Big Kinetic

turbines (wind etc)

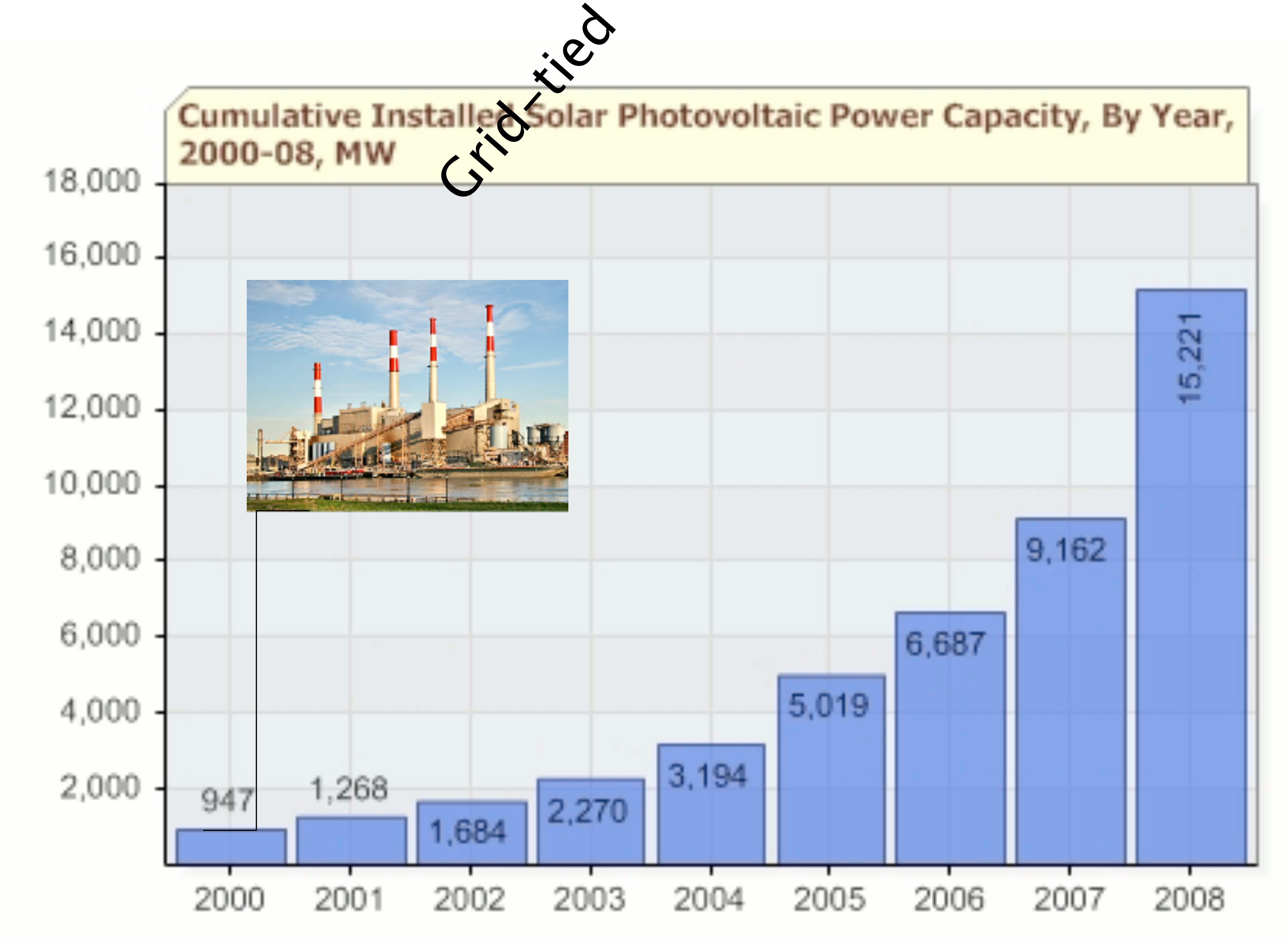
Axis

“Vertical” (Perpendicular to wind) | **“Horizontal”** (Parallel to wind)

