# Macro Solar and Macro Wind

- World wide use of Renewable energy.

Items removed due to confidentiality agreement.

# Comparing Micro Wind power to Micro Solar. (Based upon Macro prices.)

- Macro wind is 4 to 7 cents/kWh. That comes out to .004 to .007 cents for a watt hour of power.
- Micro wind will cost 0.000004 to .000007 cents per mWh. (milli-watt hour of power).
- Macro Sun is 20 to 50 cents/kWh. That comes out to .02 to .05 cents for watt hour.
- Micro Sun is 0.00002 to 0.00005 cents per mWh.

# Relative cost for kWh

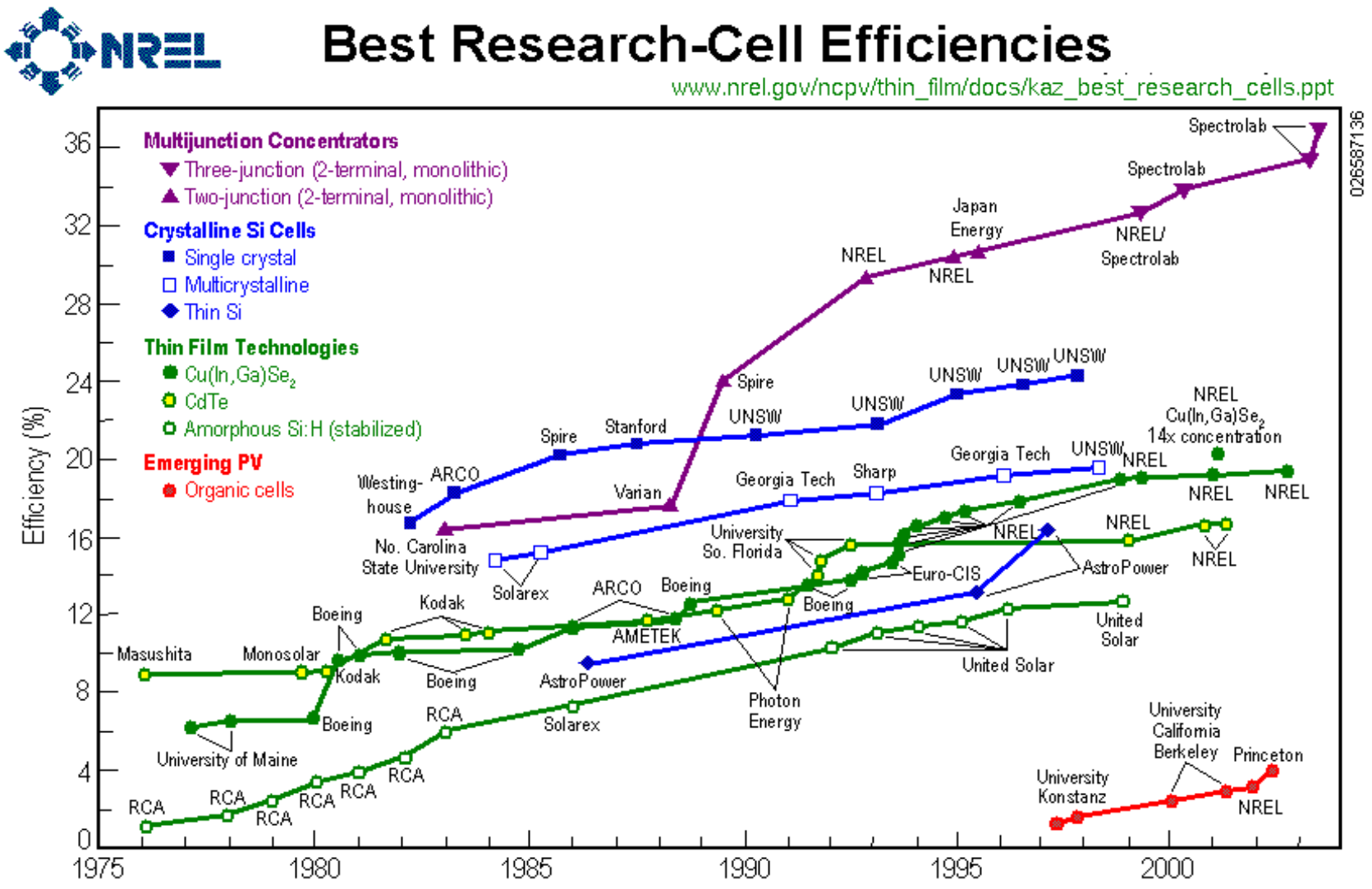
The oil industry uses **price per barrel** as its unit of price measurement. The solar energy industry typically uses **price per** Watt Peak (Wpeak/solar) as its primary unit of measurement.

A solar panel is rated to produce peak wattage under peak light conditions. The prices for high power band solar modules has dropped from around $27/Wp in 1982 to around $4/Wp today. (A 1 watt panel will cost $4. A 1Kwatt panel will cost in excess of $4000.) Prices higher and lower than this are usually dependent upon the size of the installation.

