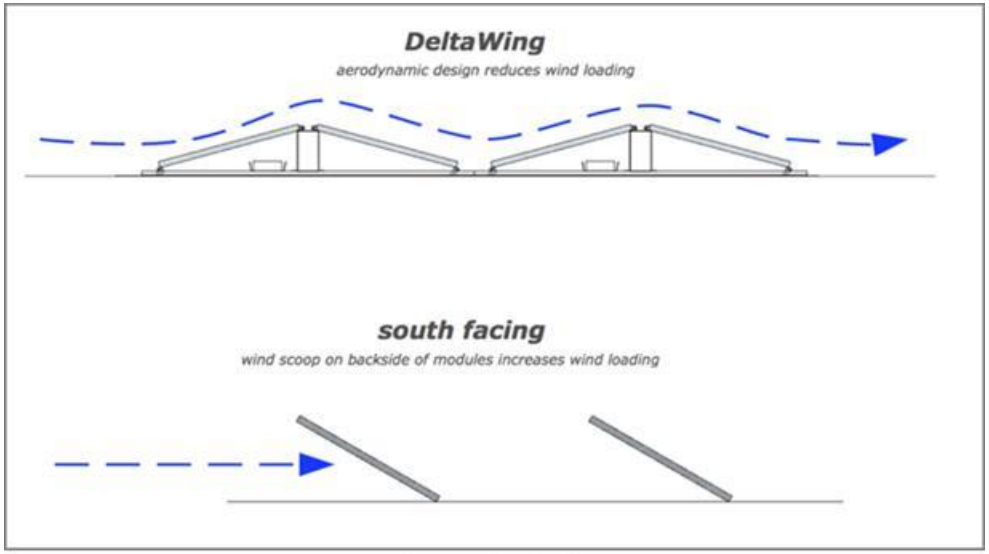


Image: SunPeak

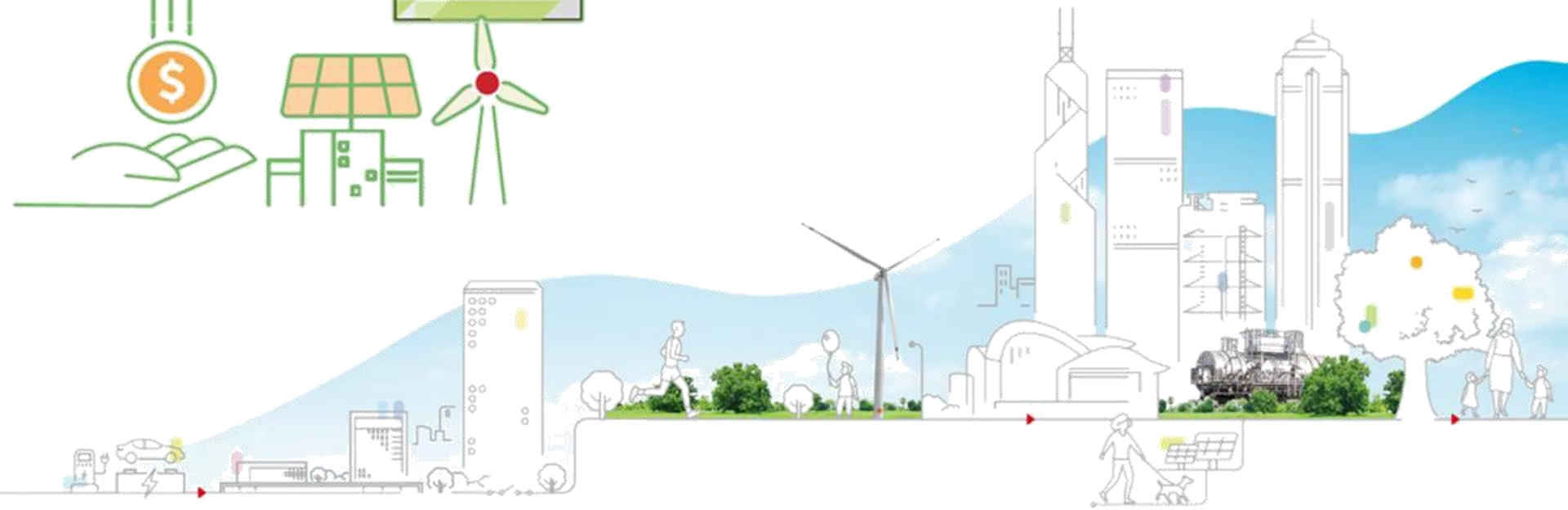
More aerodynamic / lower wind load

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

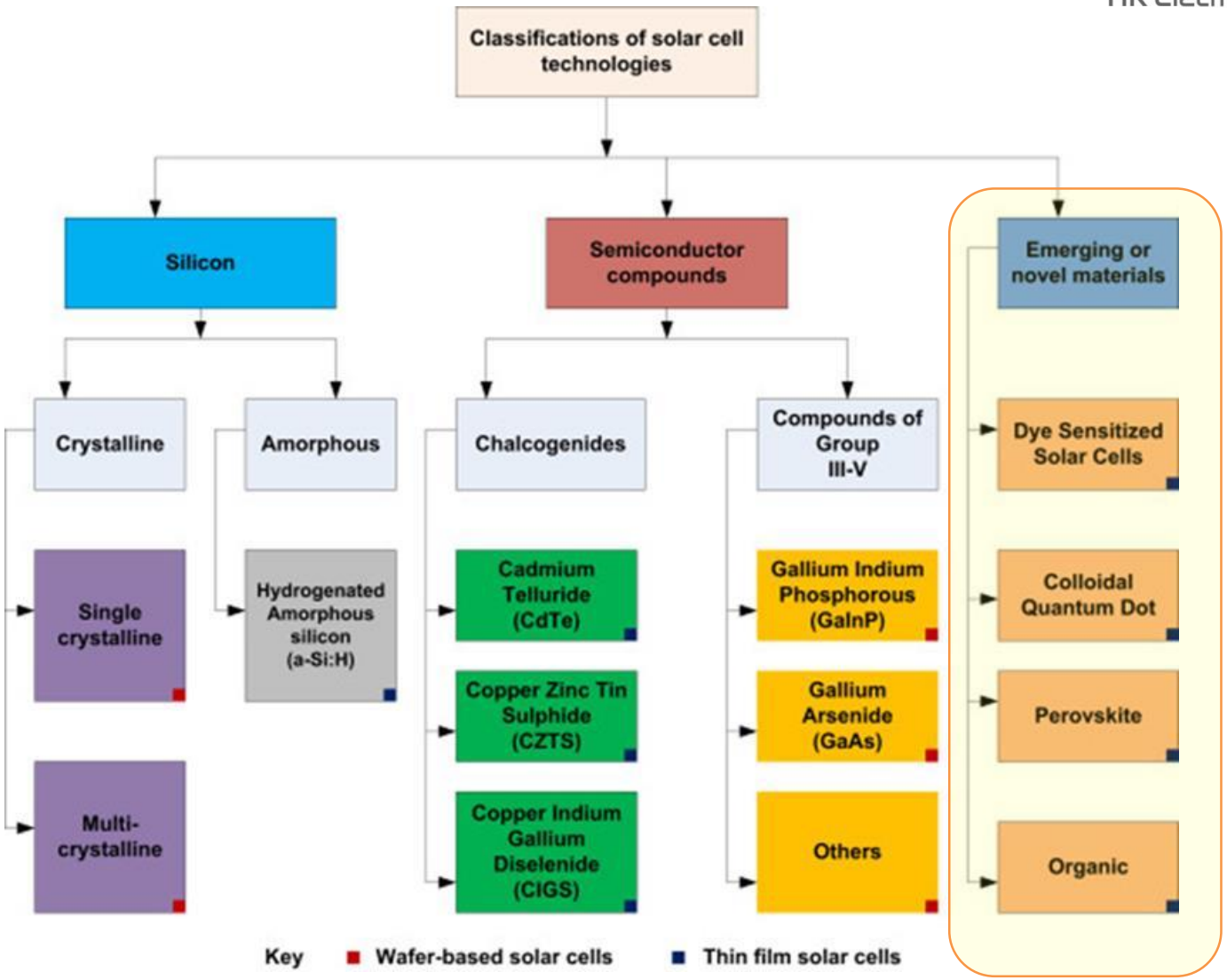
Flexible Thin-film PV Module

Image: MiaSole

Technology

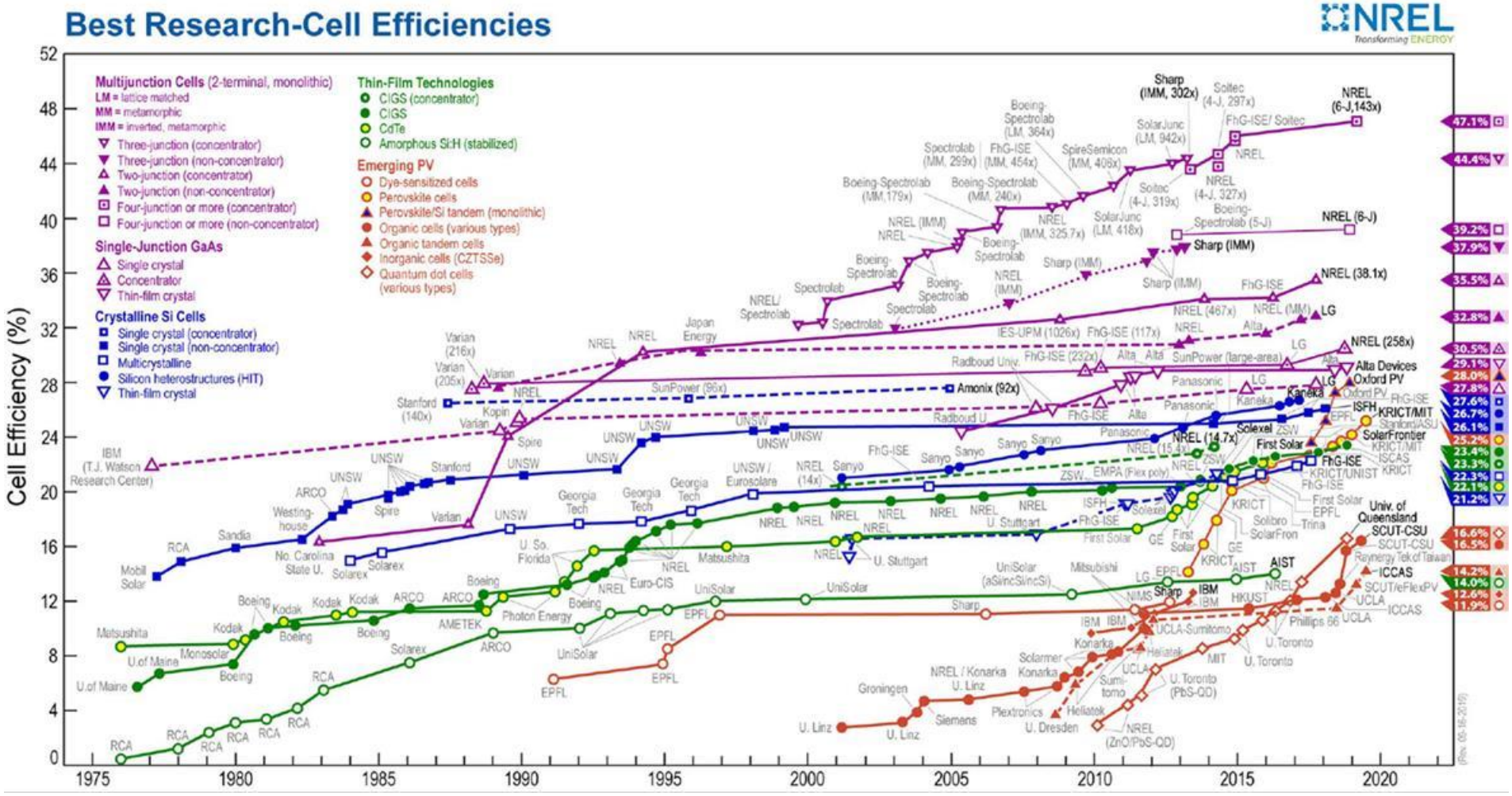


PV Technologies



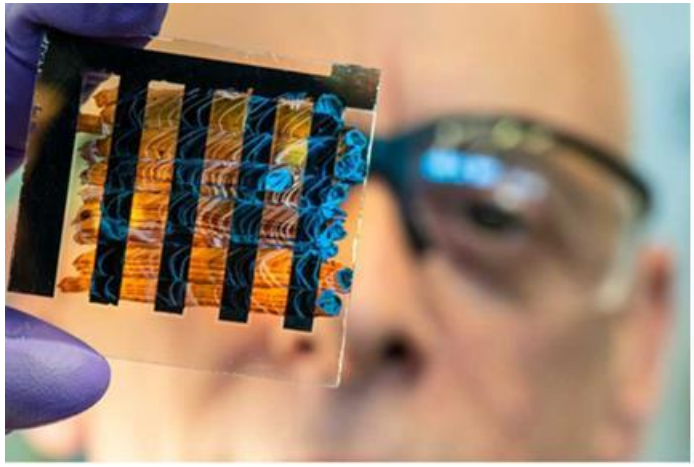
