# Homer Simulations Report

## Introduction:

Homer is a simulation program which evaluates the electrical and thermal generation in relation to climate data of the region under consideration. Homer evaluates the matching between demand and supply. The results can be on hourly, monthly or yearly basis (downloadable at www.nrel.gov/homer).

## Homer applied in our case studies:

Simulations have been followed through regarding PV panels and wind turbines on an hourly basis. System includes an inverter (efficiency 90%). Thermal energy generation is not considered due to programs limited options.

- **1st case: Glasgow**
  - ✓ Latitude 55.50 and longitude 4.15
  - ✓ Average solar Clearness: 0.397
  - ✓ Average solar radiation: 2.418 (kWh/$m^2$)
  - ✓ Average temperature: 9.4 ($^oC$)
  - ✓ Average wind speed: 3.935 (m/s)

- **2nd case: Palermo**
  - ✓ Latitude 38.7 and longitude 13.22
  - ✓ Average solar Clearness: 0.570
  - ✓ Average solar radiation: 4.572 (kWh/$m^2$)
  - ✓ Average temperature: 18.8 ($^oC$)
  - ✓ Average wind speed: 3.798 (m/s)

### Parameters of PV panels

- ✓ Glasgow:

- ✓ Derating factor: 80 (%)
- ✓ Slope: 55.83°
- ✓ Ground reflectance: 20 (%)
- ✓ Temperature coefficient of power: - 0.5 (%/°C)
- ✓ Nominal operating cell temperature: 47 (°C)
- ✓ Efficiency at std. conditions: 13 (%)

- ✓ Palermo:
  - ✓ Derating factor: 80 (%)
  - ✓ Slope : 38.11°
  - ✓ Ground reflectance: 20 (%)
  - ✓ Temperature coefficient of power : - 0.5 (%/°C)
  - ✓ Nominal operating cell temperature : 47 (°C)
  - ✓ Efficiency at std. conditions: 13 (%)

## Parameters of wind turbine

Simulations have been followed through regarding rural, urban and suburban locations:

| Environment | Surface roughness | Anemometer high | Hub high |
|---|---|---|---|
| Rural | 0.1 | 10 | 10 |
| Suburbs | 1.5 | 15 | 11 |
| Urban | 3 | 15 | 11 |

Other parameters of wind speed provided by homer are:

- ✓ Glasgow:
  - ✓ Weibull k: 1.72
  - ✓ Autocorrelation factor: 0.964

- ✓ Diurnal pattern strength: 0.241
- ✓ Hour peak of wind speed: 16

✓ Palermo:

- ✓ Weibull k: 1.09
- ✓ Autocorrelation factor: 0.958
- ✓ Diurnal pattern strength: 0.248
- ✓ Hour peak of wind speed: 15

## SIMULATIONS

### ✓ Glasgow

➢ **PV**

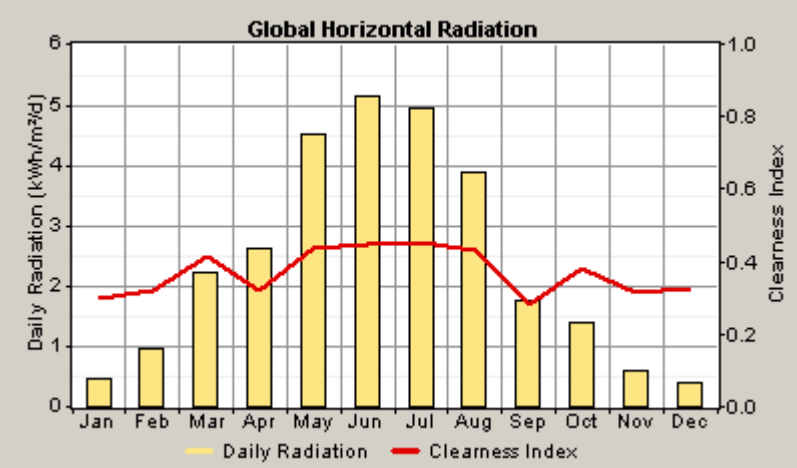
PV simulations have been made concerning Glasgow for various sizes. From the results we obtain the hourly, monthly and yearly PV generation.

