Philippine solar resource characterization, challenges and implications for the sector

Iban Vendrell, Programme Leader, Mott MacDonald
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Presentation Overview

- Mott MacDonald introduction as technical advisor
- Context and challenges for appropriate government incentive definition
- Overview: Solar Resource Characterization
- Overview: Capacity Utilization Factor (CUF)
- Case Study: Mott MacDonald study results: Independent Solar Energy Yield Assessment in the Philippines (for PSPA)
- Conclusions and recommendations

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14k

staff

We work in

140

countries

£1bn

turnover

Employee owned

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Context and Challenges

- Definition of appropriate tariff support mechanisms are instrumental to meet national renewable energy targets
- Tariff calculations driven by cost and revenue potential, with the latest driven by variable renewable resource production
- Optimal characterization of resource and estimation of system energy production are instrumental to confirm adequate tariff structure and to justify individual project viability

Challenges

- Limited measurement data for resource characterization
- Using consistent metrics for plant technical assumptions and capacity factor ratio estimations for tariff calculations

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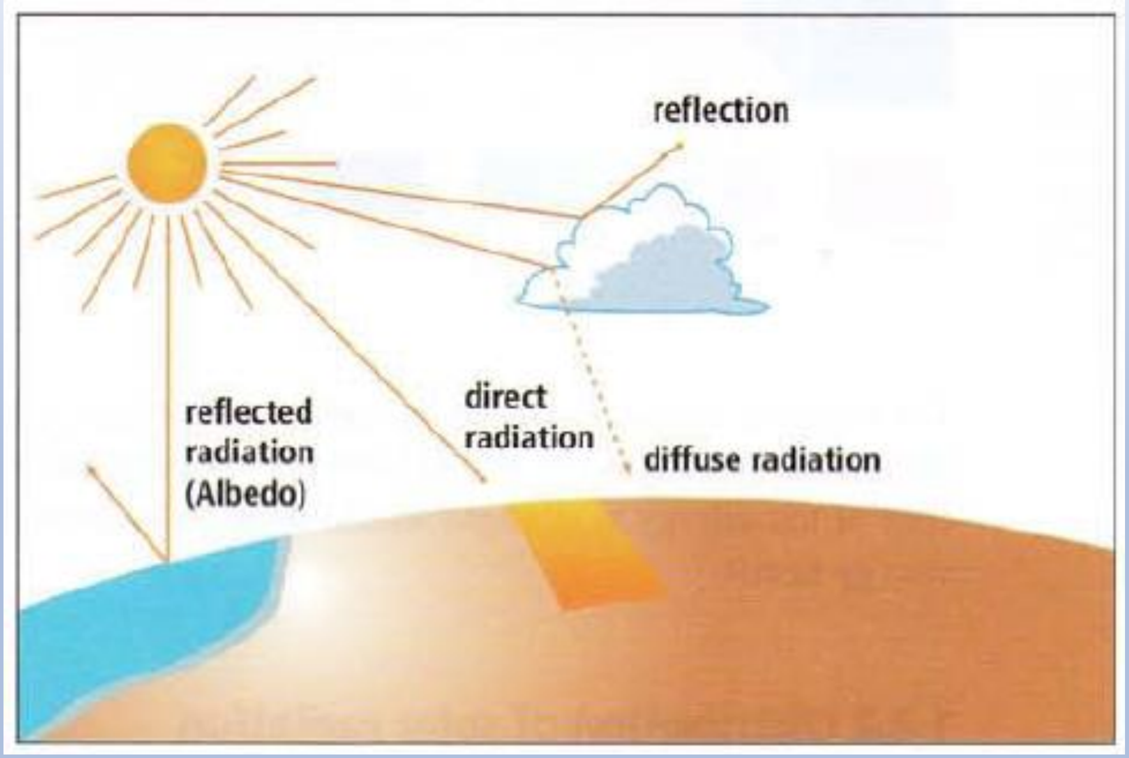
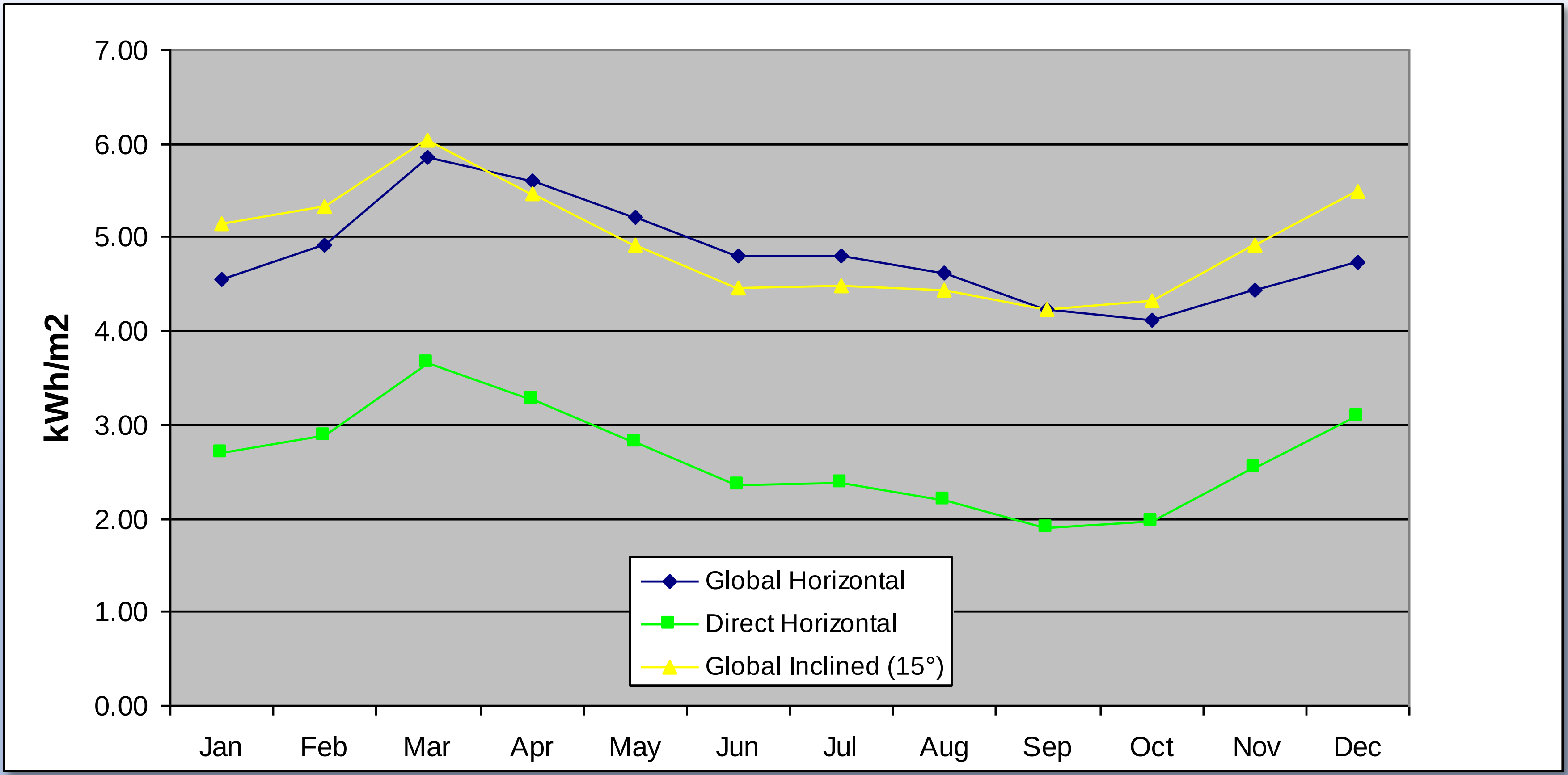
Solar Resource Characterization