Source; T.Ibn-Mohammed, S.C.L.Koh, I.M.Reaney, A.Acquaye, G.Schileo, K.B.Mustapha, R.Greenough. Perovskite solar cells: An integrated hybrid lifecycle assessment and review in comparison with other photovoltaic technologies. Volume 80, December 2017, Pages 1321-1344

Cell Efficiencies



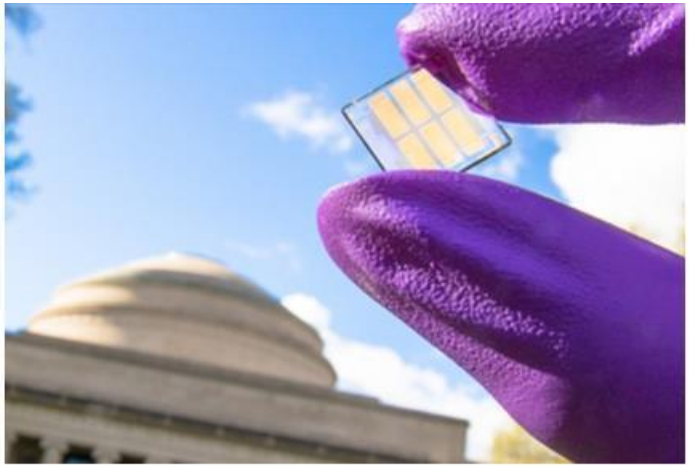
Source: NREL

3rd Generation Solar Cells



