EGEDA under EWG-APEC

APEC Asia-Pacific Economic Cooperation

IRENA International Renewable Energy Agency

Estimating off-grid solar PV electricity generation

Joint APEC-IRENA Workshop on Renewable Energy Statistics

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Outline

1. Why measure off-grid PV generation?
2. Definition and classification
3. Measurement and/or estimation of numbers and capacity
4. Aggregation into time-series
5. Estimating generation

Why measure off-grid PV generation?

1. Some remote areas are unlikely to connect to the grid.
2. Electricity access still <100% in some APEC economies (IDN, PNG, PER, PHL). Off-grid PV may meet these needs.
3. Non-household consumers may switch to PV or become new users of PV. May be quite important in APEC.
4. Large numbers of small capacities can be significant!

Fortescue Metals announces 150 MW solar PV with storage to supplement gas power for mining operations

4th February 2020

Off-grid definition and classification

1. IRENA defines off-grid power literally as: "power plants without connection to the main power grid in a country"
2. For off-grid PV we use a simple classification scheme to help collect data and calculate estimates:
   - **Solar mini-grids:** any size, mixed/unknown end-uses
   - **Solar lights** (and lighting kits): <11W each, residential
   - **Small SHS** (solar home systems): 11-50W, residential
   - **Large SHS:** >50W, residential
   - **Solar pumps:** any size, mostly agriculture
   - **Other off-grid PV:** any size; single end-use (mostly: telecoms; streetlights; schools; clinics; tourism; mining)

Measurement challenges

1. Off-grid PV power is produced in numerous different ways, by many types of producer serving many end-uses.
2. Many producers are outside the usual data collection mechanisms used for energy data.
3. A lot of production is not measured or recorded as expected (e.g. metered production) and may not be measured in the usual capacity units (kW, MW, etc.).
4. IRENA overcomes these challenges in a 3-stage process:
   - Convert non-standard units to capacity estimates
   - Aggregate over time, with assumptions about durability
   - Estimate generation from solar maps

Measurement: solar mini-grids

1. Capacity usually measured and recorded in the normal way.
2. Data sources: administrative data (operating licences, planning approvals, etc.).
3. Generation may not be recorded, if provided for a "flat fee", but estimate may be available in planning documents.

PT Surya Energi Indotama: 492 kWp mini-grid installation in East Sumba

Commissioned in 2018

Measurement: HH solar devices

What are we talking about?

Lights with attached solar cells (0.7 W)

Light with separate solar panel (3.4 W)

Lighting kits (10 W and 5 W panels)

Solar home system with 20 W panel

Measurement: HH solar devices

Equipment that can be powered at different levels of solar PV capacity

Equipment	Capacity (W_p)	
	Min	Max
Single light		<1.5
Single light + phone charger	1.5	<3.0
Multiple lights + charger	3.0	<11.0
Above + radio and/or fan (entry-level SHS)	11.0	<21.0
Basic-capacity SHS	21.0	<50.0
Medium-capacity SHS	50.0	<100
Higher-capacity SHS	100	

Source: Based on GOGLA (2017)

Measurement: HH solar devices

1. Data sources:
   - Administrative data (e.g. energy access projects)
   - Sales data (surveys of retailers/distributors)
   - Household surveys (living standards, health, others)
   - Trade data (if imported extensively)

GOGLA member sales
East Asia and Pacific 2018H1

Size (Wp)	Number
0-1.5	39,818
1.5-3	14,158
3-10	80,316
11-20	9,163
21-49	1,425
50-100	33,153
>100	0

2. Main challenge is to convert numbers into Watts.
3. IRENA uses data from GOGLA and national sources (APEC economies: about 6MW added each year).
4. End-use assumed to be residential.