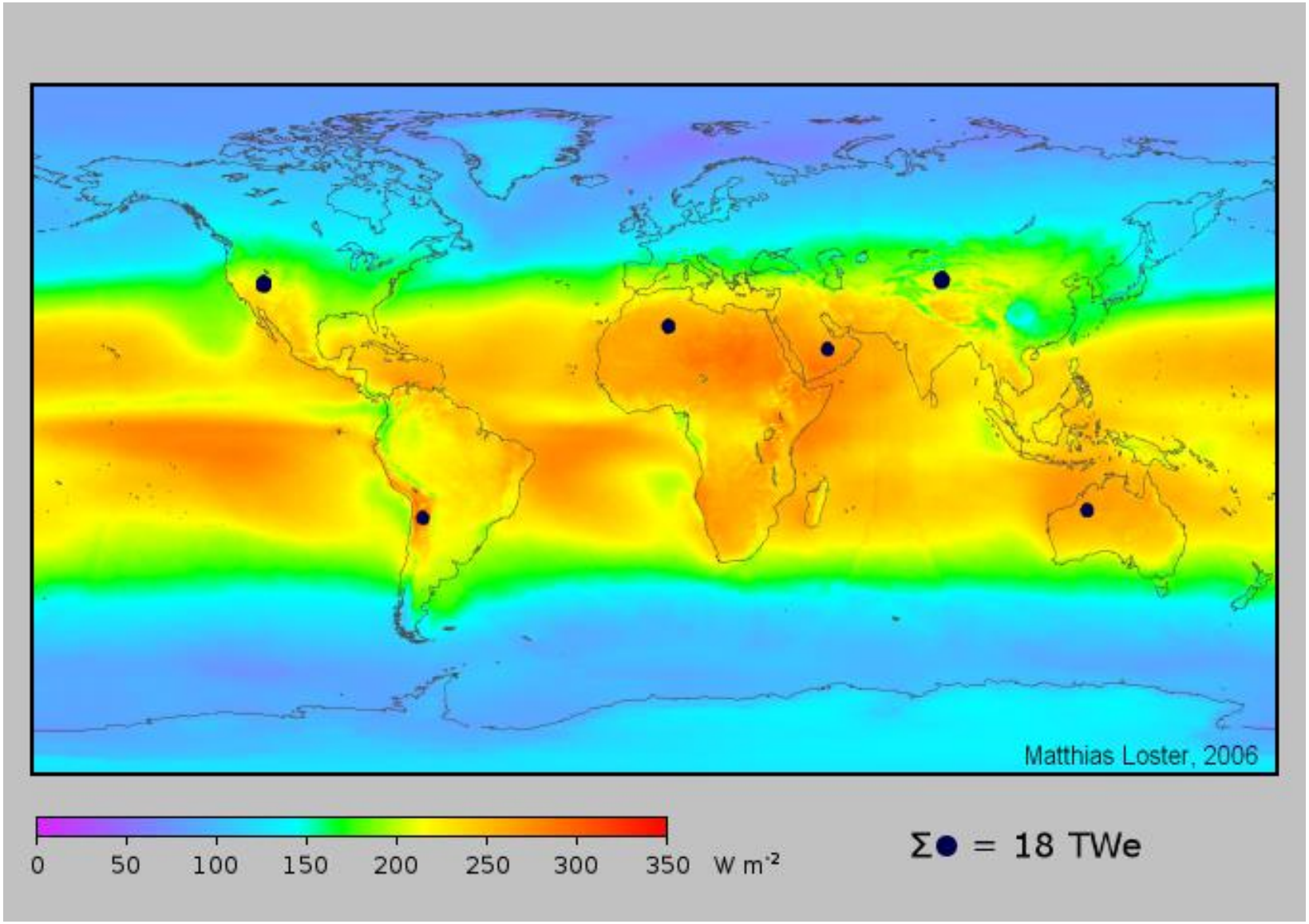
**Guideline electricity generation costs today (cents/kWh)**

| | |
|---|---|
| **Combined cycle gas turbine** | 3-5 |
| **Wind** | 4-7 |
| **Biomass gasification** | 7-9 |
| **Remote diesel generation** | 20-40 |
| **Solar PV central station** | 20-30 |
| **Solar PV distributed** | 20-50 |