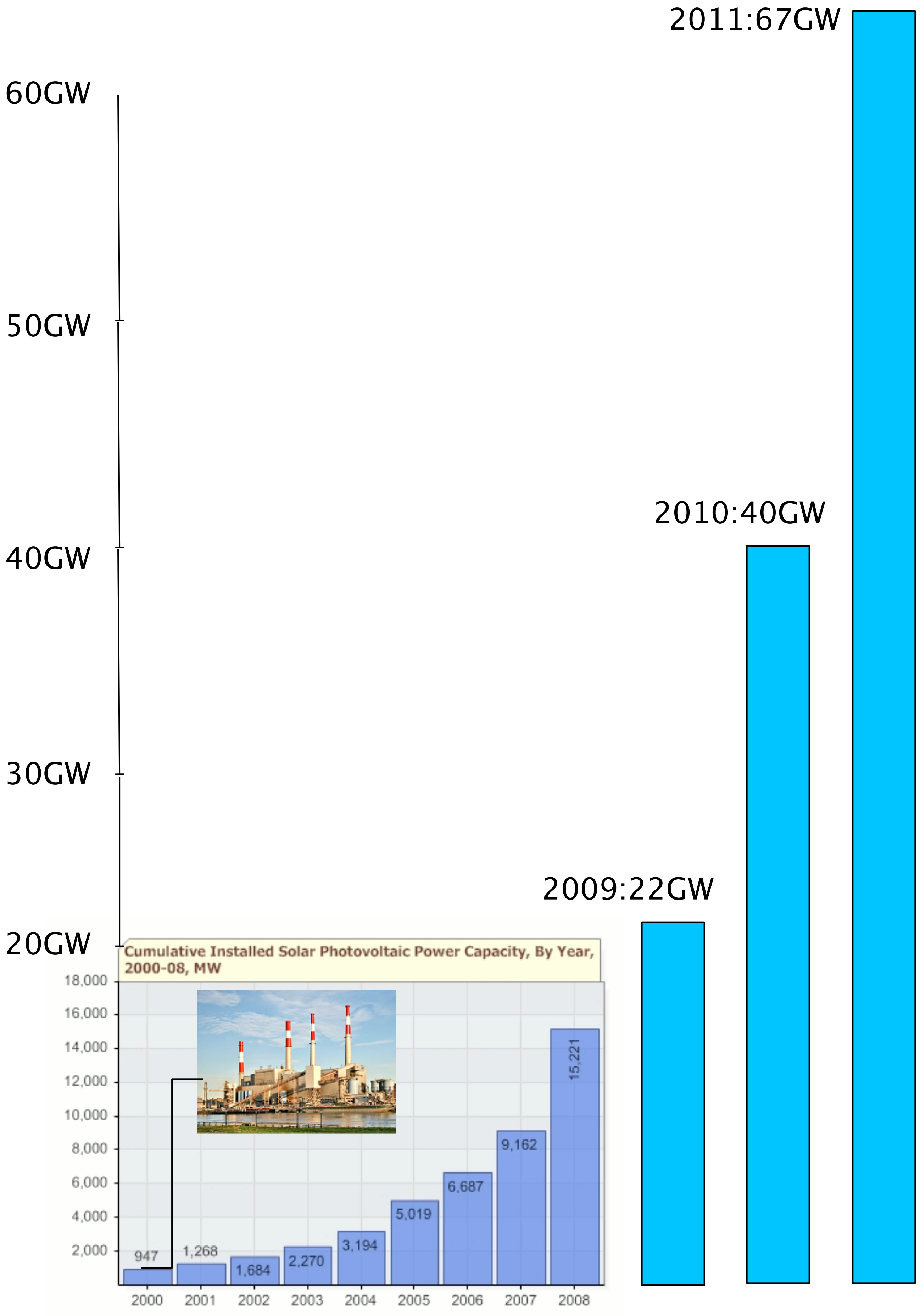
Lift

Drag

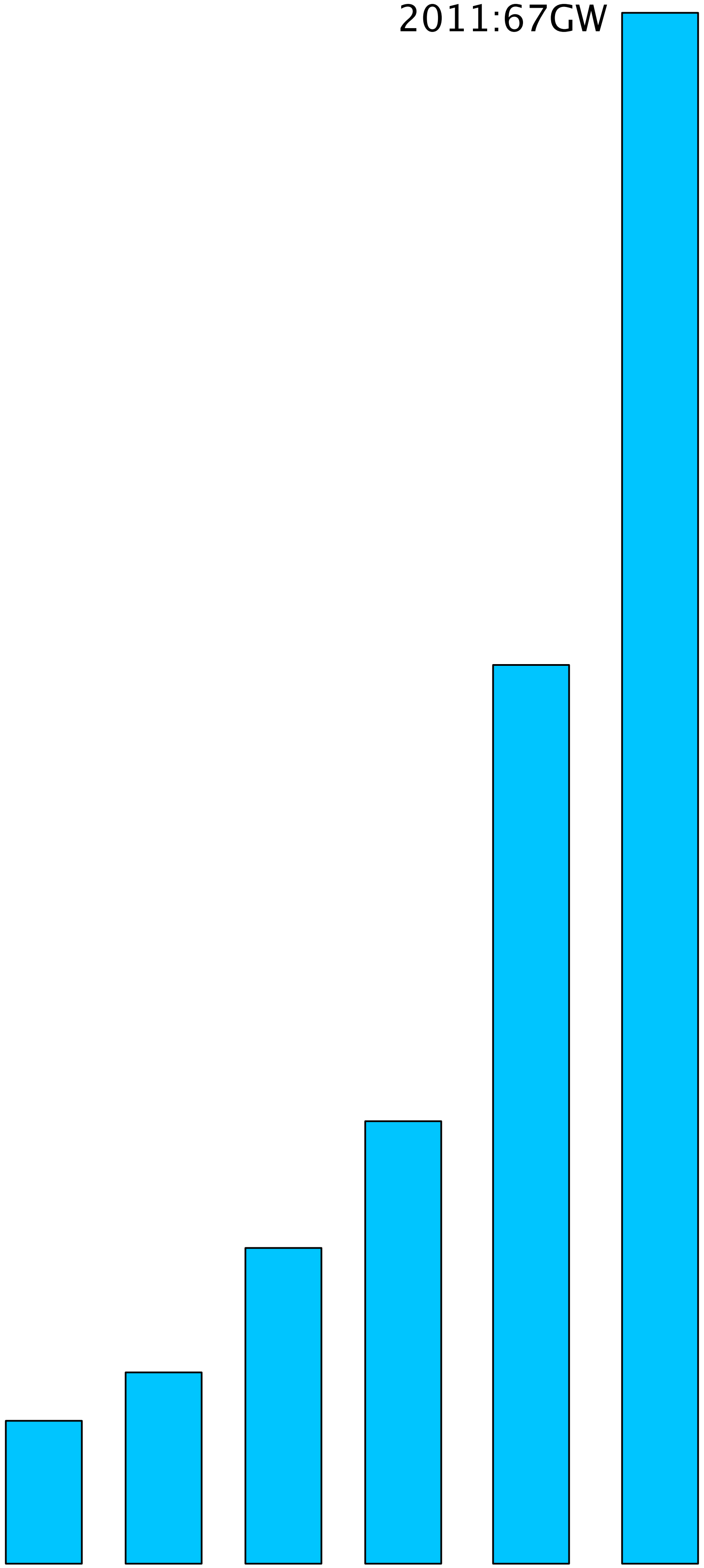
Blade Type