Solar Irradiance – Definitions

- “Global” solar radiation comprises direct, diffuse and Albedo



Solar Irradiance – Definitions



- *Average over time to understand "input energy" / "fuel"*
  - *Typical range is 1,600 – 2,000 kWh/m^2/year*

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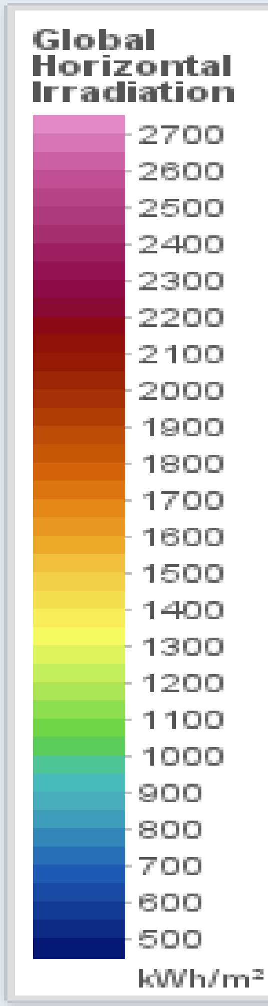
Regional Solar Irradiance Profile

National Solar Irradiation Map



Ref. SolarGIS iMaps © 2014 GeoModel Solar

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Solar Irradiance Data Sources