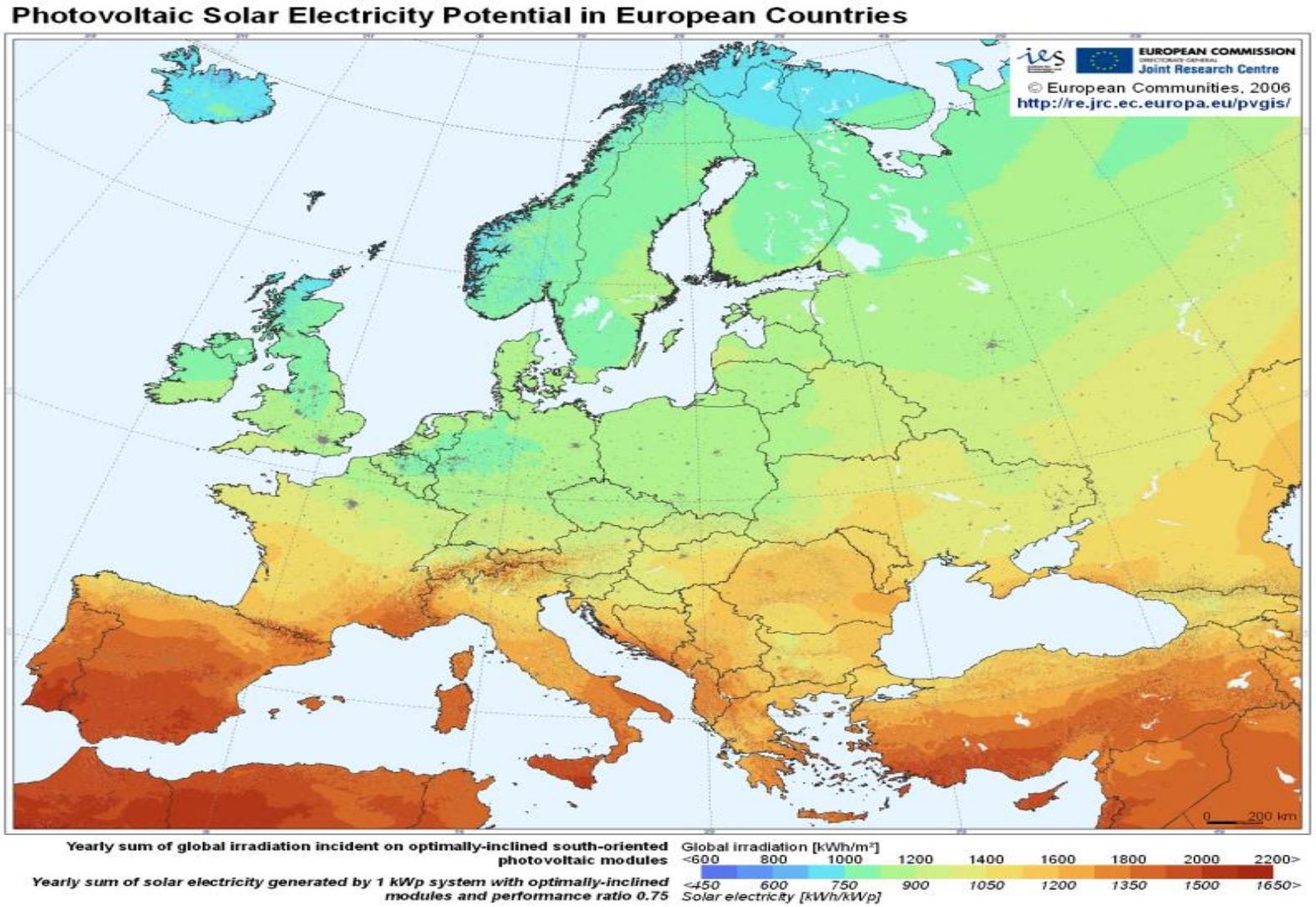
# Solar Blue Sky



# Where Solar Pays



# Solar Europe



# Macro Solar

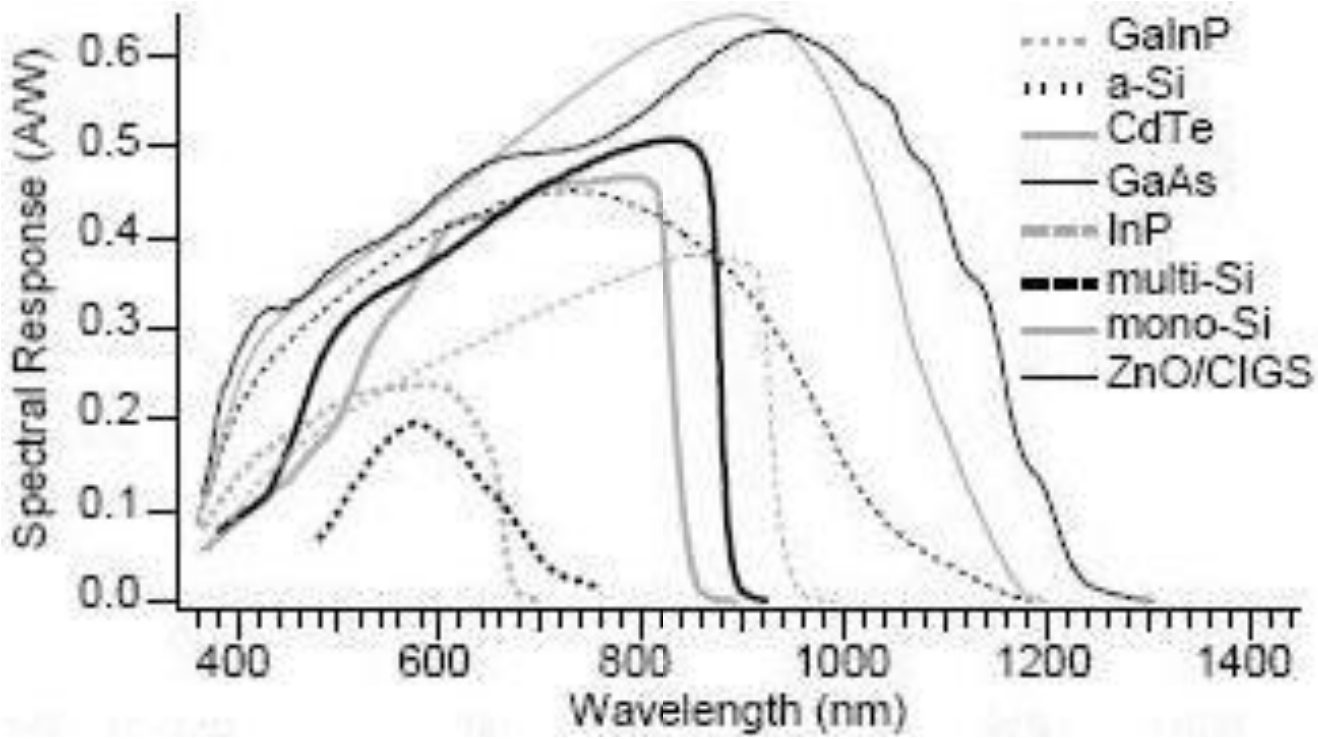
- Macro Solar works in the Sun belt regions of the world.

# Solar cells and energy payback

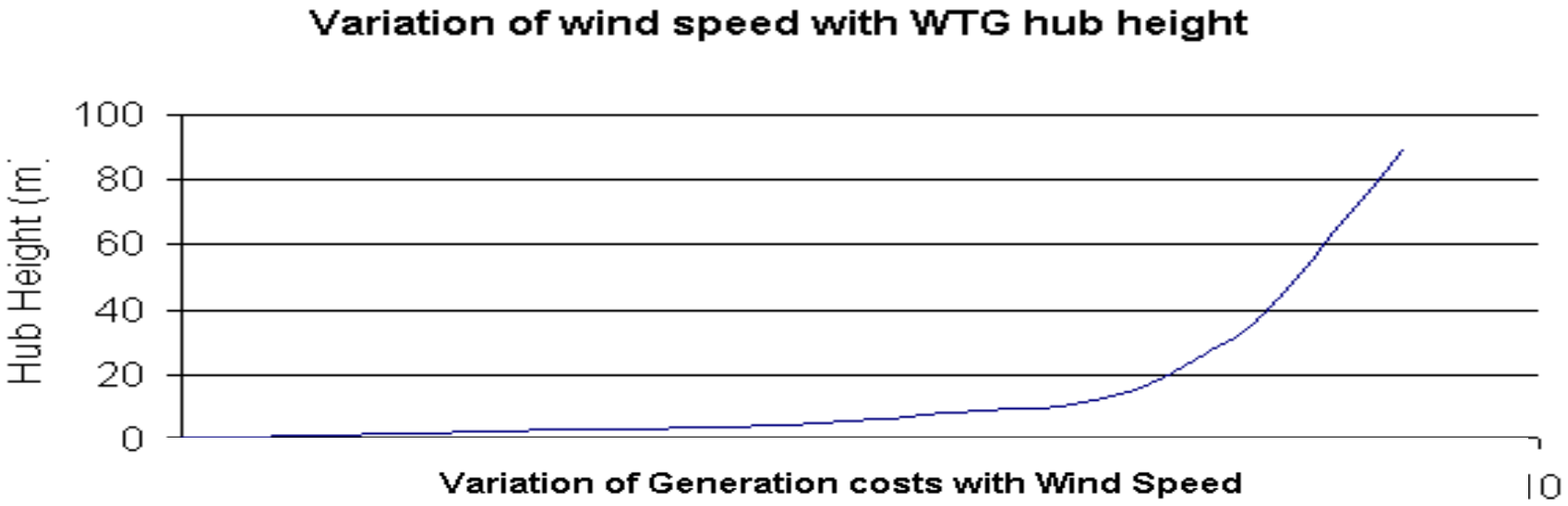
- In the 1990s, when silicon cells were twice as thick, efficiencies of 30% lower than today and lifetimes shorter, it may well have cost more energy to make a cell than it could generate in a lifetime.
- The energy payback time of a modern photovoltaic module is anywhere from 1 to 20 years (usually under five)depending on the type and where it is used
- This means solar cells can be net energy producers, meaning they generate more energy over their lifetime than the energy expended in producing them.

