7. Data validation and estimation of renewable energy

IRENA Renewable Energy Statistics Training

IRENA
International Renewable Energy Agency

Outline

Data validation

- Background
- Data validation process
- Typical shortcomings/mistakes

Estimation and conversion factors

- Measurement and estimation
- Energy conversion
- Volume-mass-energy conversion (biofuels)

Data validation

Background

- Validation procedure: plausibility of data
- Good knowledge of country's energy system and overall situation helps (economic, social, weather conditions)
- Based on the validation we engage in dialogue with Member States to understand what is happening.
- Communication is key!

Data validation

Process

- General checks: completeness of questionnaires, incl. calorific values
- Specific checks: production capacity versus production figures; efficiency of electricity production (generation) and conversion/transformation processes (energy balances)
- Time series: missing figures, drops, increases, repetition of last year's number; also for electricity own use and losses

Data validation

Typical shortcomings/mistakes

- Figures do not add up
- Electricity production bigger than given capacity
- Inconsistency in methodology / definitions between years leads to sudden changes
- Data recycling / loophole

Measurement + estimation

Electricity from renewables:

- Large-scale - metered
- Small-scale (e.g. solar PV, wind):
  - Metered and/or net metering
  - Comparison before/after or with/without
  - Capacity, production and utilization rate

    Solar radiation x system size x efficiency x utilization

Measurement + estimation

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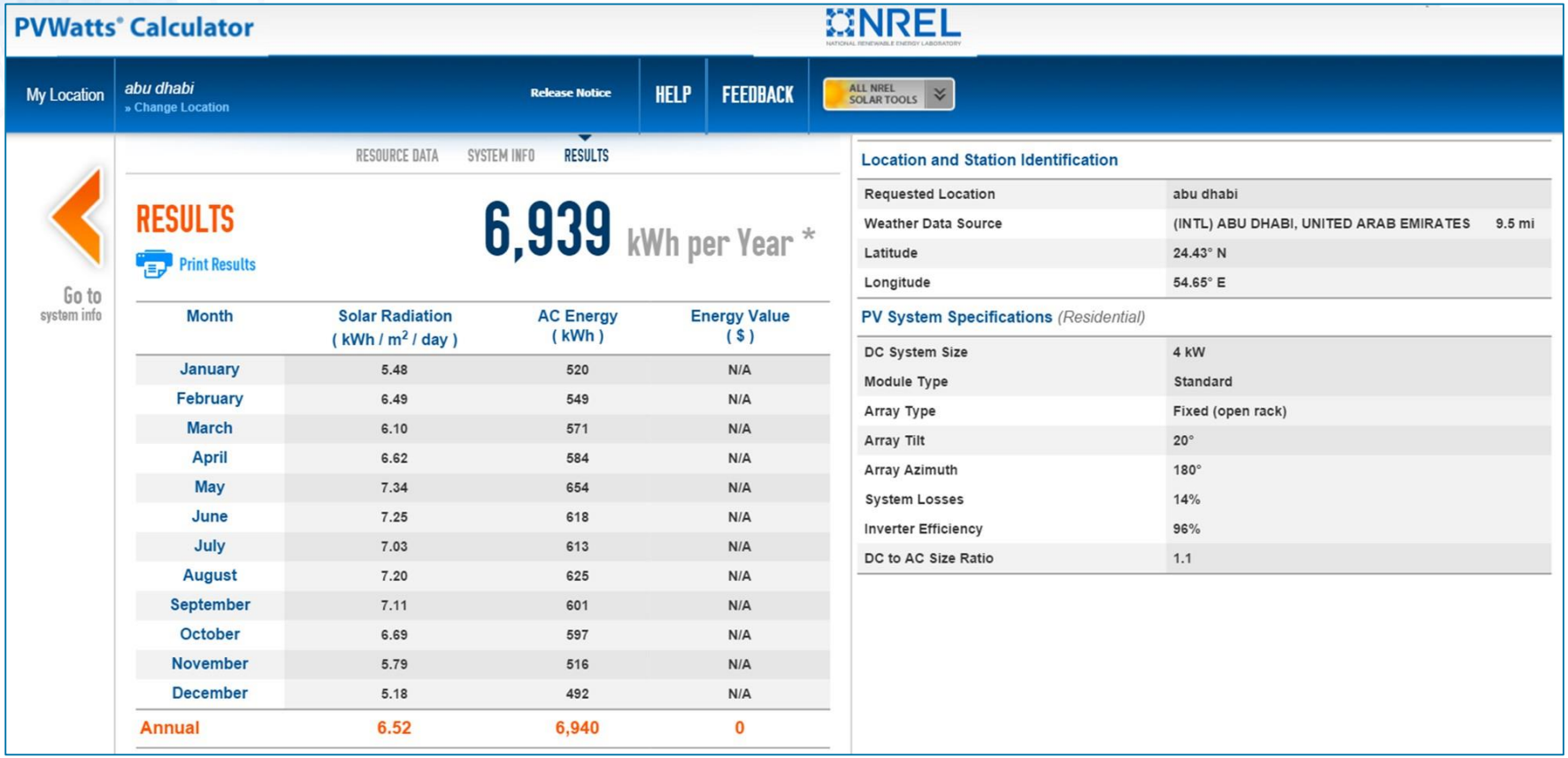

PVWatts® Calculator

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

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RESOURCE DATA | SYSTEM INFO | RESULTS

Go to system info

RESULTS

Print Results

6,939 kWh per Year *

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)	Energy Value ($)
January	5.48	520	N/A
February	6.49	549	N/A
March	6.10	571	N/A
April	6.62	584	N/A
May	7.34	654	N/A
June	7.25	618	N/A
July	7.03	613	N/A
August	7.20	625	N/A
September	7.11	601	N/A
October	6.69	597	N/A
November	5.79	516	N/A
December	5.18	492	N/A
Annual	6.52	6,940	0