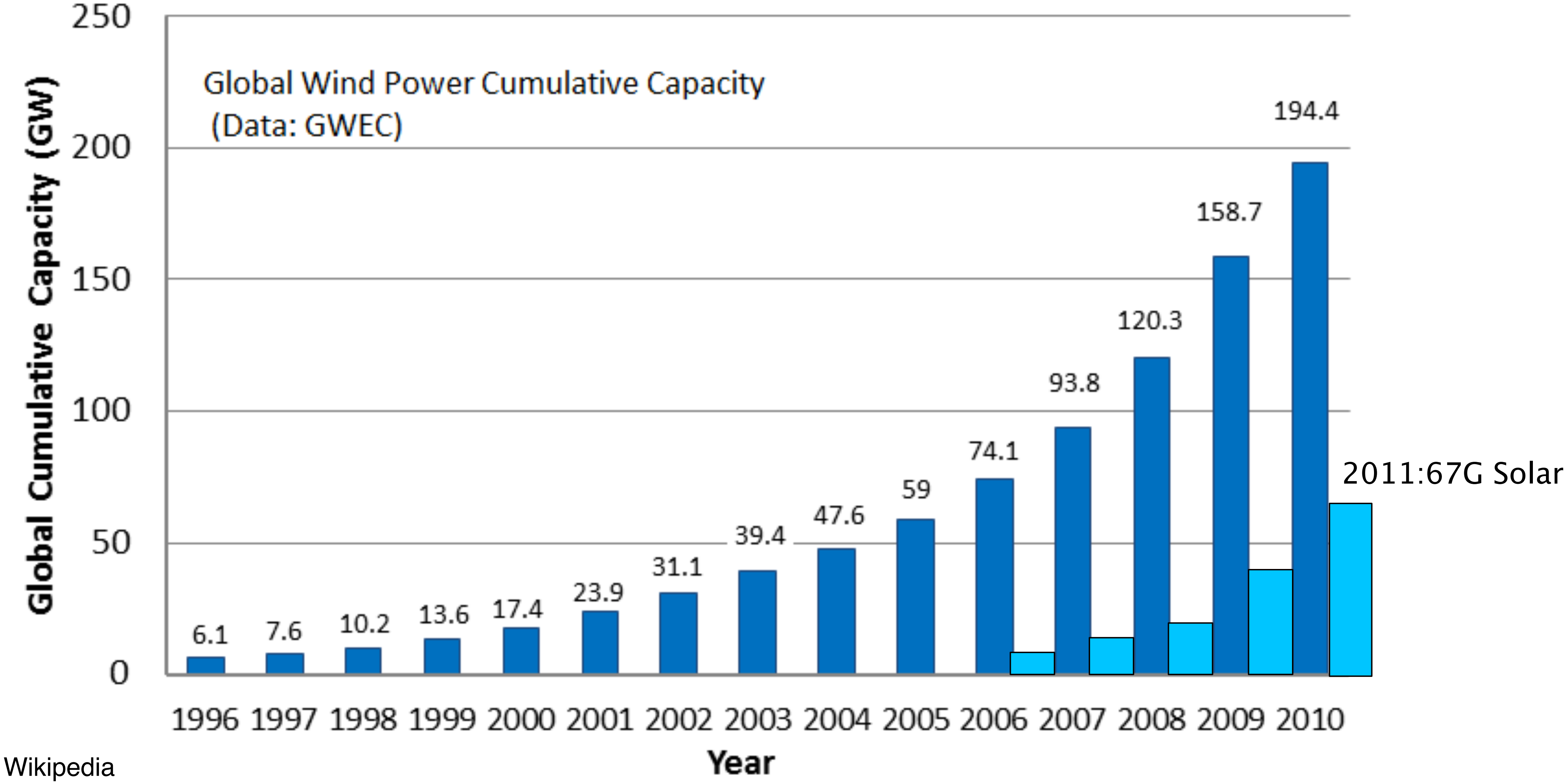


Source: http://www.energyandcapital.com/
Inset: Big Allis, first 1GW generator, in Queens.