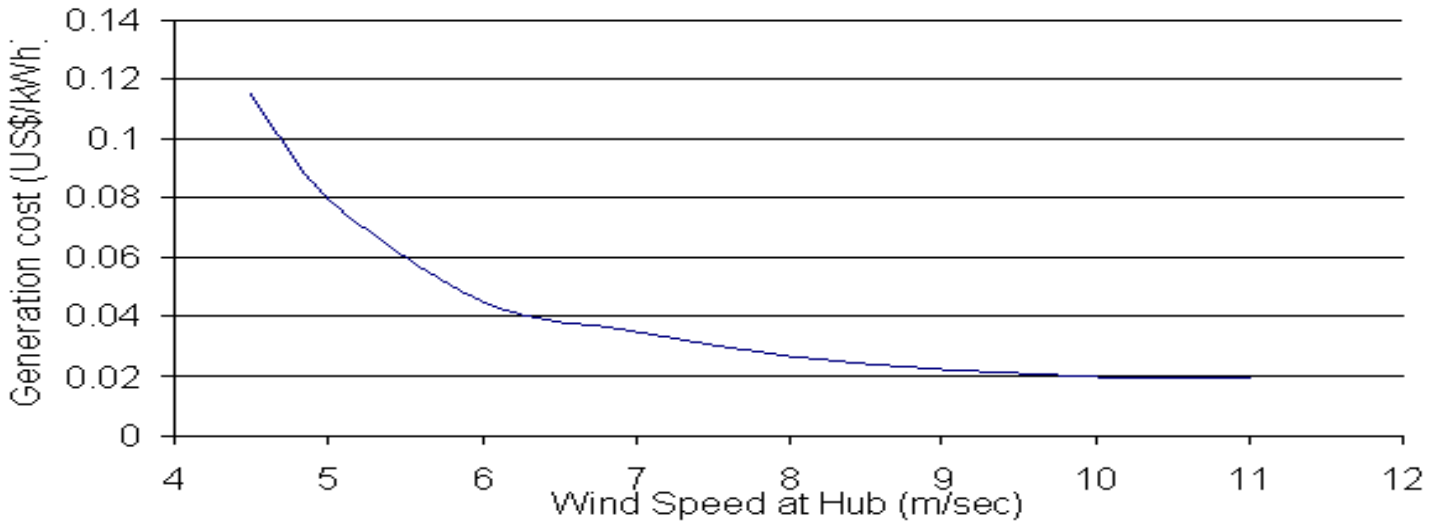
# Solar Cell Responsivity

**1 watt at 555 nm = 683.0 lumens**



# Wind Generation Cost

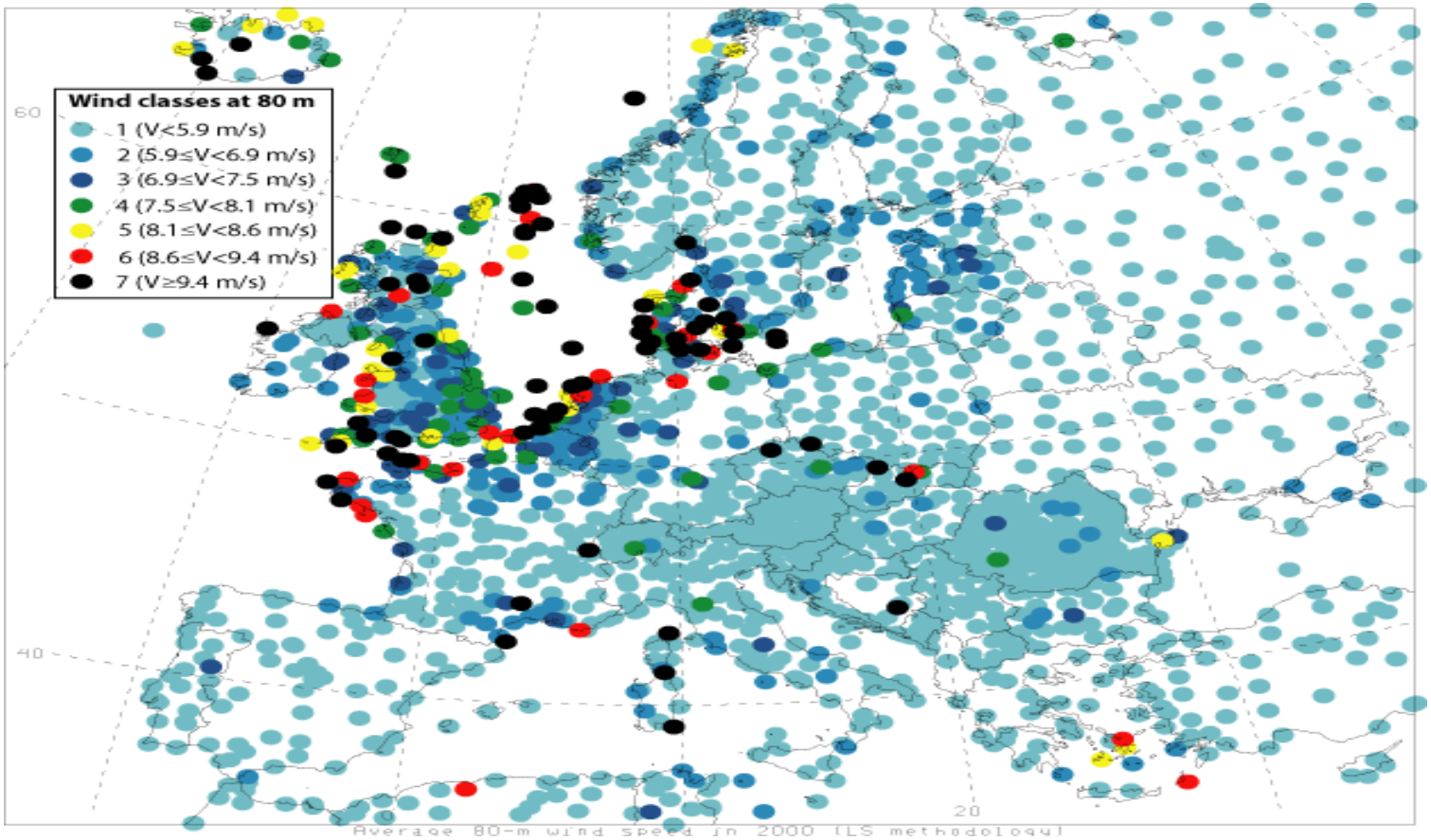


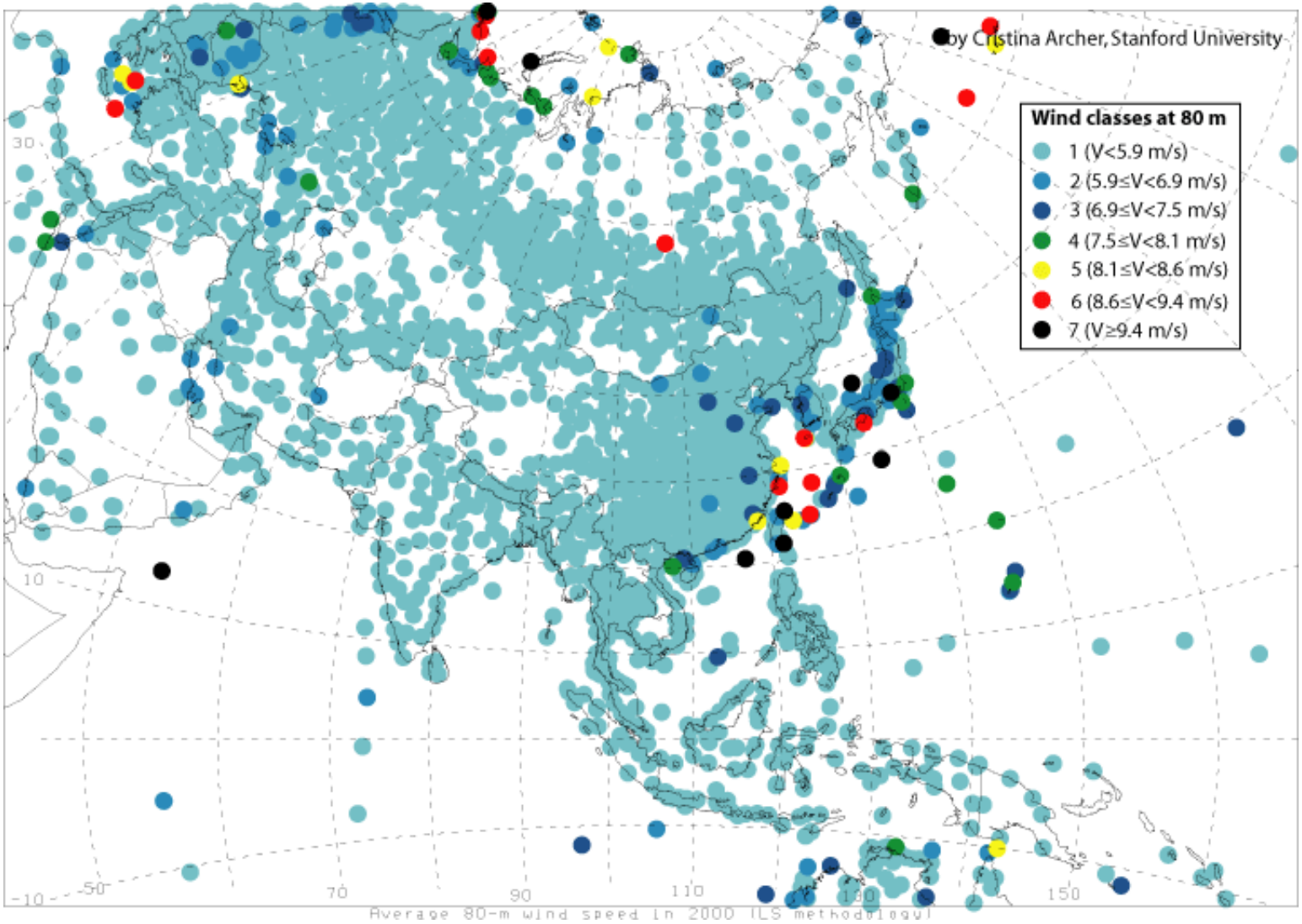
# Where Macro Wind Pays

- Macro Wind is a Blue technology. See wind maps.
- Works best in coastal areas and in

# Wind Europe


Wind classes at 80 m
1 (V<5.9 m/s)
2 (5.9≤V<6.9 m/s)
3 (6.9≤V<7.5 m/s)
4 (7.5≤V<8.1 m/s)
5 (8.1≤V<8.6 m/s)
6 (8.6≤V<9.4 m/s)
7 (V≥9.4 m/s)
60
40
20
Average 80-m wind speed in 2000 (LS methodology)