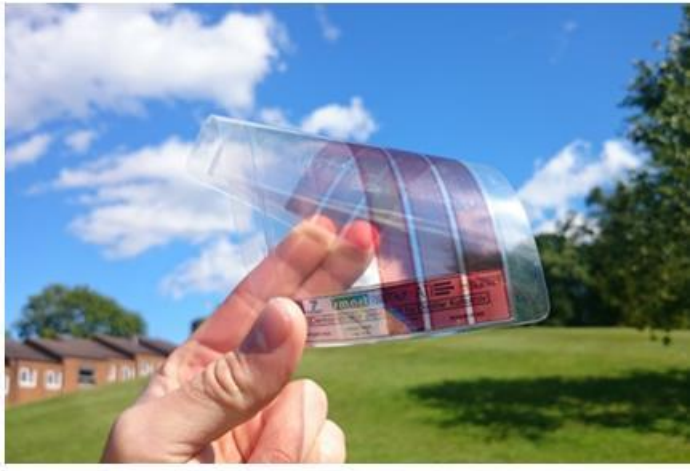
NREL researcher David Moore holds a perovskite solar cell painted with a special ink he developed. *Photo by Dennis Schroeder, NREL*

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



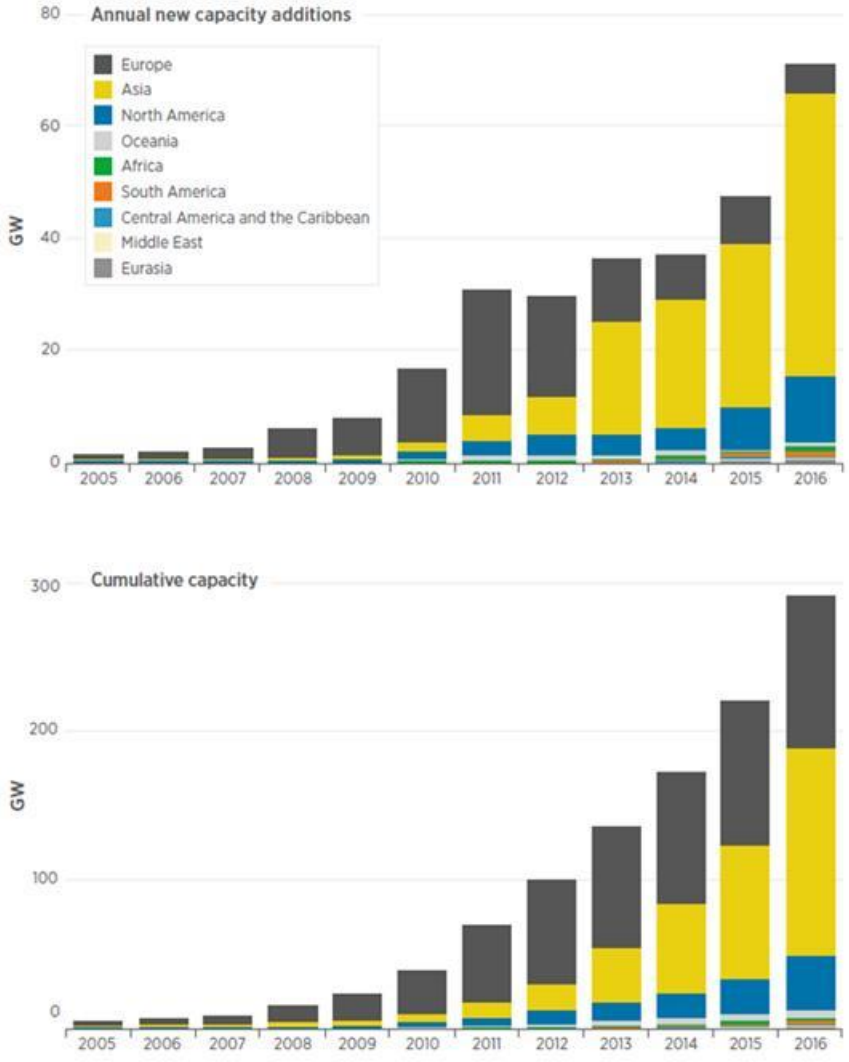
Researcher displays a sample of the record-setting new solar cell on the MIT campus (Photo courtesy of Chia-Hao Chuang