| Size PV panel | Total production (kWh) | Inverters output (kWh/yr) |
|---|---|---|
| 1 kW | 751 | 675 |
| 2 kW | 1501 | 1351 |
| 3kW | 2252 | 2026 |
| 4 kW | 3002 | 2702 |

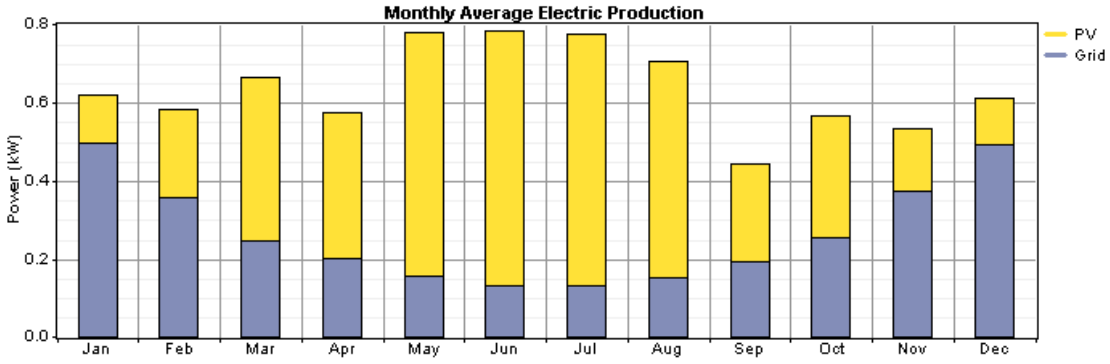
| | 1 kW | 2 kW | 3 kW | 4 kW |
|---|---|---|---|---|
| Mean output (kW) | 0.09 | 0.17 | 0.26 | 0.34 |
| Mean output (kWh/d) | 2.06 | 4.11 | 6.17 | 8.23 |
| Capacity factor (%) | 8.57 | 8.57 | 8.57 | 8.57 |
| Maximum output (kW) | 0.84 | 1.68 | 2.52 | 3.36 |

| | | | | |
|---|---|---|---|---|
| PV penetration (%) | 25.5 | 51.0 | 76.5 | 102 |
| Hours operation (hr/yr) | 3746 | 3746 | 3746 | 3746 |

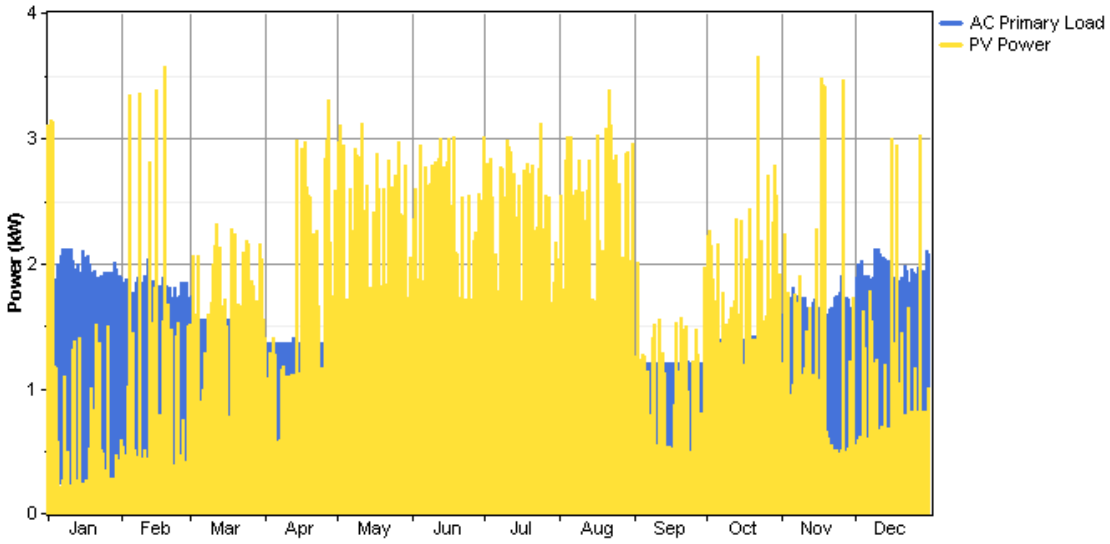
The graph below shows the monthly average global horizontal radiation. The red line is representing the clearness index which is a number between 0 and 1 and indicates the clearness of the atmosphere where homer's calculations have been based.