# Wind Asia


by Cristina Archer, Stanford University
Wind classes at 80 m
1 (V<5.9 m/s)
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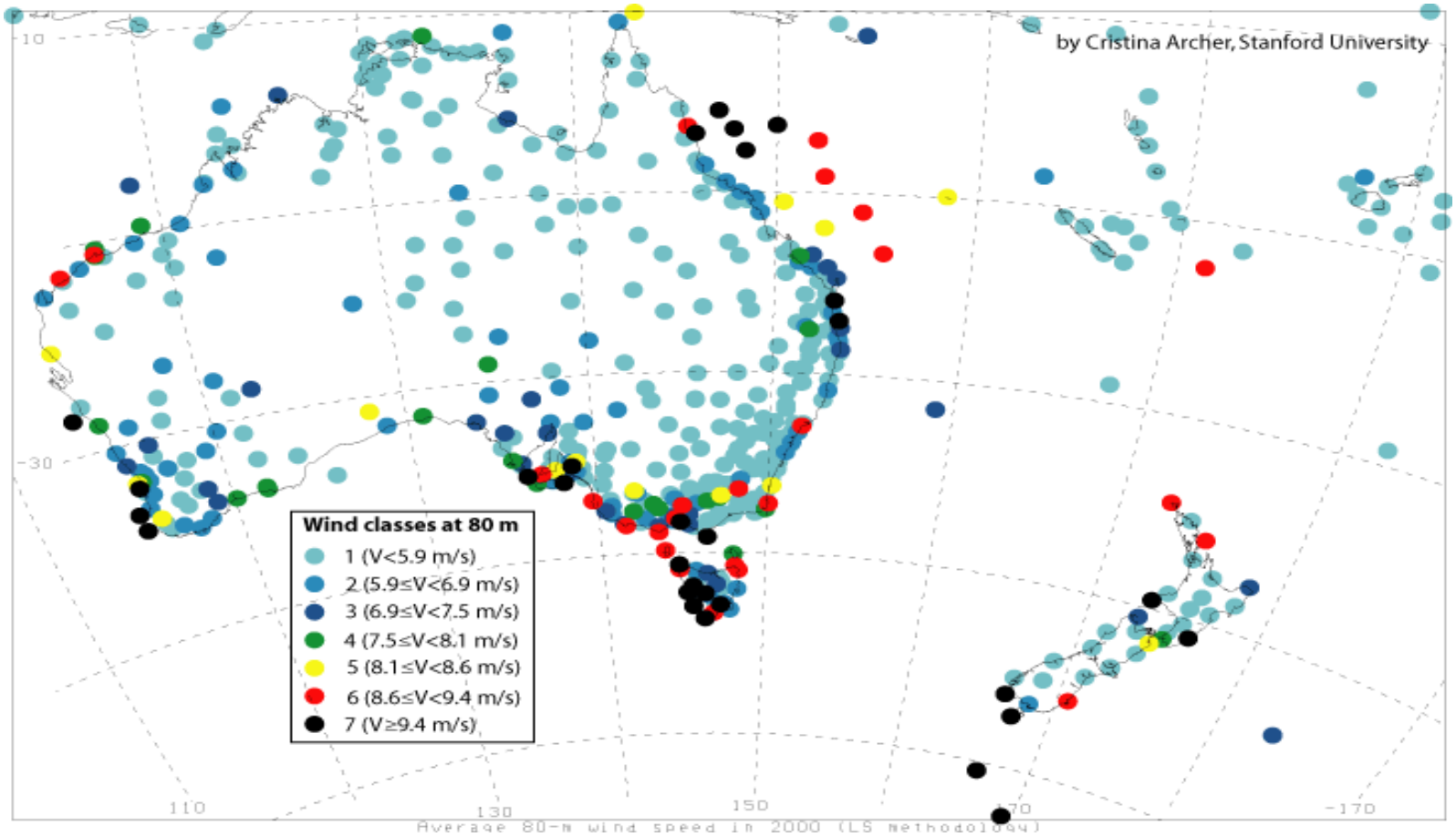
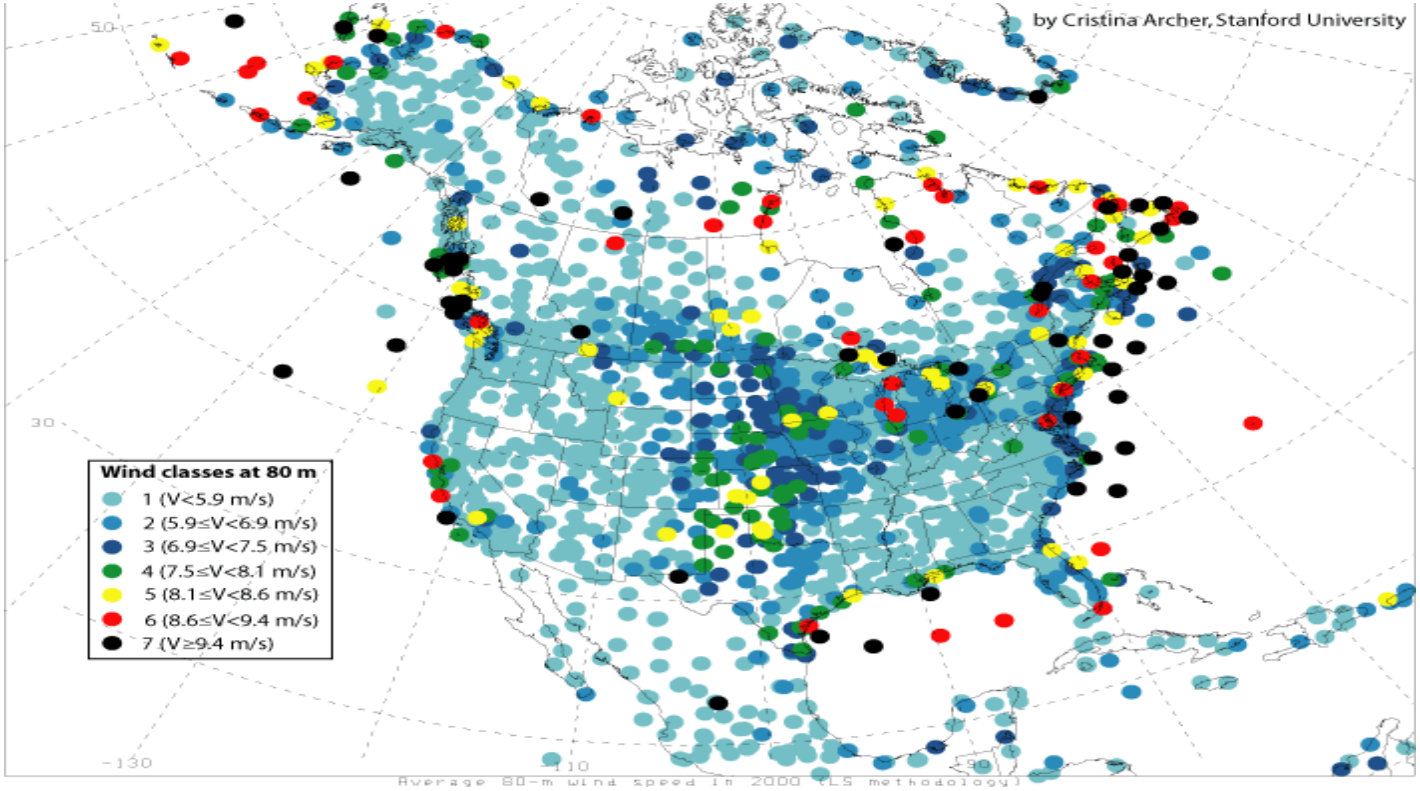
3 (6.9≤V<7.5 m/s)
4 (7.5≤V<8.1 m/s)
5 (8.1≤V<8.6 m/s)
6 (8.6≤V<9.4 m/s)
7 (V≥9.4 m/s)
30
10
-10
-50
70
90
110
130
150
Average 80-m wind speed in 2000 (LS methodology)