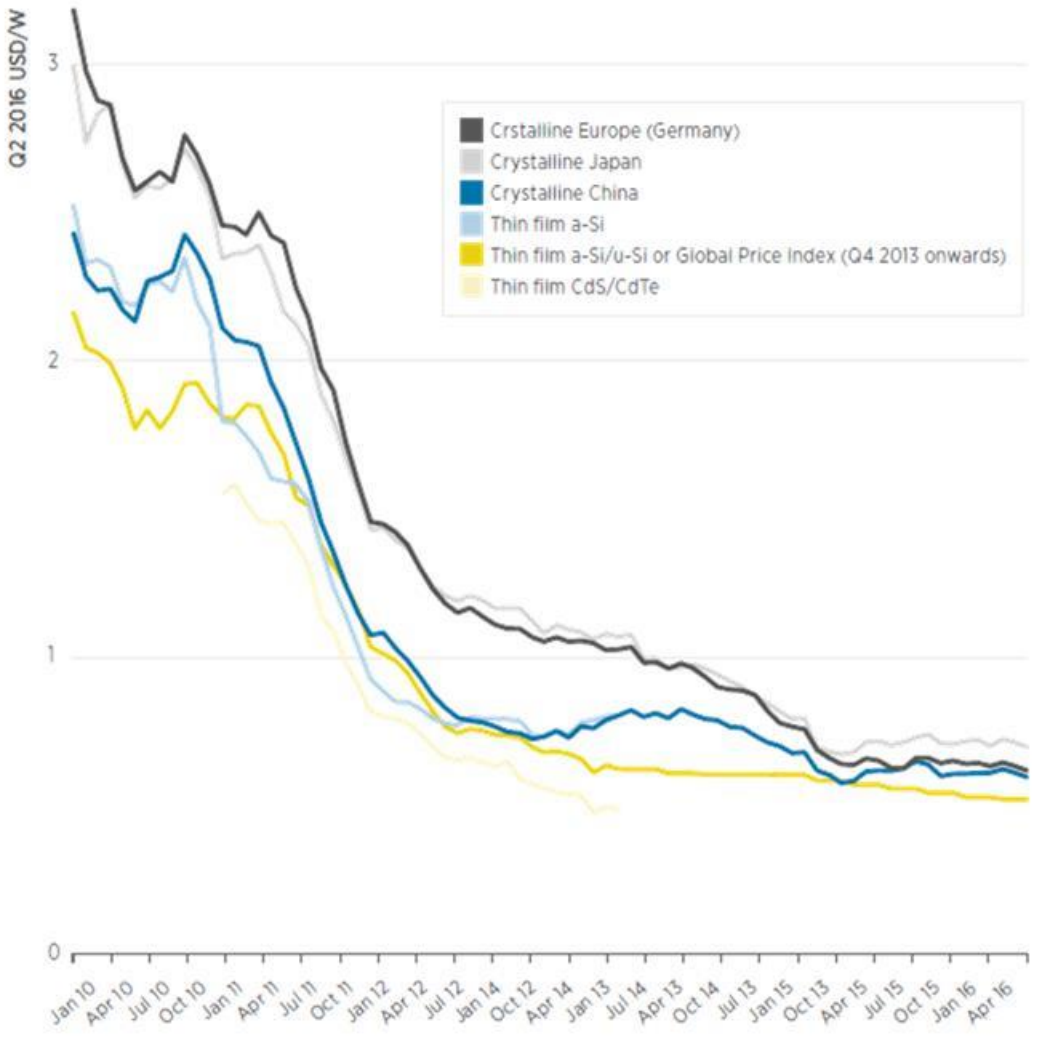
See-through solar-harvesting applications, such as this module pioneered at Michigan State University, have the potential of supplying 40 percent of U.S. electricity demand. Photo courtesy of Richard Lunt/Michigan State University



