

## Renewable Energy Statistics Training

### Exercise 5a: Estimating solar PV generation

Ideally, solar photovoltaic capacity and generation should be formally monitored and reported. However, this is not always the case, particularly for off-grid systems that are not part of a formal scheme. In those cases, and assuming that no solar cell manufacturing occurs in the country, trade data can provide us with a broad estimation of the installed capacity and generation. Yemen has been chosen as an example for this exercise. Power outages have been common in Yemen since the start of the conflict, prompting the import of solar panels for the self-generation of electricity in homes and businesses. The table below provides information on trade data of solar panels in Yemen.

#### Yemen COMTRADE data for the commodity 854140: Photosensitive Semiconductor Devices, Photovoltaic Cells And Light Emitting Diodes.

Year	Imports (kg)	Exports (kg)
2006	1,033	0
2007	4,663	0
2008	87,367	0
2009	5,074	654
2010	1,052	0
2011	27,900	0
2012	8,040	0
2013	100,209	0
2014	940,785	0
2015	8,700,420	0

Source: [comtrade.un.org](http://comtrade.un.org)

The objective of this exercise is to calculate the solar PV generation of Yemen in 2015 in GWh following these steps:

- First, estimate installed capacity from solar panel import weight, using a conversion factor of **10W/kg**. This conversion factor has been calculated by IRENA statistics team based on the analysis of the technical characteristics of dozens of solar PV systems. Assume all panels installed since 2006 are still in operation.
- Second, calculate electricity generation using PVWatts Calculator and selecting the closest available weather station. If you do not have access to a computer, the next page offers information on the annual generation of 1 kW of installed solar capacity from one of the closest stations.
- What are the main limitations of this estimation? How reliable it is?

## Extract from PVWatts Calculator for a solar PV installation of 1kW in Dire Dawa, Ethiopia.



Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at <http://sam.nrel.gov>) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

Disclaimer: The PVWatts® Model ("Model") is provided by the National Renewable Energy Laboratory ("NREL"), which is operated by the Alliance for Sustainable Energy, LLC ("Alliance") for the U.S. Department Of Energy ("DOE") and may be used for any purpose whatsoever.

The names DOE/NREL/ALLIANCE shall not be used in any representation, advertising, publicity or other manner whatsoever to endorse or promote any entity that adopts or uses the Model. DOE/NREL/ALLIANCE shall not provide

any support, consulting, training or assistance of any kind with regard to the use of the Model or any updates, revisions or new versions of the Model.

YOU AGREE TO INDEMNIFY DOE/NREL/ALLIANCE, AND ITS AFFILIATES, OFFICERS, AGENTS, AND EMPLOYEES AGAINST ANY CLAIM OR DEMAND, INCLUDING REASONABLE ATTORNEYS' FEES, RELATED TO YOUR USE, RELIANCE, OR ADOPTION OF THE MODEL FOR ANY PURPOSE WHATSOEVER. THE MODEL IS PROVIDED BY DOE/NREL/ALLIANCE "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY DISCLAIMED. IN NO EVENT SHALL DOE/NREL/ALLIANCE BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES OR ANY DAMAGES WHATSOEVER, INCLUDING BUT NOT LIMITED TO CLAIMS ASSOCIATED WITH THE LOSS OF DATA OR PROFITS, WHICH MAY RESULT FROM ANY ACTION IN CONTRACT, NEGLIGENCE OR OTHER TORTIOUS CLAIM THAT ARISES OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF THE MODEL.

The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

## RESULTS

# 1,695 kWh per Year \*

Month	Solar Radiation ( kWh / m <sup>2</sup> / day )	AC Energy ( kWh )	Energy Value ( \$ )
January	7.10	162	N/A
February	6.98	144	N/A
March	6.16	143	N/A
April	5.59	126	N/A
May	5.55	127	N/A
June	5.60	124	N/A
July	5.53	128	N/A
August	5.81	135	N/A
September	6.16	136	N/A
October	6.57	151	N/A
November	7.01	155	N/A
December	7.06	164	N/A
<b>Annual</b>	<b>6.26</b>	<b>1,695</b>	<b>0</b>

### Location and Station Identification

Requested Location	Sanaa
Weather Data Source	(INTL) DIRE DAWA (MIL/CIV), ETHIOPIA 428 mi
Latitude	9.6° N
Longitude	41.87° E

### PV System Specifications (Residential)

DC System Size	1 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

### Economics

Average Cost of Electricity Purchased from Utility	No utility data available
--	---------------------------

### Performance Metrics

Capacity Factor	19.4%
-----------------	-------

Source: NREL PVWatts Calculator: <http://pvwatts.nrel.gov>

## Answers

Total imports: 9,876,543 kg

Total exports: 654 kg

Total supply: 9,875,889 kg

Installed capacity:  $9,875,889 \text{ kg} * 10 \text{ W per kg} / 1,000,000 = 98.8 \text{ MW}$

Generation:  $98.8 * 1,695 / 1,000 = 167 \text{ GWh}$