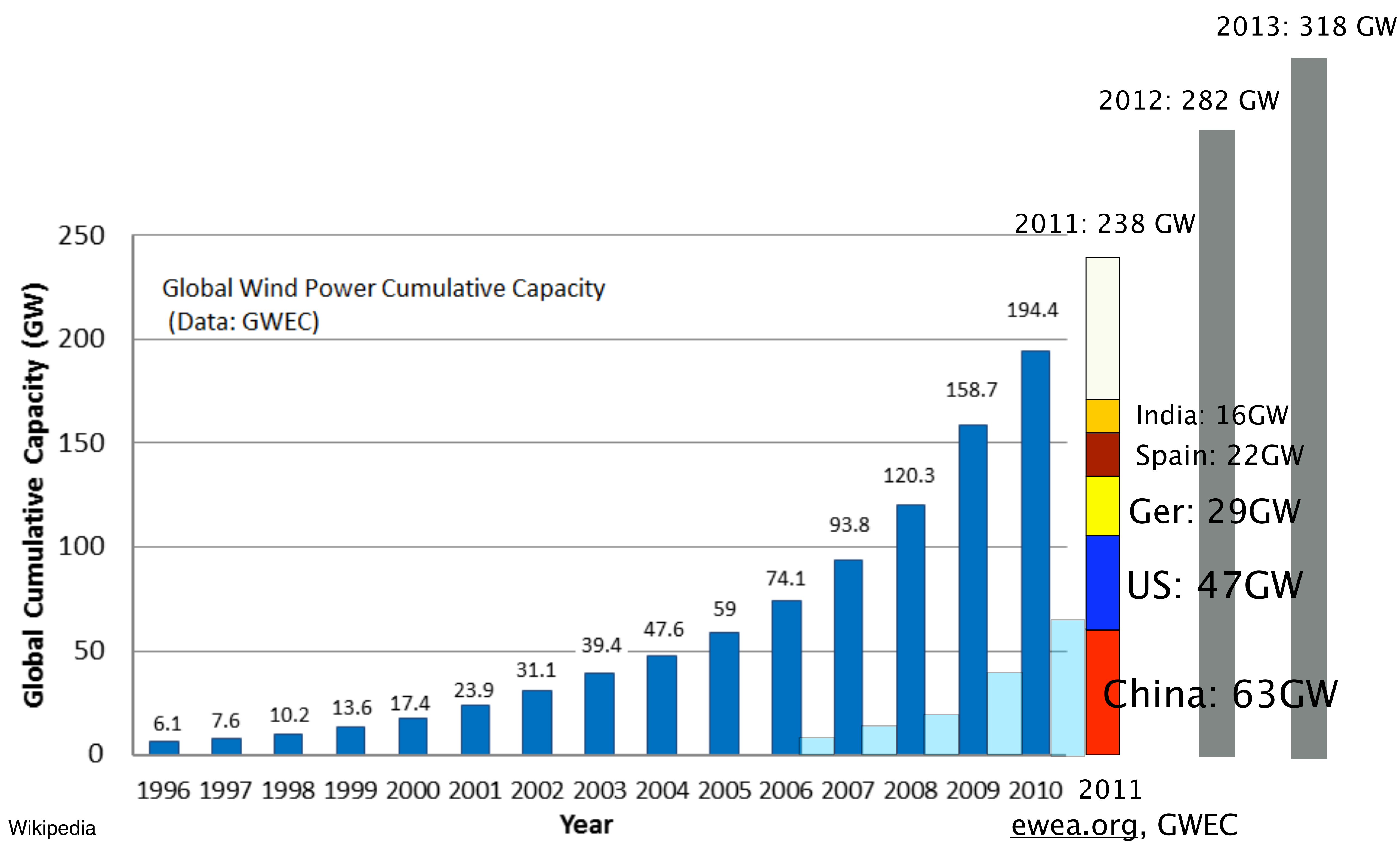
GTMedia, wikipedia


2011:67GW

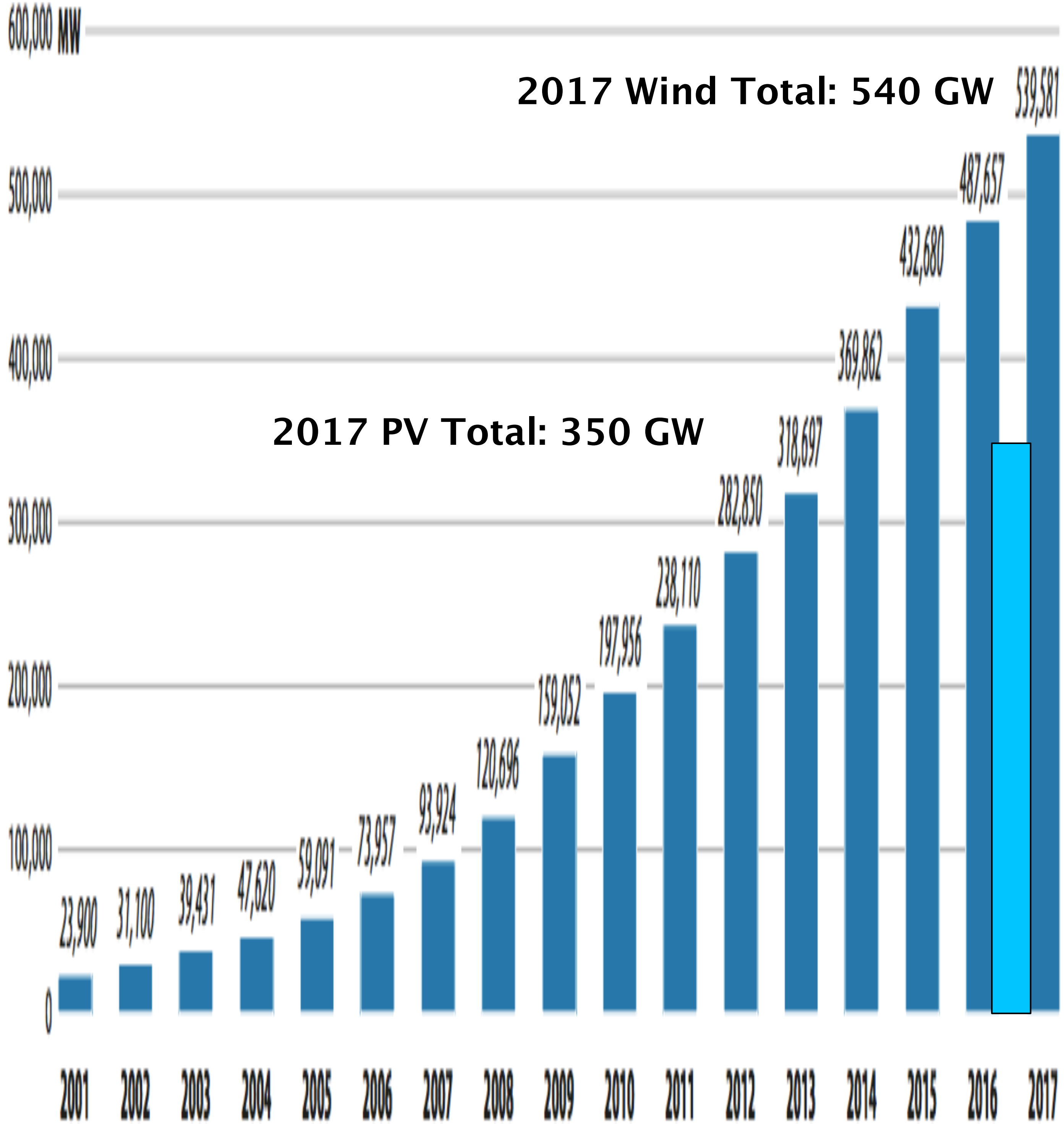


Global Wind Power Cumulative Capacity
(Data: GWEC)
Global Cumulative Capacity (GW)
250
200
150
100
50
0
6.1
7.6
10.2
13.6
17.4
23.9
31.1
39.4
47.6
59
74.1
93.8
120.3
158.7
194.4
2011:67G Solar
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
Year