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

Declining PV Module Price



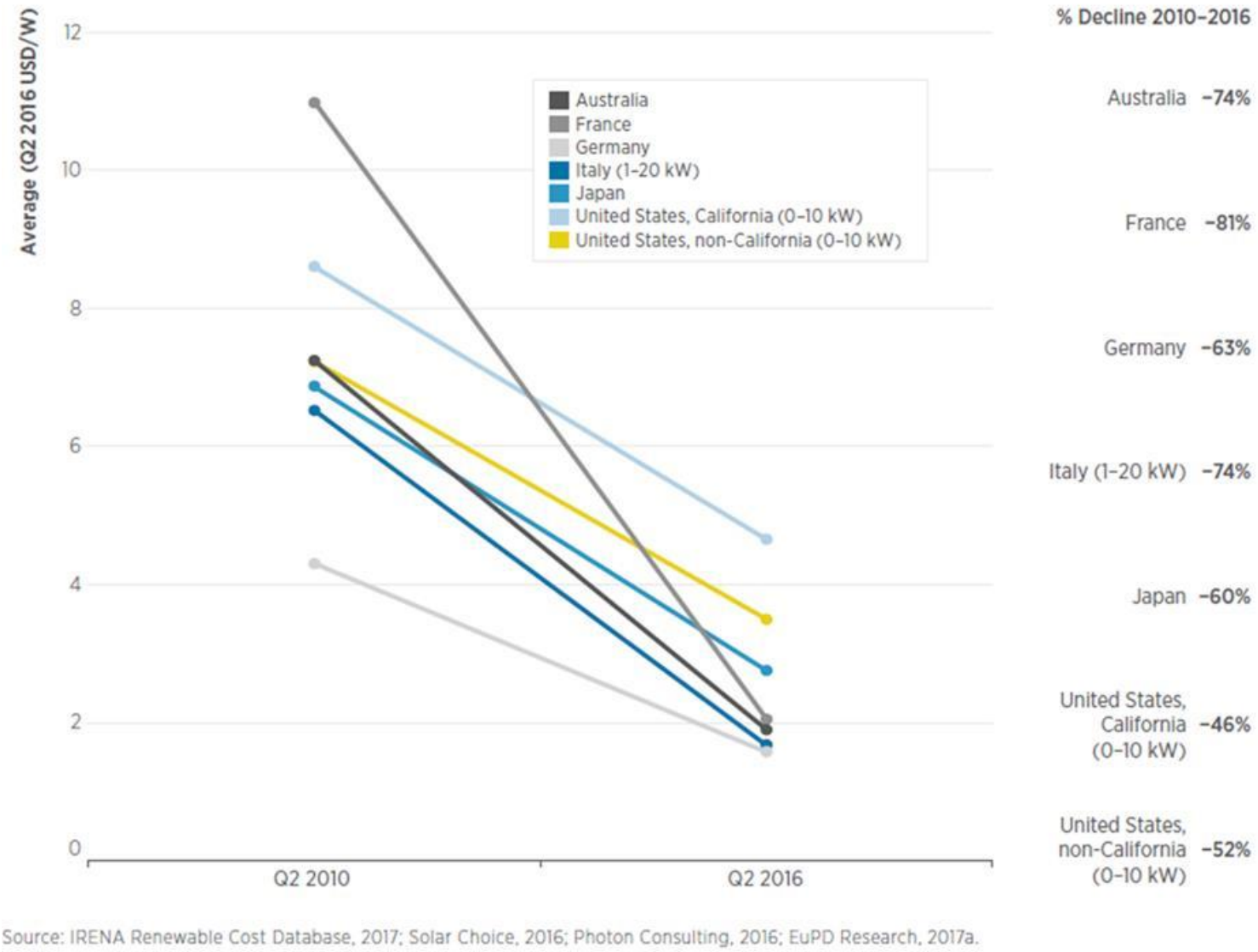


Source: GlobalData, 2015; pvXchange, 2016.

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

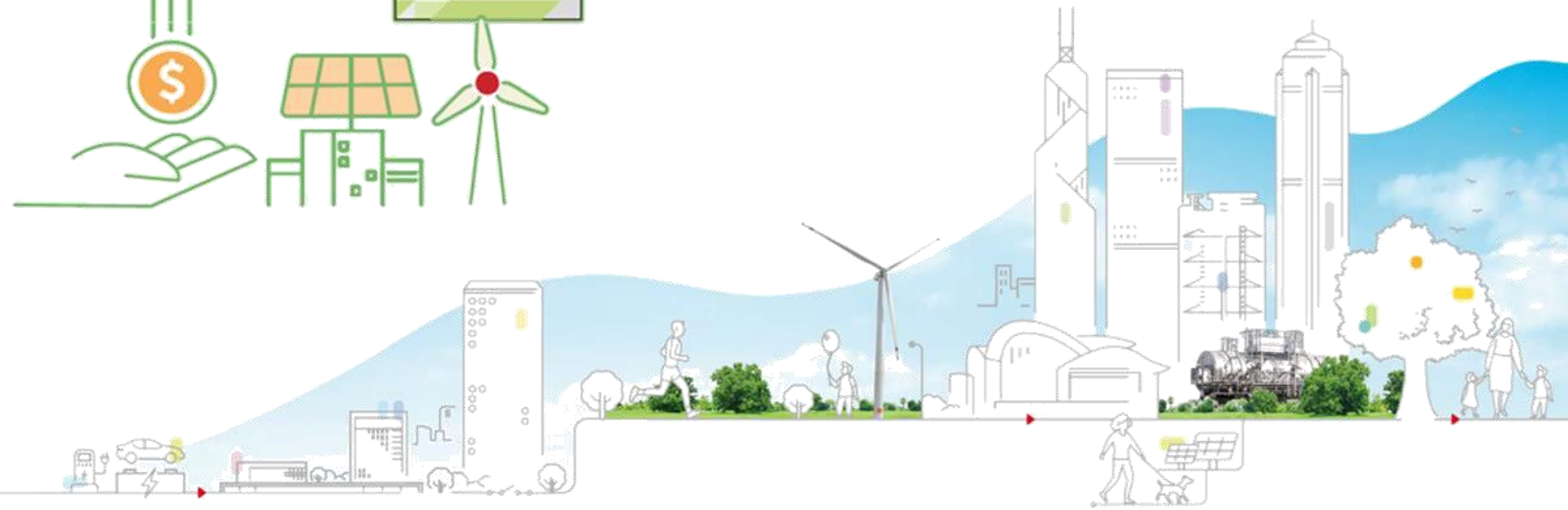