Gathering Data

- Terrestrial versus satellite data sources – fundamentals
- Available data sources in region (e.g. MeteoNorm, SolarGIS, 3Tier, National Meteorological Agency,etc)
- Availability of ground measurement stations in region
- Site meteorological station for accurate long term prediction (pyrometers, reference cell)

Data Analysis

- *Correlation/verification of two independent sources of Irradiance data e.g.*
  - *National Meteorological Agency, SolarGIS, etc*
- *Independent Energy Yield Analysis, using:*
  - *In-house modelling*
  - *off-the-shelf software (PVSYST)*

meteonorm 3TIER. solargis

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Solar Irradiation Selection Considerations

- Available irradiation data accuracy varies significantly across the region
  - Countries with more complex topography subject to higher variations in irradiance conditions
  - Long-term, quality-controlled pyranometer measurements close to the site (e.g. within 20 km) the best possible irradiance data source
- Satellite-derived irradiation data an essential tool, but only subject to suitable validation
  - Validation must be for ground measured data in a similar climate to the Project site, and ideally located close by

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Irradiation Data Sources – Philippines

- PAGASA - Solar Irradiation ground data:
  - Davao from 2012-2014
  - El Salvador, Cagayan De Oro from 2011-2014
  - ISU, Isabela from 2011-2014
  - Quezon City from 2011-2014
- Solar PV Plant Generation data:
  - CEPALCO 1 MWp DC (Gross capacity), from 2004
  - SACASOL 22 MWp DC (Gross capacity) from August 2014
- Other – Commercial satellite data providers
  - SolarGIS, 3Tier, Vortex, (MeteoNorm)

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Metrics for Capacity Utilization Factor (CUF)

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Calculating CUF For a Solar Plant

- Maximum possible power that can be produced by a 1MW plant over 1 year:

  1MW * 365 Days * 24 hours = 8,760 MWH

- A 1 MW power plant that produces 8,760 MWH over 1 year has a CUF of 100%
- CUF = Generation / (Plant Size * 8760)
- Plant Size = Solar plant size in MWp (DC)

$$Capacity\ factor = \frac{Actual\ energy\ output}{Installed\ capacity\ x\ 8{,}760}$$

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Solar vs. Other Power Plants

- CUF 10-40% (solar and wind) vs 80% + (thermal and hydro)
- Solar PV plants have significant internal losses between the sunlight striking the modules to generate DC electricity and the inverters converting to AC electricity, to supply to the grid
- Solar PV is the only power technology where there is a significant difference between DC (Gross) capacity and AC (Net) capacity – DC (Gross) capacity is typically from 1.1 to 1.4 times the AC (net) capacity
- CUP needs to be clearly defined (e.g. AC or DC?) and plant assumptions for energy estimation representative of latest industry trends

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Case Study: Mott MacDonald study results for Independent Solar Energy Yield Assessment in the Philippines (for Philippine Solar Power Alliance)

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Philippine Irradiation Data Selection: Key Questions to Address

- PAGASA data is short-term
  - Representative of long-term?
  - Consistent with other data sources?
- SolarGIS "iMaps" satellite-mapping shows irradiance at any location in the Philippines
  - Modelling accuracy?
  - How to validate?

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Philippine Irradiation Data Selection: Six candidate solar PV plant sites

Title	City/Town	Coordinates	Horizontal Global Irradiation (kWh/m^2yr)	Summary Description
Luzon 1	Santiago City, Isabela	16.700° 121.667°	1,764	Mid-range irradiation for Luzon
Luzon 2	Bayambang, Pangasinan	15.837° 120.440°	1,987	High irradiation for Luzon
Visayas 1	Iloilo, Panay	11.051° 122.812°	1,873	High irradiation for Visayas
Visayas 2	Jaro, Leyte	11.160° 124.763°	1,644	Low irradiation for Visayas
Mindanao 1	El Salvador City, Misamis Oriental	8.533° 124.550°	1,974	High irradiation for Mindanao
Mindanao 2	Kidapawan City, Cotabato	7.041° 125.046°	1,851	Mid-range irradiation for Mindanao

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DC Capacity Factor Results, 1 MWp PV plant

Areas	Annual Average Irradiance (kWh/m^2)	Initial PR (%)	Plant Energy Yield (MWh/year) Year 1	Average DC Capacity Factor, Years 1-20	Average AC Capacity Factor, Years 1-20
Luzon 1	1,799.3	79.9%	1,433	15.4%	17.8%
Luzon 2	2,066.5	79.3%	1,634	17.6%	20.4%
Visayas 1	1,899.2	79.1%	1,498	16.1%	18.7%
Visayas 2	1,655.5	79.6%	1,314	14.1%	16.4%
Mindanao 1	1,991.8	79.0%	1,569	16.9%	19.5%
Mindanao 2	1,862.1	79.5%	1,476	15.9%	18.4%
Average				**16.0%**	**18.5%**