Location and Station Identification

Requested Location	abu dhabi	
Weather Data Source	(INTL) ABU DHABI, UNITED ARAB EMIRATES	9.5 mi
Latitude	24.43° N	
Longitude	54.65° E	

PV System Specifications *(Residential)*

DC System Size	4 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	20°
Array Azimuth	180°
System Losses	14%
Inverter Efficiency	96%
DC to AC Size Ratio	1.1

Source: http://pvwatts.nrel.gov

There are many online tools to estimate production

Measurement + estimation

Renewable heat:

- Large-scale - metered
- Small-scale (water heater):
  - Based on collector area
  - Capacity: 0.7 kW_{th}/m^2
  - Production derived from capacity (various models)

http://www.valentin-software.com

Measurement + estimation

Liquid biofuels:

- Weight and/or volume is recorded
- Energy content is generally known
- Blending has to be taken into account

  (E10, E20, E80, B10, B20, B80, etc.
  blends are usually measured by volume)

Measurement + estimation

Biogas:

- Primary energy content can be measured:
  - though direct measurement of production
  - or calculated from final energy production

Direct measurement:

Parameter measured	Analytical methods	Results
Gas flow	Thermal mass flow meters	Biogas volume
Gas composition	Gas chromatography Infrared spectroscopy	Share of CH_4, CO_2
Gas flow rate, gas temperature, gas composition	Integrated measurement systems	

Biogas energy [MJ] = biogas volume [m^3] x CH_4 in biogas [%] x NCV of CH_4 [MJ/Mn^3]

Where NCV of CH_4 = 33.9389 MJ/Mn^3

Measurement + estimation

Biogas measuring devices:

© Awite Bioenergie

Measurement system for biogas composition

Integrated measuring systems

- **Gas composition**
- **Gas mass flow rate**
- **Gas temperature**

© Endress+Hauser

Automated ultrasonic flow meter for biogas volume measurement

© BAGGI

©SIERRA

Measurement + estimation

Direct measurement is used for:

- Upgraded biogas for injection into the natural gas grid or use as transport fuel
- Large (modern) anaerobic fermentation plants
- Biogas production through thermal processes

Direct measurement equipment is complicated and expensive and is not often used for landfill and sewage sludge gas and small anaerobic fermentation plants, but sampling may be used.

Measurement + estimation

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Estimation from energy production:

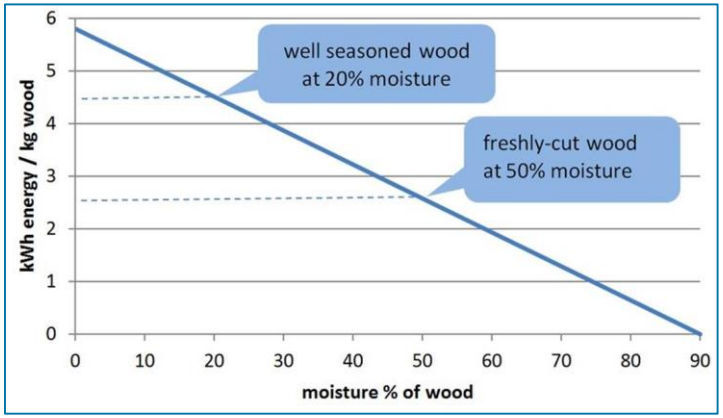
Energy production system	Relevant parameters
Combined heat and power (CHP)	Electricity produced (sum of own consumption and electricity injected into the grid) Power to heat ratio (electrical efficiency) Total efficiency of engine
$$Biogas\ energy\ [MJ] = \frac{El.\ supplied\ into\ the\ grid + Own\ El.consumption\ [MJ]}{Power\ to\ heat\ ratio \times Total\ engine\ efficiency}$$	
Steam production (process use)	Steam produced Efficiency of steam boiler Own heat consumption
$$Biogas\ energy\ [MJ] = \frac{Steam\ produced\ [MJ]}{Steam\ boiler\ efficiency} + \frac{Own\ heat\ consumption\ [MJ]}{Boiler\ efficiency}$$	
Heat production (water and space heating)	Heat delivered for space/water heating Distribution losses Own heat consumption Efficiency of boiler(s)
$$Biogas\ energy\ [MJ] = \frac{Heat\ develired \times (1 + distribution\ losses)[MJ]}{Boiler\ efficiency} + \frac{Own\ heat\ consumption\ [MJ]}{Boiler\ efficiency}$$	

Measurement + estimation

Solid biofuels:

- Measured by weight and/or volume
- Energy content is variable
- Moisture content is a critical variable
- Waste can sometimes be measured as a function of commodity production:
  - Sawmill waste = c. 50% of wood use
  - Bagasse (wet) = c. 30% of sugar cane use
  - Rice husks = c. 20% of rice entering mill

Energy content of temperate hardwoods



Energy conversion

Energy to energy:

- 1 kWh = 3.6 MJ
- Multiples: J - kJ - MJ - GJ - TJ - PJ - EJ (x10^3)

  Useful source: https://www.iea.org/statistics/resources/unitconverter

Volume to mass:

- Ethanol (average) = 0.79 kg/litre
- Biodiesel (average) = 0.88 kg/litre
- Woodfuel = 625-750 kg/m^3 (20% moisture)
- Wood waste = 550-700 kg/m^3 (10% moisture)

Mass to energy (NCV): in questionnaire

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Questions?

Thank you!