Source: IRENA Cost and Competitiveness Indicators (Rooftop Solar PV (Dec 2017), IRENA

Average Total Installed Cost of Residential Solar PV Systems



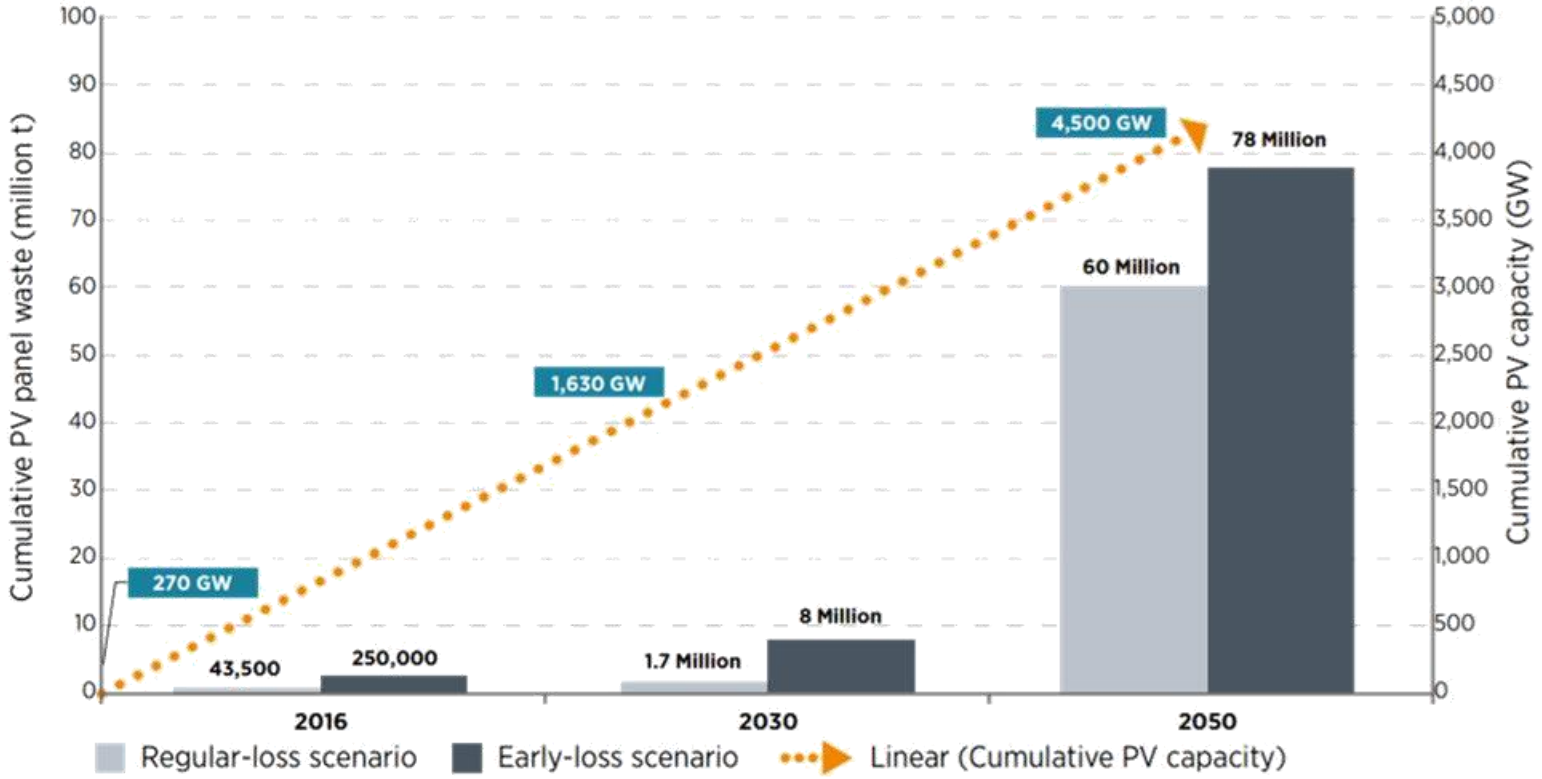
Source: IRENA Cost and Competitiveness Indicators (Rooftop Solar PV (Dec 2017), IRENA