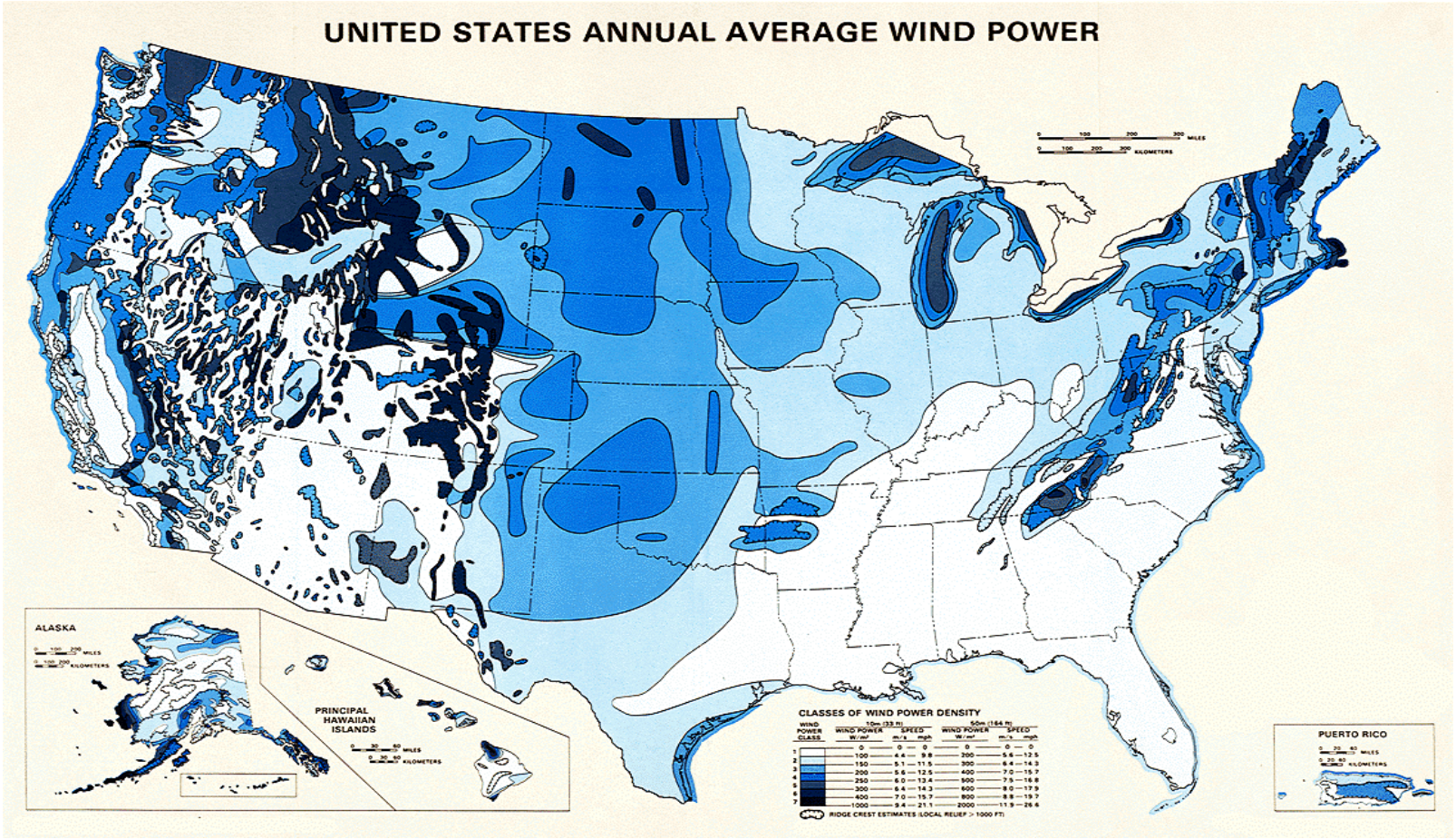
# Wind Australia



# Wind North America



# US Average Wind Power



# US DOE Wind Classes

**Table 1 Classes of wind power density at 10 m and 50 m[a]**

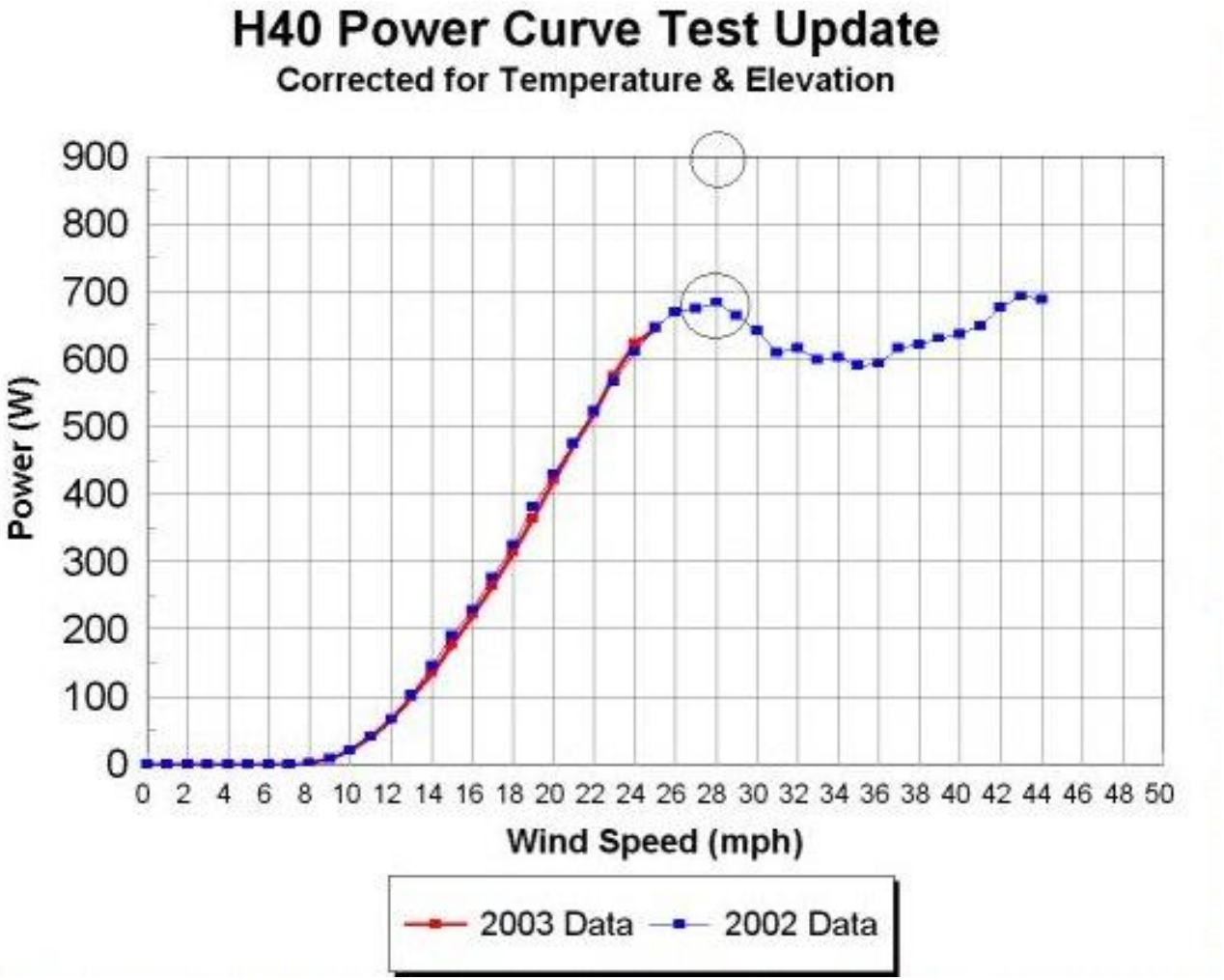
| Wind Power Class* | 10 m (33 ft) | | 50 m (164 ft) | |
|---|---|---|---|---|
| | Wind Power Density ($W/m^2$) | Speed[b] m/s (mph) | Wind Power Density ($W/m^2$) | Speed[b] m/s (mph) |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 100 | 4.4 (9.8) | 200 | 5.6 (12.5) |
| 3 | 150 | 5.1 (11.5) | 300 | 6.4 (14.3) |
| 4 | 200 | 5.6 (12.5) | 400 | 7.0 (15.7) |
| 5 | 250 | 6.0 (13.4) | 500 | 7.5 (16.8) |
| 6 | 300 | 6.4 (14.3) | 600 | 8.0 (17.9) |
| 7 | 400 | 7.0 (15.7) | 800 | 8.8 (19.7) |
| | 1000 | 9.4 (21.1) | 2000 | 11.9 (26.6) |

(a) Vertical extrapolation of wind speed based on the 1/7 power law.
(b) [b] Mean wind speed is based on Rayleigh speed distribution of equivalent mean wind power density. Wind speed is for standard sea-level conditions. To maintain the same power density, wind speed must increase 3%/1000 m (5%/5000 ft) elevation.

# Basic Wind Conversion Formulas

| **English units** | **Metric units** |
| --- | --- |
| $w = 0.0052 A v^3$ | $w = 0.625 A v^3$ |
| where w is power in watts, and A is the cross-sectional area in square feet swept out by the wind turbine blades, and v is the wind speed in miles per hour. | where w is power in watts, and A is the cross-sectional area in square meters swept out by the wind turbine blades, and v is the wind speed in meters per second. |

# Small Wind Turbine Comparison



# Micro Wind

- Micro Wind plays in areas with low wind velocity.

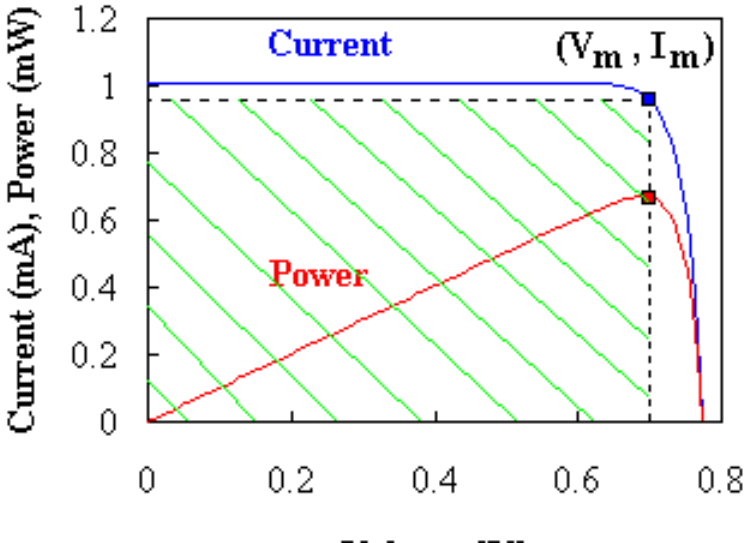