The following graph indicates the monthly average electric production.




The following graph displays the hourly simulation data of the 4.35 kW PV panels. On yellow is the PV power while on blue the primary load.




## ➢ Wind turbine

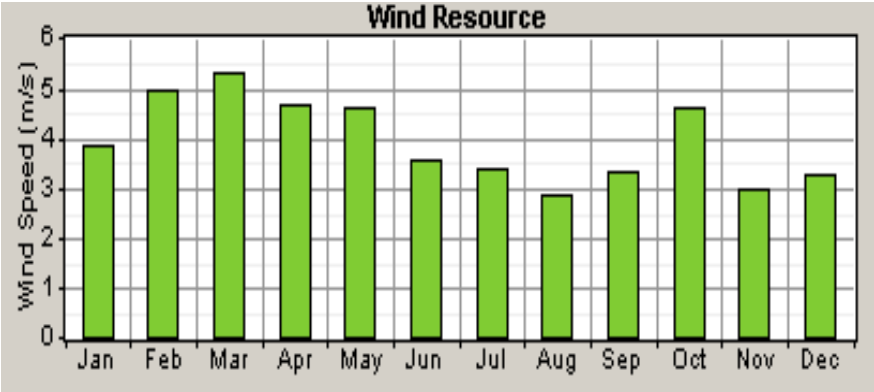
Wind turbine simulations made for 1 kW power:

For these simulations we considered different location types based upon the surface roughness length. Following tables show the yearly production for different location types and the wind turbines operations details.

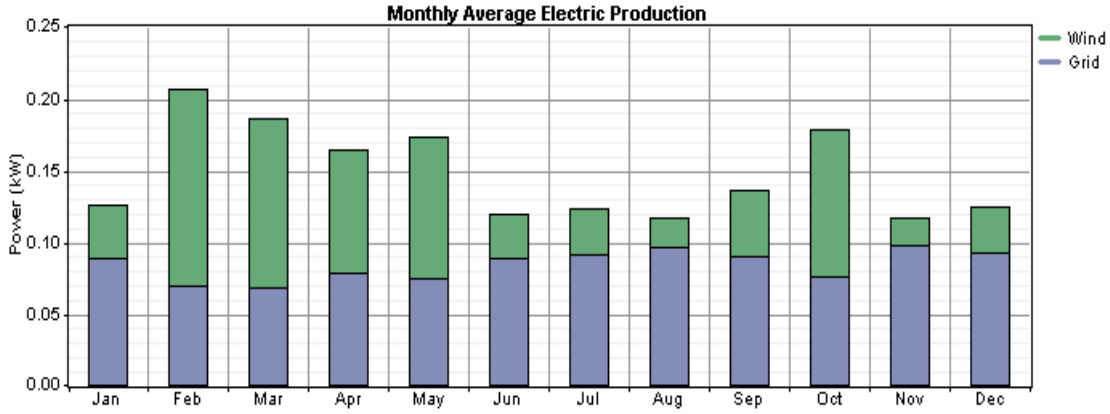
| 1kW Wind turbine | Total production (kWh) |
|---|---|
| Rural | 553 |
| Suburban | 320 |
| Urban | 242 |

| | Rural | Suburbs | Urban |
|---|---|---|---|
| Mean output (kW) | 0.06 | 0.04 | 0.03 |
| Capacity factor (%) | 6.31 | 3.65 | 2.76 |
| Maximum output (kW) | 1.00 | 0.97 | 0.93 |
| Wind penetration (%) | 57.8 | 33.4 | 25.3 |
| Hours operation (hr/yr) | 5591 | 4864 | 4456 |

