# 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*

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.

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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.



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$^2$ / 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 |
| Annual | 6.26 | 1,695 | 0 |

### 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 kg * 10 W per kg / 1,000,000 = 98.8 MW

Generation: 98.8 * 1,695 / 1,000 = 167 GWh