Measurement: solar water pumps

1. PV capacity may be recorded or an average estimated (usually 2-3kW per pump)
2. Data sources:
   - Administrative data (development projects)
   - Solar water pump suppliers
   - Agricultural census/surveys
3. Not significant in non-IEA APEC economies as far as we know (about 1MW in total)

Solar water pump for livestock

Lift height (metres)	Maximum water requirement (m^3/day)				
	10	20	30	40	50
10	0.1	0.2 - 0.3	0.3 - 0.4	0.4 - 0.5	0.5 - 0.7
20	0.2 - 0.3	0.4 - 0.5	0.7 - 0.8	0.9 - 1.1	1.1 - 1.3
30	0.3 - 0.4	0.7 - 0.8	1.0 - 1.2	1.3 - 1.6	1.6 - 2.0
40	0.4 - 0.5	0.9 - 1.1	1.3 - 1.6	1.8 - 2.1	2.2 - 2.7
50	0.5 - 0.7	1.1 - 1.3	1.6 - 2.0	2.2 - 2.7	2.7 - 3.3
60	0.7 - 0.8	1.3 - 1.6	2.0 - 2.4	2.6 - 3.2	3.3 - 4.0
70	0.8 - 0.9	1.5 - 1.9	2.3 - 2.8	3.1 - 3.8	3.8 - 4.7
80	0.9 - 1.1	1.8 - 2.1	2.6 - 3.2	3.5 - 4.3	4.4 - 5.4
90	1.0 - 1.2	2.0 - 2.4	3.0 - 3.6	3.9 - 4.8	4.9 - 6.0
100	1.1 - 1.3	2.2 - 2.7	3.3 - 4.0	4.4 - 5.4	5.5 - 6.7

PV capacity (kW_p) required for pumping (15-20% capacity factor, 55% pump efficiency)

Measurement: other solar PV

1. Many varied uses, including
   - Telecom towers
   - Solar streetlights
   - Clinics (e.g. for solar fridges)
   - Rural schools
   - Tourist sites
   - Industry (mining, etc.)
2. Frequently recorded as numbers of units, so it's necessary to estimate average sizes.

Measurement: other solar PV

Estimations (conversion of numbers of units to capacities):

1. **Telecom towers:** 3-5kW (1-2 base transceiver stations)
2. **Solar streetlights:** 100-200W per light on minor roads, 300-400W on major roads. Note: PV capacity is 3-4 times power rating of lamp
3. **Clinics:** most solar vaccine fridges (80-100 litre) typically have a 300-400W supply

3kW supply for telecom tower

Solar streetlights in China (10kW shown)

Catuden clinic, Peru (300W supply)

Measurement: other solar PV

1. Data sources:
   - Administrative data, often from other government agencies (communications, health, education, cities)
   - Industry, donor and NGO data
2. Main challenge is to convert numbers into Watts.
3. Not much known about these uses in APEC economies (IRENA counts about 8MW in non-IEA APEC economies).
4. However, these capacities could be huge (e.g. solar streetlight sales of 750,000 annually in Asia = c.150MW/yr, projected to grow at 10%/year).

Estimation from international trade data

1. Solar energy technologies are covered by international trade codes (Harmonized System or HS)
2. Current codes (HS2016) are unclear, but IRENA has worked with the World Customs Organization to adopt new codes.
3. These may be used to show where the use of solar devices is growing, <u>if imports are the main source of products</u>.