Wikipedia

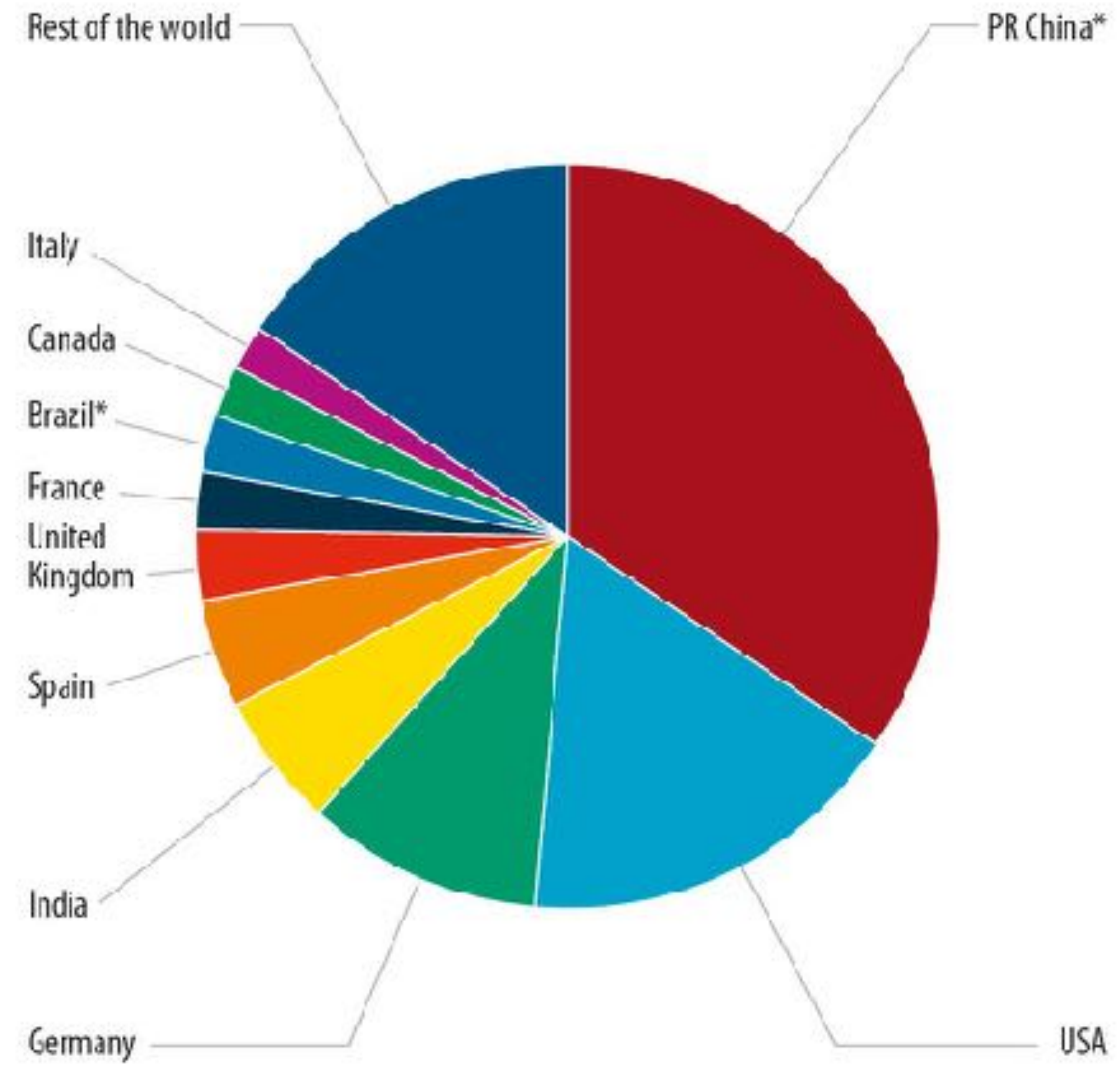

2013: 318 GW
2012: 282 GW
2011: 238 GW
Global Wind Power Cumulative Capacity
(Data: GWEC)
Global Cumulative Capacity (GW)
250
200
150
100
50
0
6.1
7.6
10.2
13.6
17.4
23.9
31.1
39.4
47.6
59
74.1
93.8
120.3
158.7
194.4
India: 16GW
Spain: 22GW
Ger: 29GW
US: 47GW
China: 63GW
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
Year
Wikipedia
ewea.org, GWEC

GLOBAL CUMULATIVE INSTALLED WIND CAPACITY 2001-2017



Source: GWEC

TOP 10 CUMULATIVE CAPACITY DEC 2017



Country	MW	% Share
PR China*	188,232	35
USA	89,077	17
Germany	56,132	10
India	32,848	6
Spain	23,170	4
United Kingdom	18,872	3
France	13,759	3
Brazil*	12,763	2
Canada	12,239	2
Italy	9,479	2
Rest of the world	83,008	15
Total TOP 10	**456,572**	**85**
World Total	**539,581**	**100**