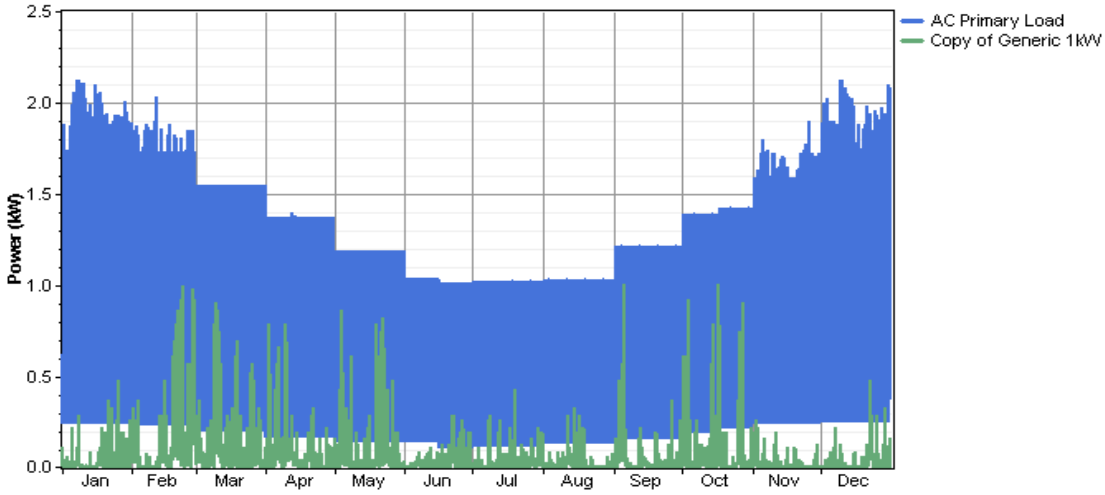
Following graph indicates the available wind resources. Output of wind turbines is calculated using hourly resource data.




The graph below shows the monthly average electric generation. Green represents wind production and in blue deficit electricity.




The following graph represents the distribution of the demand and the wind turbine power supply for a year. The graph represents the rural environment. In blue color is the demand while in green the wind turbine electrical production.




## ✓ Palermo

### ➢ PV

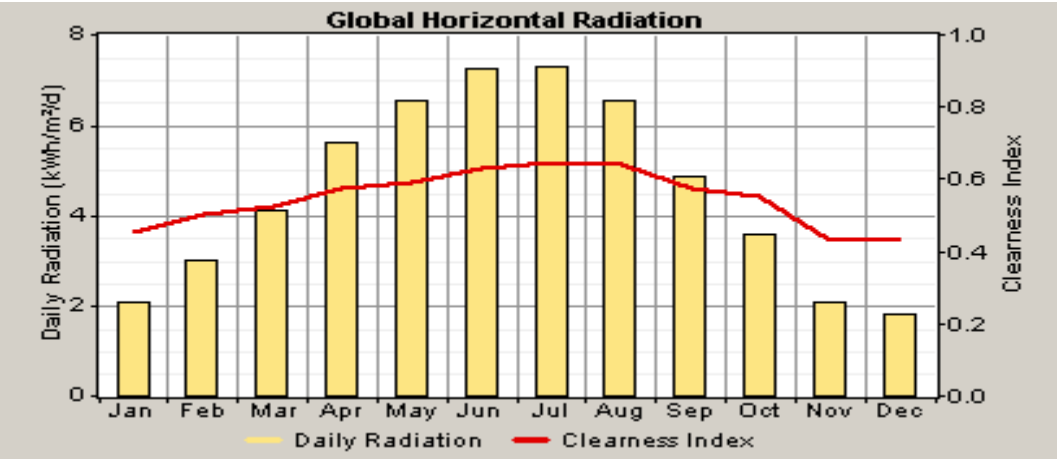
PV simulations for Palermo concerning same sizes as in Glasgow:

From the results we obtained the hourly, monthly and yearly PV generation. Next tables show yearly values and details about the PV operation array:

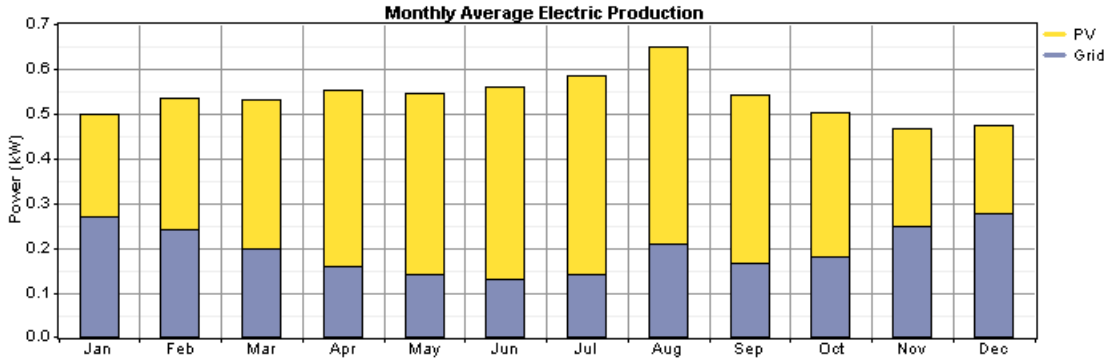
| Size PV panel | Total production (kWh) | Converters output (kWh/yr) |
|---|---|---|
| 1 kW | 1424 | 1282 |
| 2 kW | 2849 | 2564 |
| 3kW | 4274 | 3847 |
| 4 kW | 5699 | 5129 |

| | 1 kW | 2 kW | 3 kW | 4 kW |
|---|---|---|---|---|
| Mean output (kW) | 0.16 | 0.33 | 0.49 | 0.65 |
| Mean output (kWh/d) | 3.90 | 7.81 | 11.7 | 15.6 |
| Capacity factor (%) | 16.3 | 16.3 | 16.3 | 16.3 |
| Maximum output (kW) | 0.83 | 1.65 | 2.48 | 3.31 |
| PV penetration (%) | 63.8 | 128 | 191 | 255 |
| Hours operation (hr/yr) | 4122 | 4122 | 4122 | 4122 |

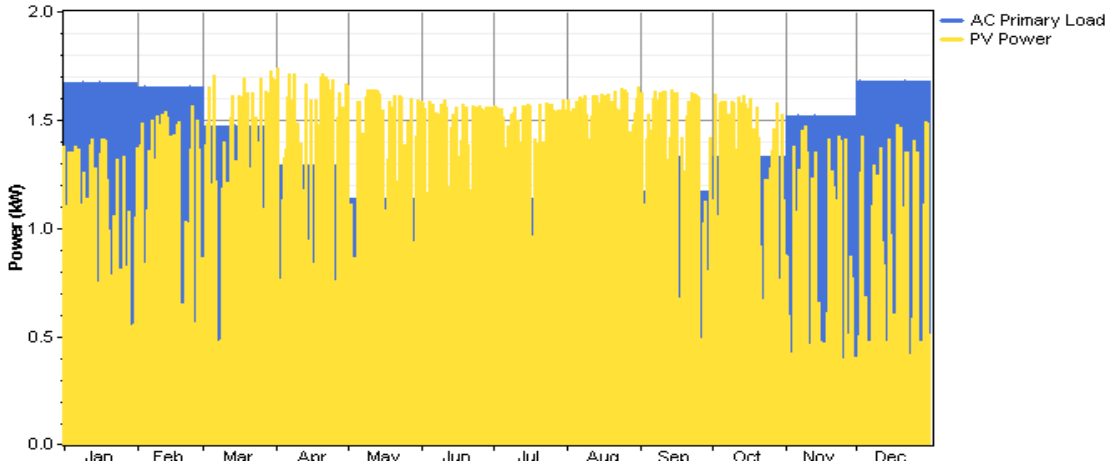
The following graph shows the monthly average global horizontal radiation. The red line is representing the clearness index which is a number between 0 and 1 and indicates the clearness of the atmosphere where homer's calculations are based.