Life-cycle Management



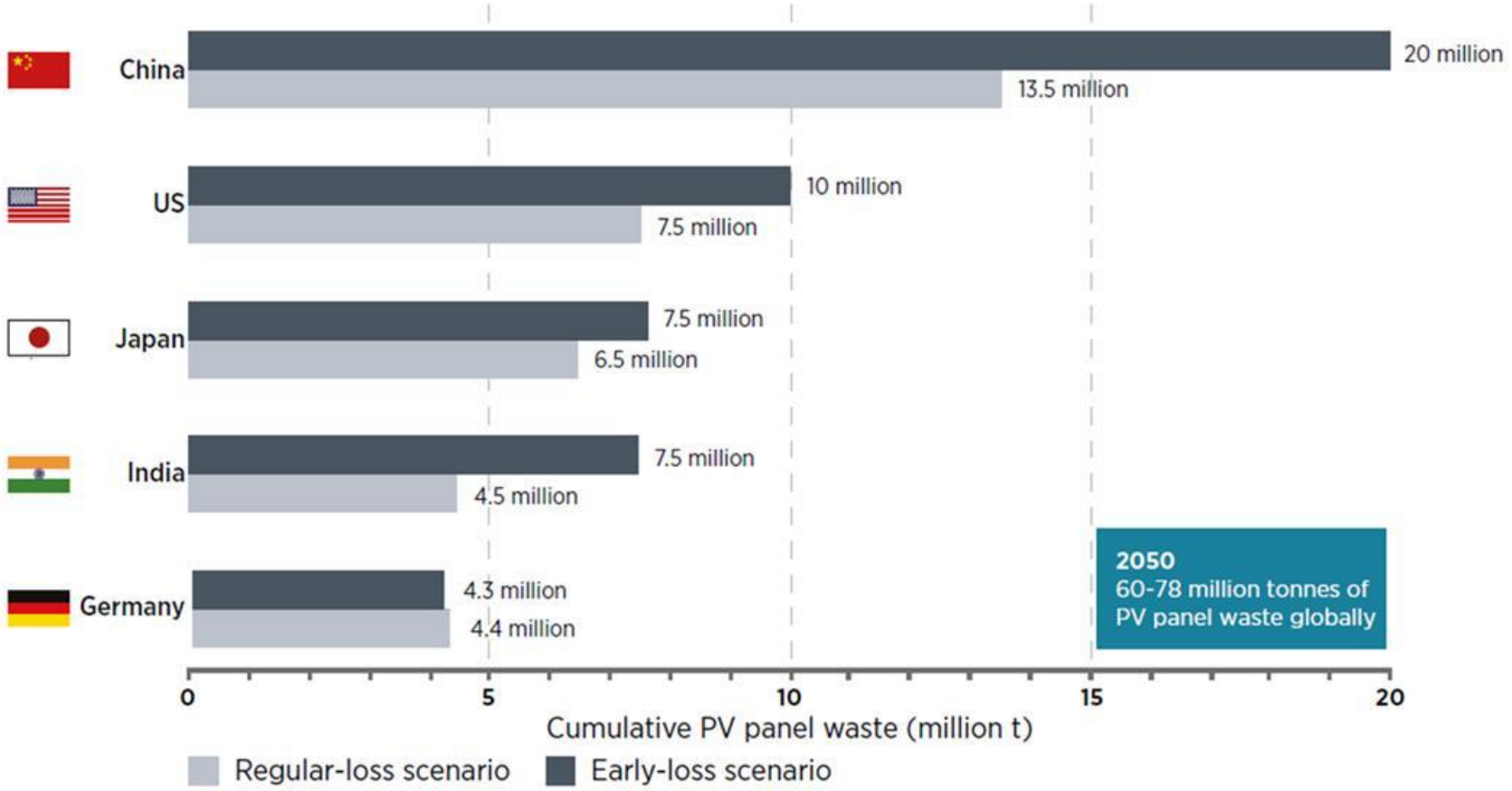
PV Panel Waste Projection

Overview of global PV panel waste projections, 2016-2050



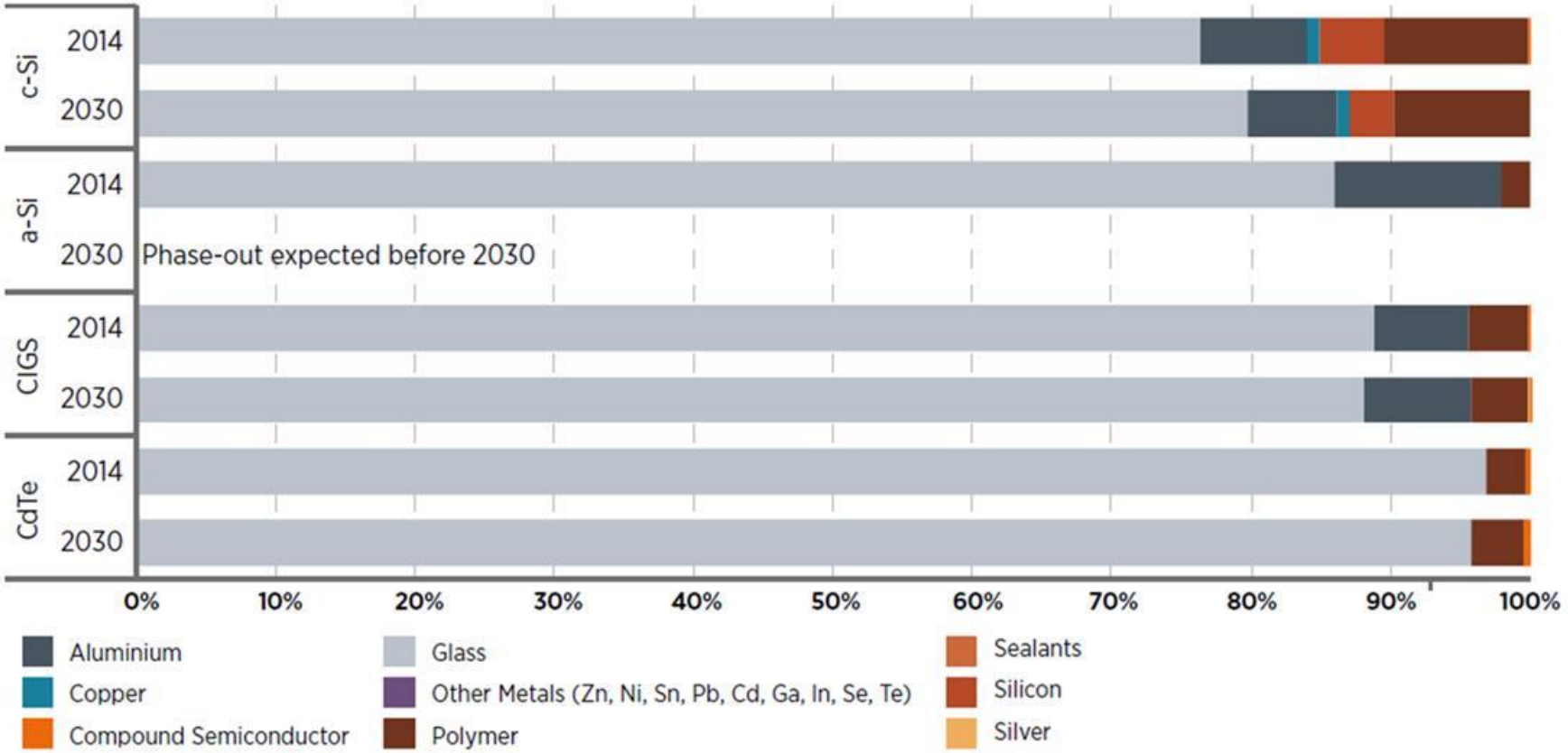
Source: End-of-Life Management Solar Photovoltaic Panels ((Jun 2016), IRENA

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



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

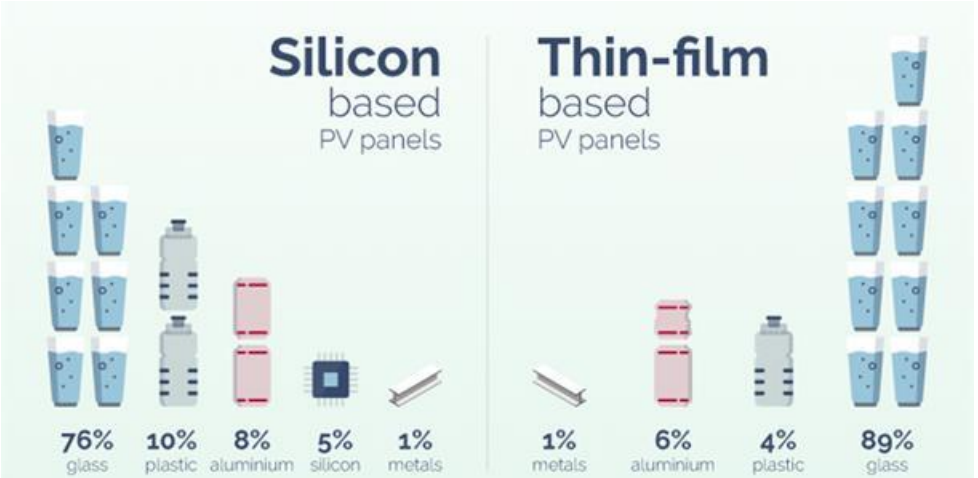
Materials Used for Different PV Panel Technologies (% of Total Panel Mass)