Source: GWEC


2.3 MW
~ 2MW typical turbine size


2.3 MW
x 11,500*
*200 watt output


2.3 MW
x 22*
*140 hp output


2.3 MW
x 435
*1000 MW

http://www.juwisolar.com/

2.2 MW solar installation for
Mars Corp, Hackettstown, NJ

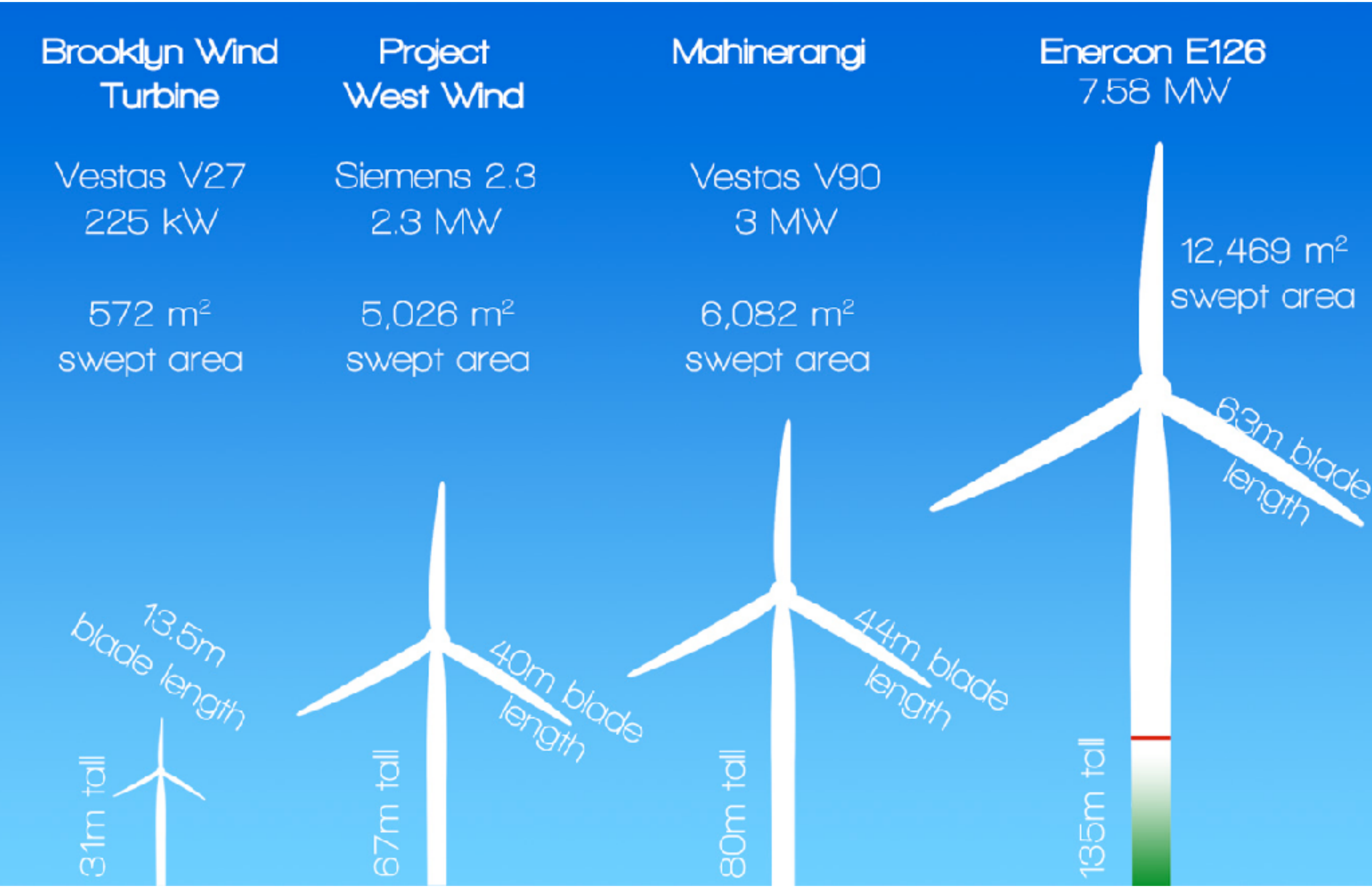
Google Earth

Three factors in wind turbine design:

Swept area, and thus power, increases with ***square*** of radius (**πr^2**)

Kinetic energy increases with ***square*** of velocity (**$1/2\ mv^2$**)

Capacity factor - effective portion of "*nameplate capacity*" delivered in real world conditions



Brooklyn Wind Turbine
Vestas V27
225 kW
572 m²
swept area
13.5m blade length
31m tall
Project West Wind
Siemens 2.3
2.3 MW
5,026 m²
swept area
40m blade length
67m tall
Mahinerangi
Vestas V90
3 MW
6,082 m²
swept area
44m blade length
80m tall
Enercon E126
7.58 MW
12,469 m²
swept area
63m blade length
135m tall

“Ninety individual blades, each of them 128 feet long and weighing 77,000 pounds, were offloaded from the Chinese freighter ‘Gong Yin 1’ at the port and are now being loaded onto railcars. The blades were manufactured by Vestas Wind Systems, a Danish company, and are bound for a terminal in Manly, Iowa, that handles wind turbine components. The blades are composed of carbon and glass fiber.”