Following graph indicates monthly average electric generation.




Next graph shows the hourly simulation data of 2.1 kW PV panels. Yellow represents PV power while blue the primary load.



## ➢ Wind turbine

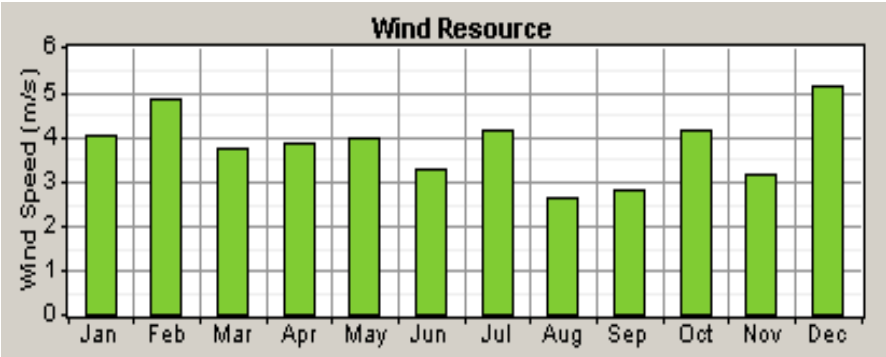
Wind turbine simulations made for 1 kW power:

For these simulations we considered different location types based on the surface roughness length. Yearly generation and details concerning wind turbines operation are the following:

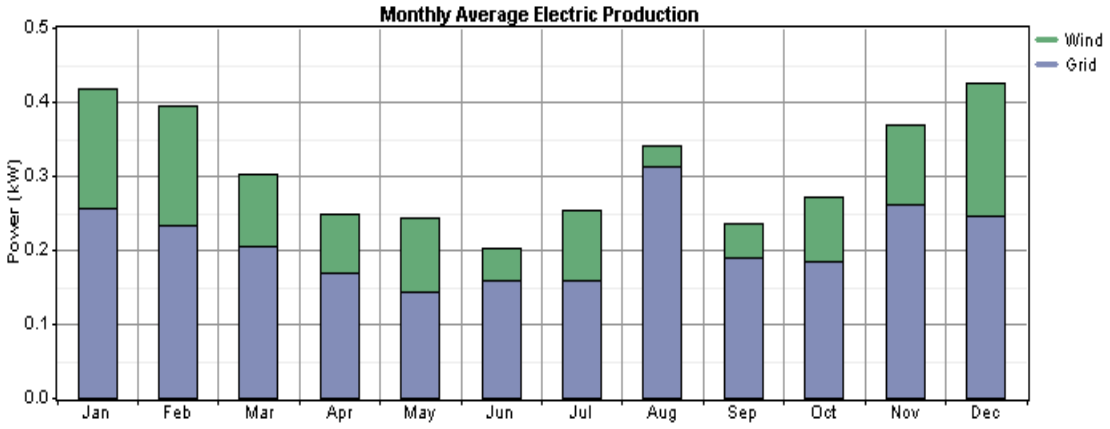
| 1kW Wind turbine | Total production (kWh) |
|---|---|
| Rural | 866 |
| Suburbs | 579 |
| Urban | 466 |

| | Rural | Suburbs | Urban |
|---|---|---|---|
| Mean output (kW) | 0.10 | 0.07 | 0.05 |
| Capacity factor (%) | 9.89 | 6.60 | 5.32 |
| Maximum output (kW) | 1.00 | 1.00 | 1.00 |
| Wind penetration (%) | 90.6 | 60.5 | 48.7 |
| Hours operation (hr/yr) | 4730 | 4116 | 1286 |