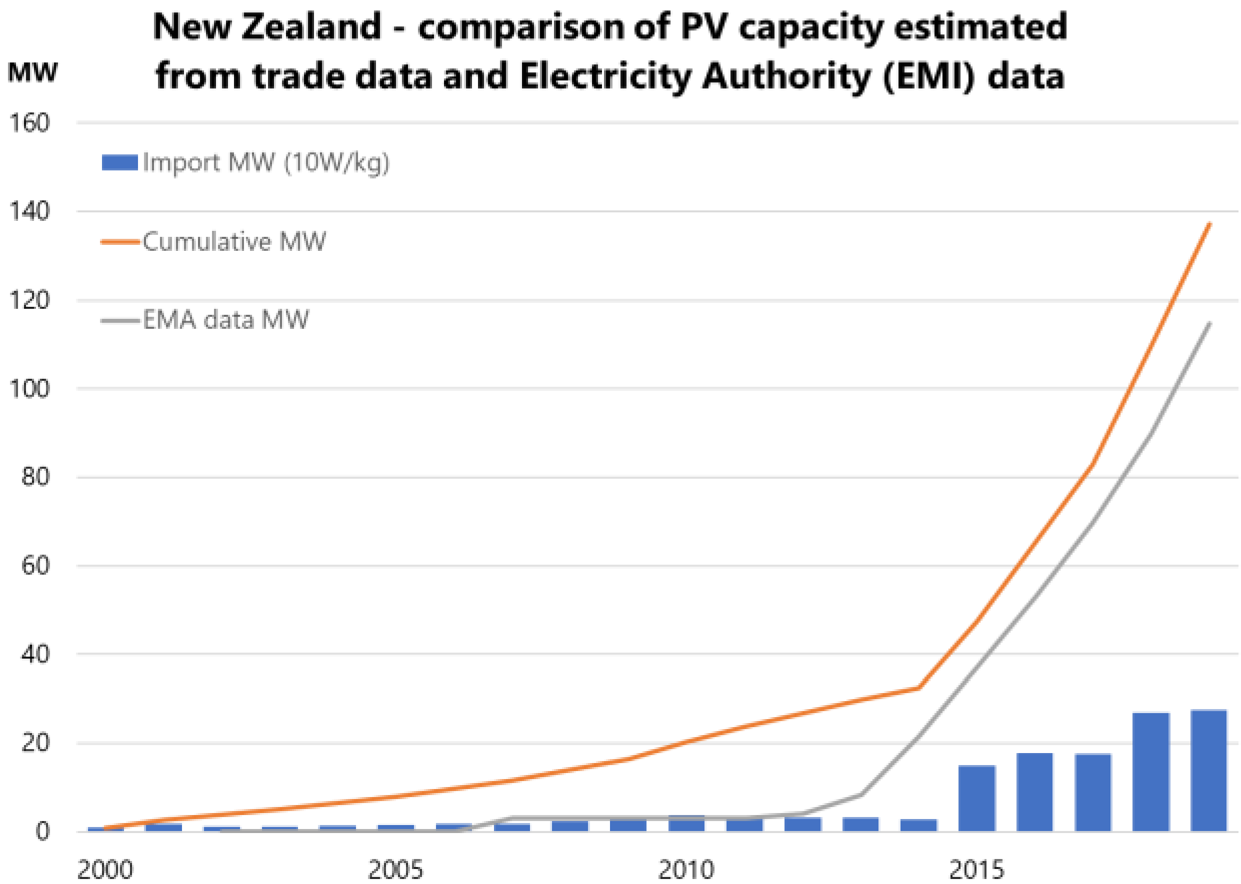
New international trade codes

Product	HS2016		HS2022	
Solar water heaters	8419.19-	Non-gas, non-electric water heaters (part)	**8419.12-** 8419.19-	**Solar water heaters** Other
Solar panels	8541.40-	Photosensitive semiconductor devices (part)	 8541.41- **8541.42-** **8541.43-** 8541.49-	Photosensitive semiconductor devices Light-emitting diodes (LED) **PV cells not assembled in modules or panels** **PV cells assembled in modules or panels** Other
Solar lights	8513.10-	Portable electric lamps with own energy source (part)	**8513.10-**	**Portable electric lamps with own energy source (part)**
	9405.40-	Electric lamps and light fittings, other (part)	 **9405.41-** 9405.42- 9405.49-	Other electric luminaires and light fittings **PV lights, designed for use with LEDs** Other, designed for use with LEDs Other
Solar Home Systems	Currently not clear		 **8501.71-** **8501.72-** **8501.80-**	**Photovoltaic DC generators:** **Of an output not exceeding 50 W** **Of an output exceeding 50 W** **Photovoltaic AC generators**

Estimation from international trade data

1. International trade data records product imports in value (USD), standard weight (kg) and secondary units (number, local weight measures, other).
2. Where local production is minimal, IRENA uses import data to estimate capacity of solar products, mostly using quantities (weight or number of units).
3. Import values or numbers of units needs to be treated with much caution!
4. These estimations are used for many countries with little or no solar PV data (assumed to be off-grid). Baseline assumption is solar panel capacity = 10W/kg

Example of PV estimation from trade data



Accumulated imports of PV panels into New Zealand shows similar trend to reported capacity data with slight difference in timing
(estimate from trade data approximately one-year ahead)