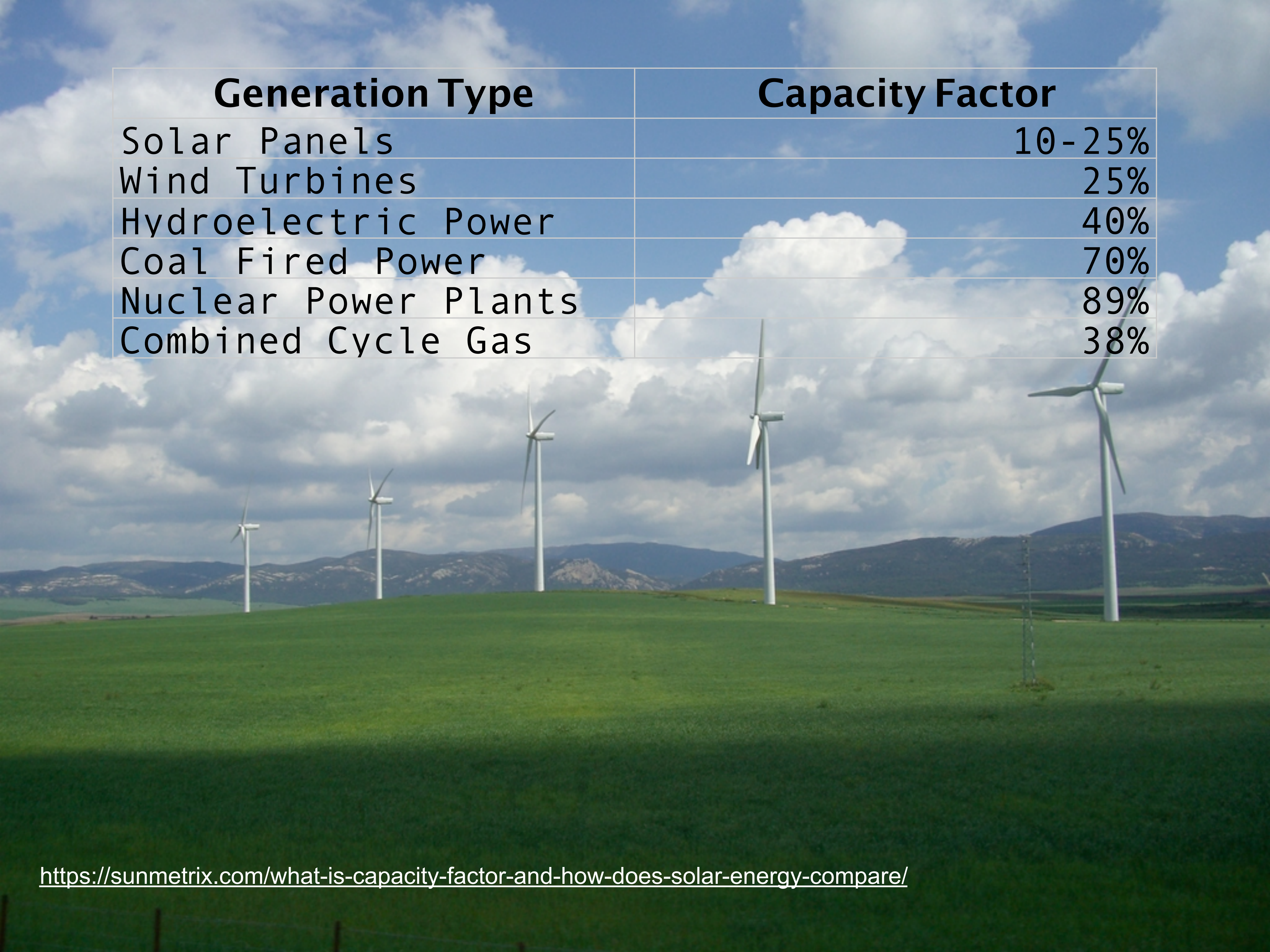
http://omnitrax.com/

An 83.5-m-long blade made by Denmark’s SSP Technology in transit to Scotland in 2013. It was called the longest blade in the world at the time.

http://www.globalconstructionreview.com

With the largest wind turbine blade more than 200 ft long, moving wind blades from the factory floor to the project site can require up to eight hauls using multiple transportation modes. The Aeroscraft can pick up wind blades from the factory floor and deliver them directly to locations without infrastructure.

http://aeroscraft.com



Generation Type	Capacity Factor
Solar Panels	10-25%
Wind Turbines	25%
Hydroelectric Power	40%
Coal Fired Power	70%
Nuclear Power Plants	89%
Combined Cycle Gas	38%

https://sunmetrix.com/what-is-capacity-factor-and-how-does-solar-energy-compare/


Capacity factor: 20 - 40%
2.3 MW × 365 days × 30% = 6 GWh
Wikipedia

Offshore wind


Makani M30 30kW
prototype airborne turbine

Airborne Wind Turbines

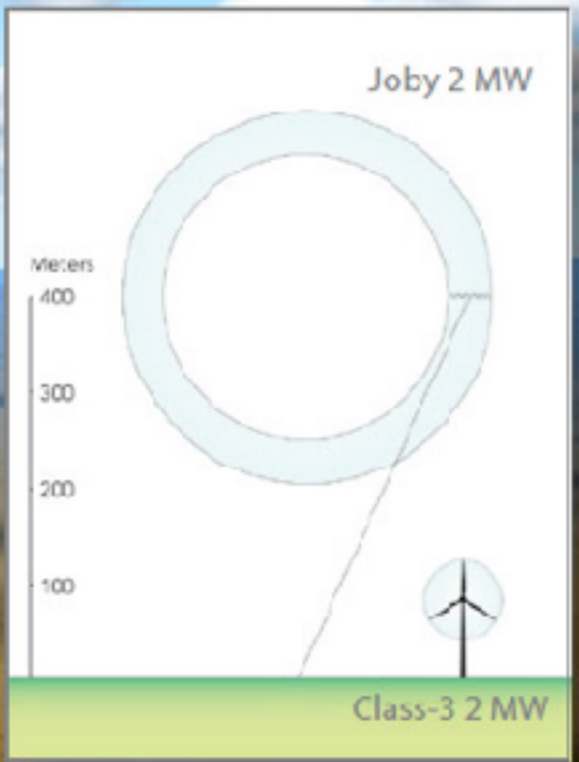
Joby RIP 2012

Joby Energy is developing airborne wind turbines which will operate in the upper boundary layer and the upper troposphere.