# Power Density of Solar

**The p-n diode solar cell**

Solar cells are typically illuminated with sunlight and are intended to convert the solar energy into electrical energy. The solar energy is in the form of electromagnetic radiation, more specifically "black-body" radiation, due to the fact that the sun has a temperature of 5800 K. The radiation spectrum has a peak at 0.8 eV, while a significant part of the spectrum is in the visible part of the spectrum (400 - 700 nm). The power density is approximately 100 mW/cm$^2$.

Only part of the solar spectrum actually makes it to the earth's surface because of scattering and absorption in the earth's atmosphere, while the angle with respect to a normal to the surface - and therefore also the power density - depends on the time of the day, the time of the year and the latitude of a specific location.

Of the solar light which does reach a solar cell only photons with an energy larger than the energy bandgap of the semiconductor generate electron-hole pairs. In addition one finds that the voltage across the solar cell at the point where it delivers its maximum power is less than the bandgap energy in electron volt. The overall power conversion efficiency of single crystalline solar cells ranges from 10 to 30% yielding 10 to 30 mW/cm$^2$.



# Link and Resources.

- http://www.nooutage.com/windmaps.htm#US%20DOE%20Wind%20Classes
- http://www.wind-works.org/articles/small_turbines.html
- http://www.stanford.edu/group/efmh/winds/global_winds.html
- http://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIES/RYER/index.html
- http://mapserve2.nrel.gov/website/PVWATTSLITE/viewer.htm
- http://www.udel.edu/igert/pvcdrom/index.html
- http://ece-www.colorado.edu/~bart/book/solar.htm
- http://www.ucsusa.org/assets/images/renewable_energy/NREL-wind-map-large.jpg
- http://www.energy.iastate.edu/renewable/wind/wem/wem-08_power.html

http://www.geocities.com/pemnq/windscan.html