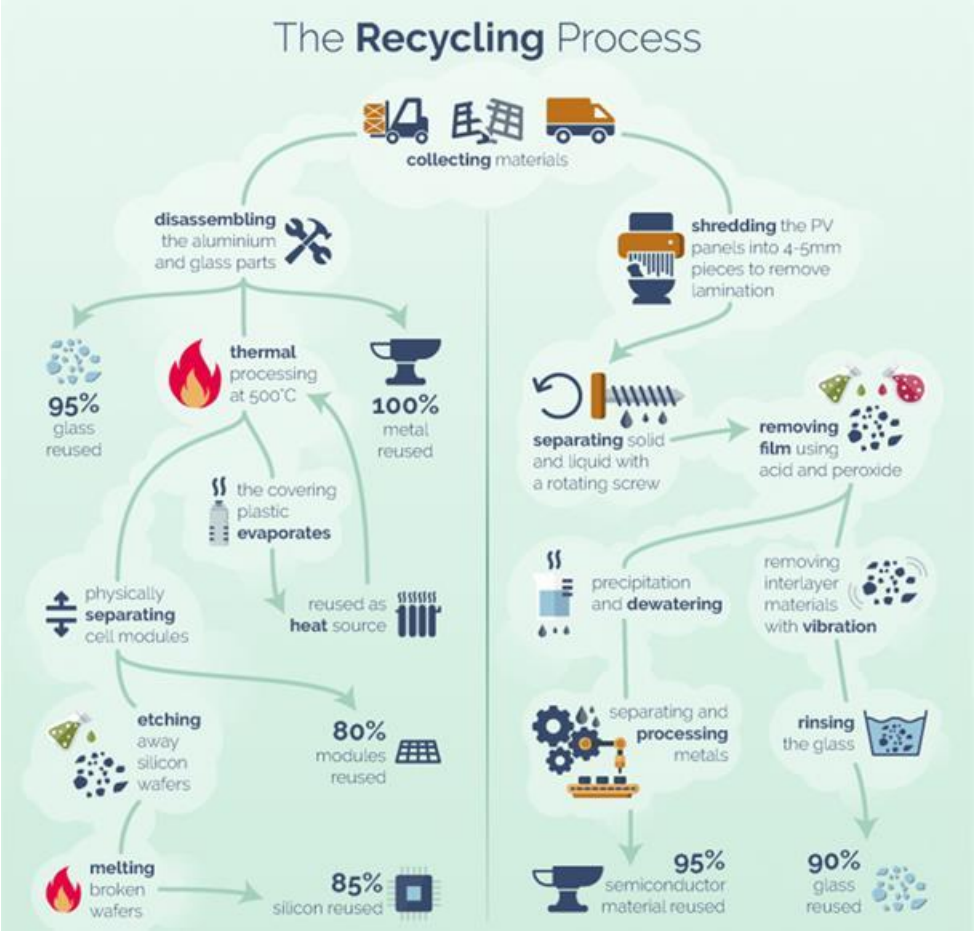


Based on Marini et al., (2014); Pearce (2014); Raithel (2014); Bekkelund (2013); NREL (2011) and Sander et al., (2007)

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

PV Panel Recycling





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

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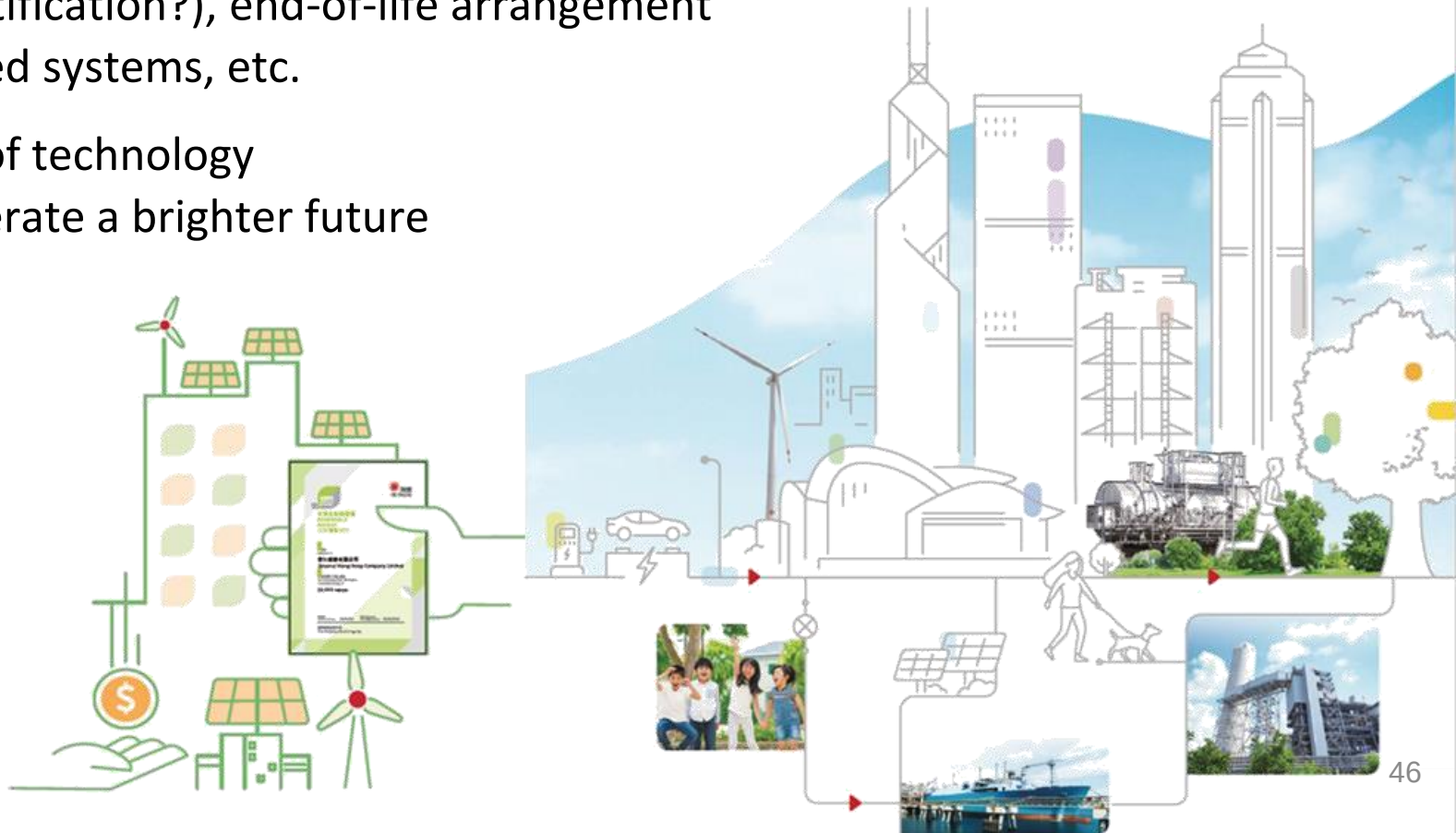
PV Waste Management

- **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**

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

Concluding Remarks

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



Thank You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查詢 / 申請
Enquiry/Application
2843 3228
智惜用電樓宇基金 Smart Power Building Fund
SPBF@hkelectric.com
www.hkelectric.com/SPBF
智惜用電能源審核 Smart Power Energy Audit
SPEA@hkelectric.com
www.hkelectric.com/SPEA
智惜用電貸款基金 Smart Power Loan Fund
SPLF@hkelectric.com
www.hkelectric.com/SPLF
智惜用電關懷基金 Smart Power Care Fund
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SPEF@hkelectric.com
www.hkelectric.com/SPEF
上網電價計劃 Feed-in Tariff Scheme
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REC@hkelectric.com
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