Aggregation into time series

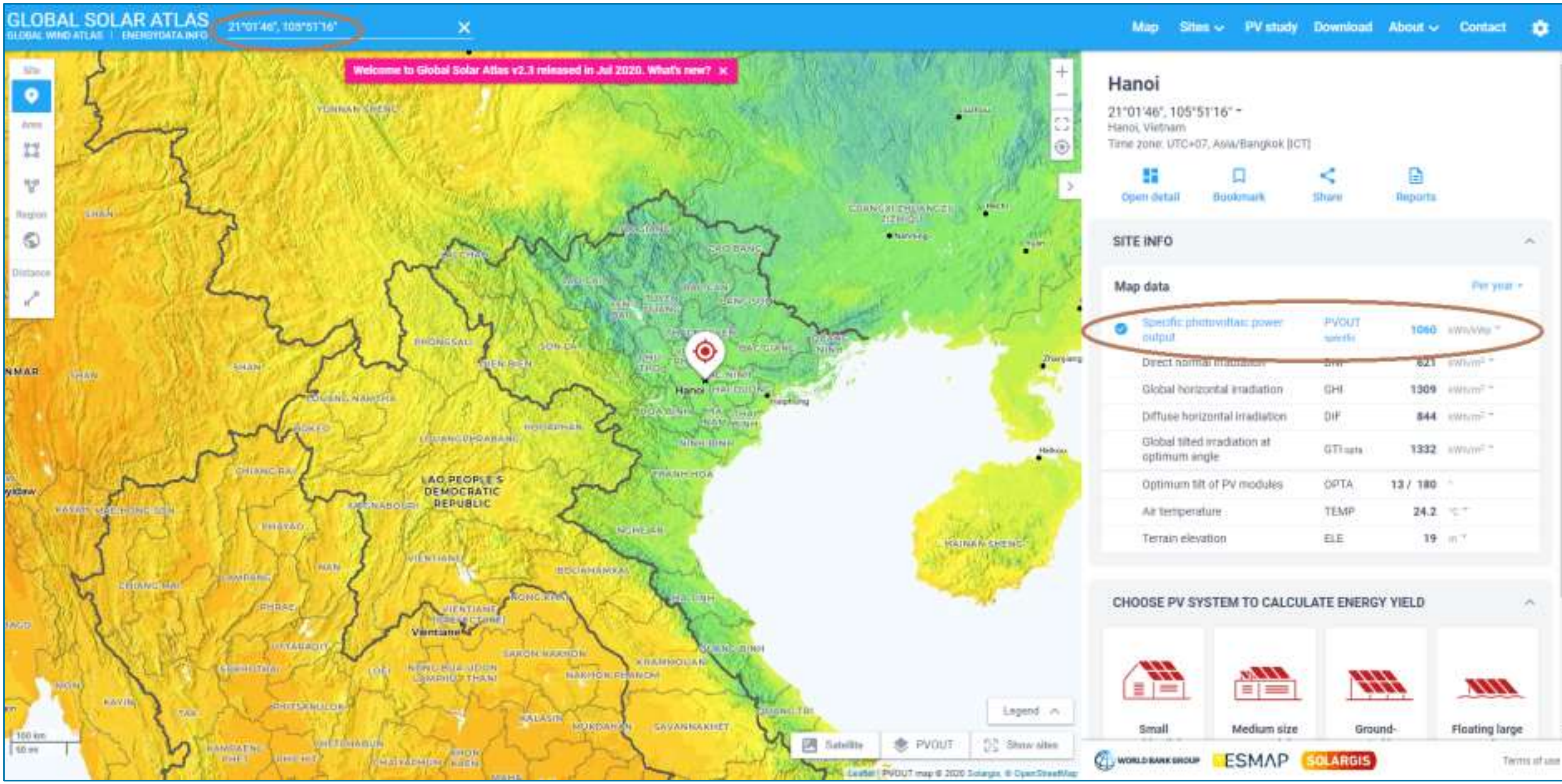
1. If off-grid PV capacity data is collected regularly through surveys, then aggregation over time is not a problem
2. If capacity is calculated by aggregating annual additions (e.g. sales data) then assumptions must be made.
3. Based on discussions with GOGLA, we aggregate data for annual capacity additions (converted to MW), assuming:
   - Solar lights last 3 years (aggregate last 3 years)
   - Solar home systems last 5 years (aggregate 5 years)
   - Also assume 3% losses every year due to breakage
4. All other PV is assumed to last for 20 years (solar water heaters as well).

Estimating generation

1. Capacity factor: CF x 8,760 x MW
   (CF usually 15-20%)
2. Peak sunshine hours (similar)
3. Online tools
   - PV Watts
   - WB Solar Atlas
   - IRENA Global Atlas
4. Adjust DC generation estimate
   to get net generation (x0.95)

(Note: capacity is often recorded in MWp)

Estimating generation



Example: Global Solar Atlas (https://globalsolaratlas.info)