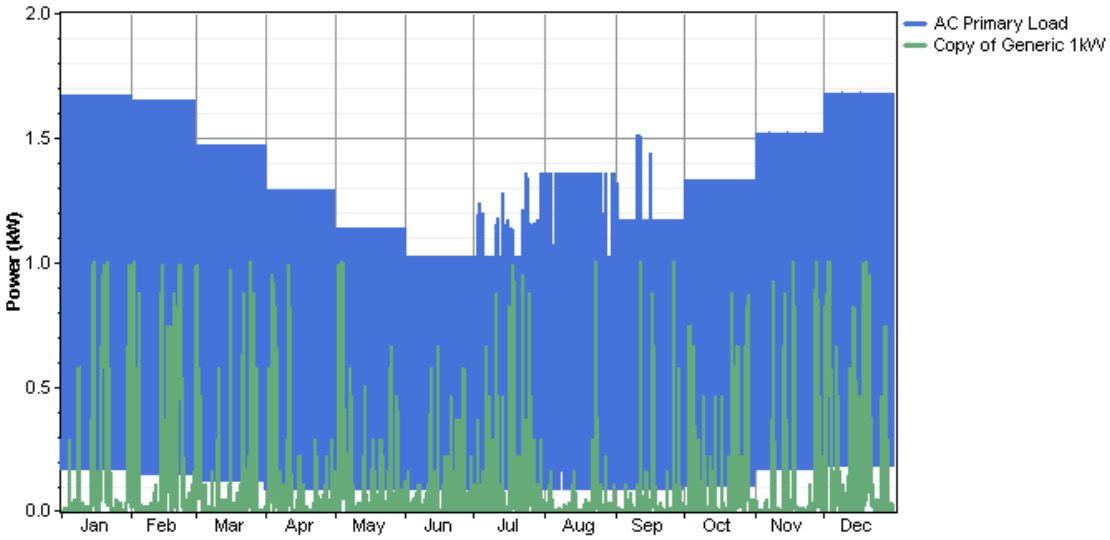
Below graph indicates the available wind resources. Based on the hourly data provided, homer calculates wind turbine outputs.




Next graph shows the monthly average electric generation. Green represents the wind production and blue the deficit electricity.




Following graph shows the distribution of annual demand and wind turbine power supply. The graph represents a rural location. Blue represents demand while green wind turbine electrical generation.




## Information

- ✓ **Clearness** of the atmosphere is the fraction of the solar radiation that is transmitted through the atmosphere to strike the Earth's surface of the Earth. It is a number between 0 and 1, defined as the surface radiation divided by the extraterrestrial radiation.

- ✓ **Derating factor is a** scaling factor applied to the PV array power output to account for reduced output in real-world operating conditions compared to operating conditions at which the array was rated.

- ✓ **Slope** is the angle at which the panels are mounted relative to the horizontal.

- ✓ **Ground reflectance** is the fraction of solar radiation incident on the ground that is reflected.
- ✓ **Temperature coefficient of power** is a number indicating how strongly the power output of the PV array depends on cell temperature
- ✓ **Nominal operating cell temperature**: The cell temperature at 0.8 kW/m2, 20°C ambient temperature, and 1 m/s wind speed
- ✓ **Efficiency at std. conditions**: The maximum power point efficiency under standard test conditions
- ✓ **Anemometer high**: The height above ground at which the wind speed data were measured
- ✓ **Weibull k** is a measure of the long-term distribution of wind speeds.
- ✓ **Autocorrelation factor** is a measure of the hour-to-hour randomness of the wind speed
- ✓ **Diurnal pattern strength** is a measure of the hour-to-hour randomness of the wind speed.
- ✓ **Hour peak of wind speed** is the time of day that tends to be windiest on average
- ✓ **Mean output** is the mean power amount of the PV array/wind turbine over the year
- ✓ **Capacity factor** is the average power output of the wind turbine/PV array divided by the total wind turbine capacity.
- ✓ **Penetration** is the average power output of the wind turbine/PV array divided by the average primary load.

# References


- Getting started guide for Homer version 2.1 - April 2005 National Renewable - National Renewable Energy Laboratory
- Micro power systems modeling with Homer – Tom Lambert – Paul Gilman and Peter Lilienthal- National Renewable Energy Laboratory