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Study Results – Capacity Factor

- Average P50 lifetime capacity factor:
  - DC basis: 14.1-17.6%
  - AC basis: 16.4-20.4% (can raise with plant design)
- Operating plant DC capacity factors:
  - 15.0-16.5% during the first operating years, per range of 15.0-18.7% estimated by this study
- For P90 case typically used for debt financing, lifetime: DC capacity factor of 12.9-16.0%

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Conclusions and Recommendations

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Conclusions

- To justify tariff structure, the Philippine ERC released a paper in 2012 in which a 22% capacity factor was proposed for solar PV projects in the Philippines, by reference to international PV plant operating experience.
- Our independent study identified capacity factors in the range 14.1-20.4%, depending on definition and design
- The case study illustrates how poor resource data and large variations in country-wide resource can lead to both inappropriate policy and misdirected project siting
  - Undermines the ability to meet national targets
  - Discusses mitigation actions that can be taken

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Recommendations

- Derive CUF from optimized resource characterization at national/regional level using a combination of satellite-derived simulation (e.g. mapping) and available measurement data
- Increase ground resource mapping and validation of simulated resource data to reduce typical spatial variability due to topographical and climate regional characteristics
- Consistent capacity factor definitions are adopted for calculations of tariff structure


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Thank you for your attention

PR

	Typical Losses	Typical Annual Average Losses in % (in SEA)
Capture Losses	Spectral	0.5% loss to 0.5% gain
	Shading	1 - 5% loss
	Soiling	1 - 2% loss
	Angular	1 - 3.5% loss
	Low irradiance performance	3.5% loss to 2% gain
	Temperature losses	4 – 12 % loss
	Power tolerance	3% loss to 2% gain
	Light-induced degradation (LID)	0 – 2 % loss
System Losses	MPP tracking losses	0 - 1% loss
	Mismatch	0.5 – 1% loss
	DC and AC cabling losses	1 - 4% loss
	Inverter curtailment	0 - 4% loss
	AC/DC Inverter conversion	1 - 4% loss
	Transformer	1 - 2% loss
	Auxiliary	0 – 2% loss
	Unavailability	0 - 2% loss

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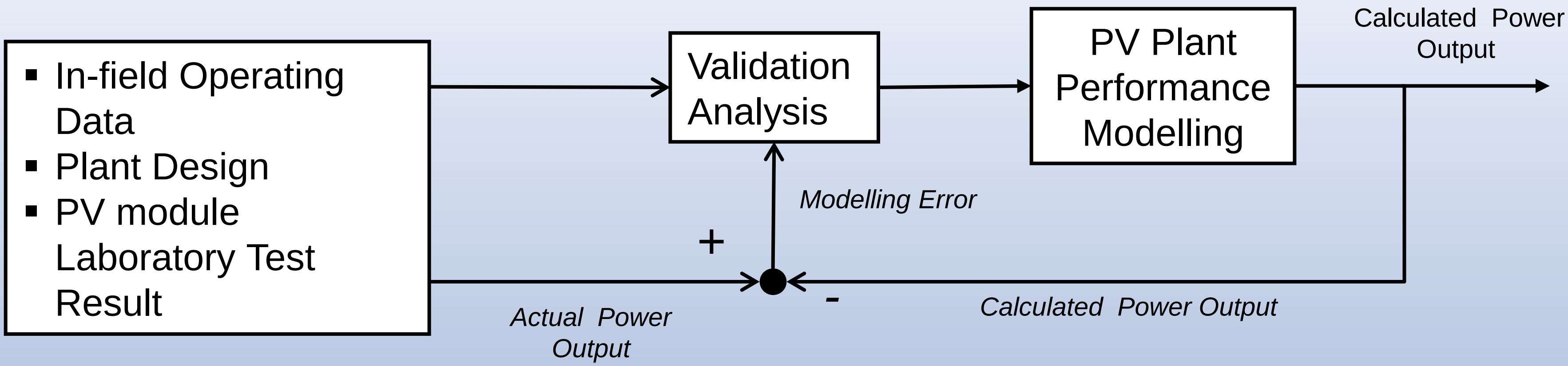

- *Less than 1 % difference compared to actual energy output*
- *High correlation coefficient on a one minute basis (more than 99%)*

Good agreement between Mott MacDonald's in-house modelling and actual plant performance under the observed environmental conditions for both plants

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