While knowledge of the tremendous energy in high-altitude wind is not new, recent advances in power electronics, sensors, and control systems now make our technology practical.

Our multi-wing structure supports an array of turbines. The turbines connect to motor-generators which produce thrust during takeoff and generate power during crosswind flight. Orientation in flight is maintained by an advanced computer system that drives aerodynamic surfaces on the wings and differentially controls rotor speeds. A reinforced composite tether transmits electricity and moors the system to the ground. The high redundancy of the array configuration can handle multiple points of failure and remain airborne.

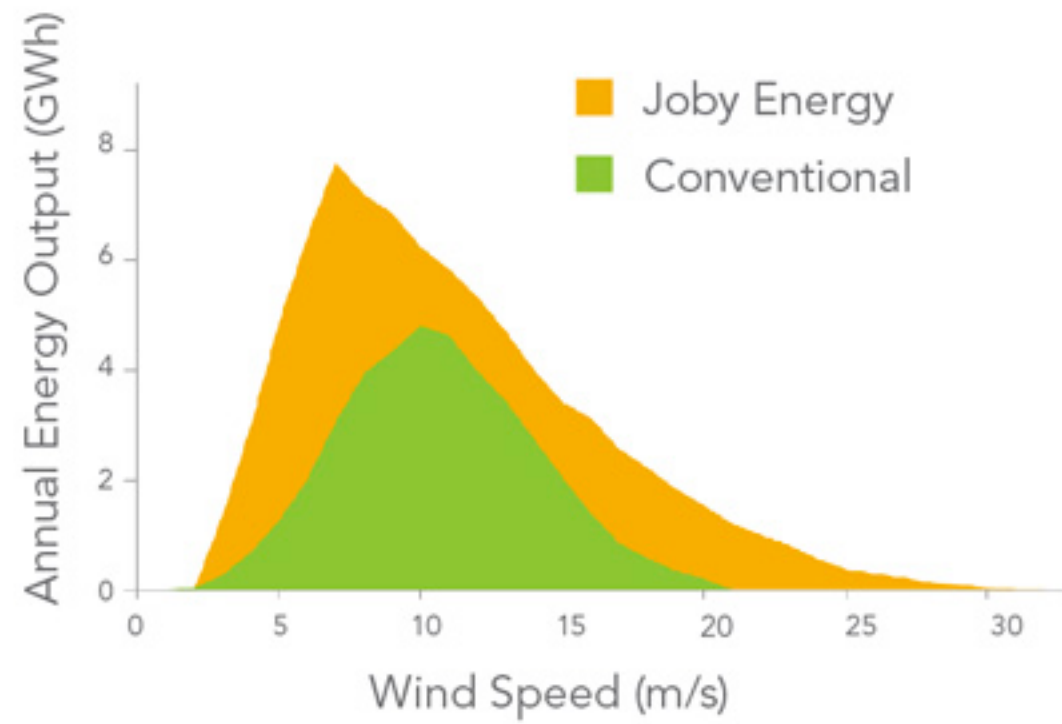
Joby turbine

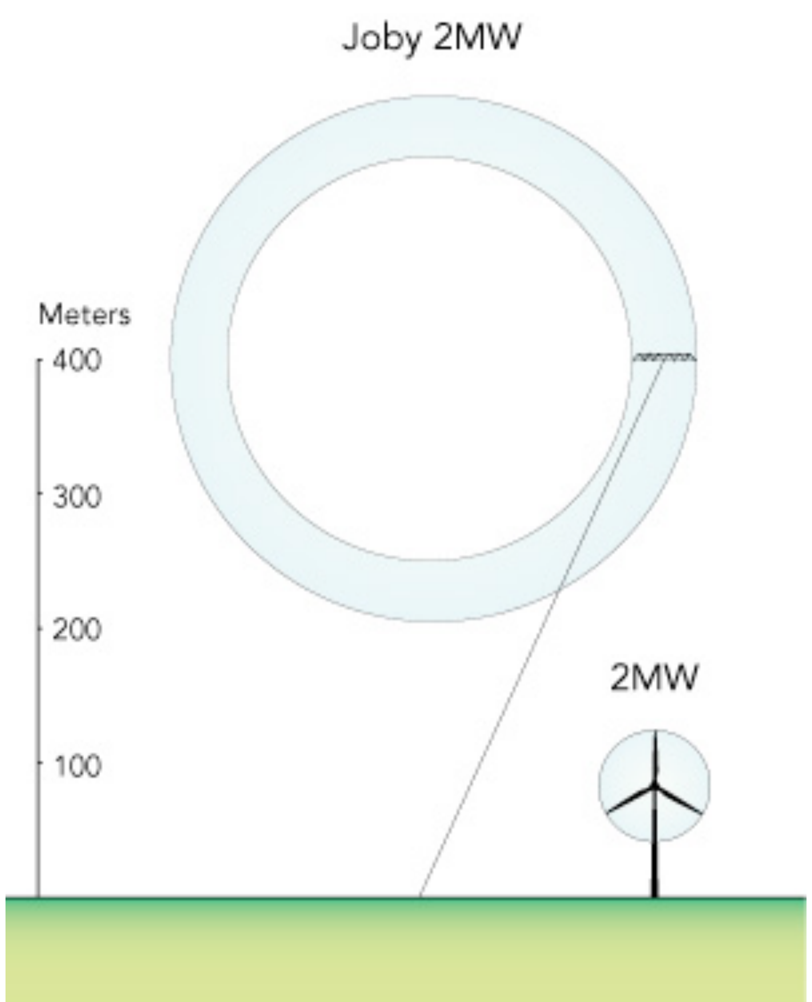


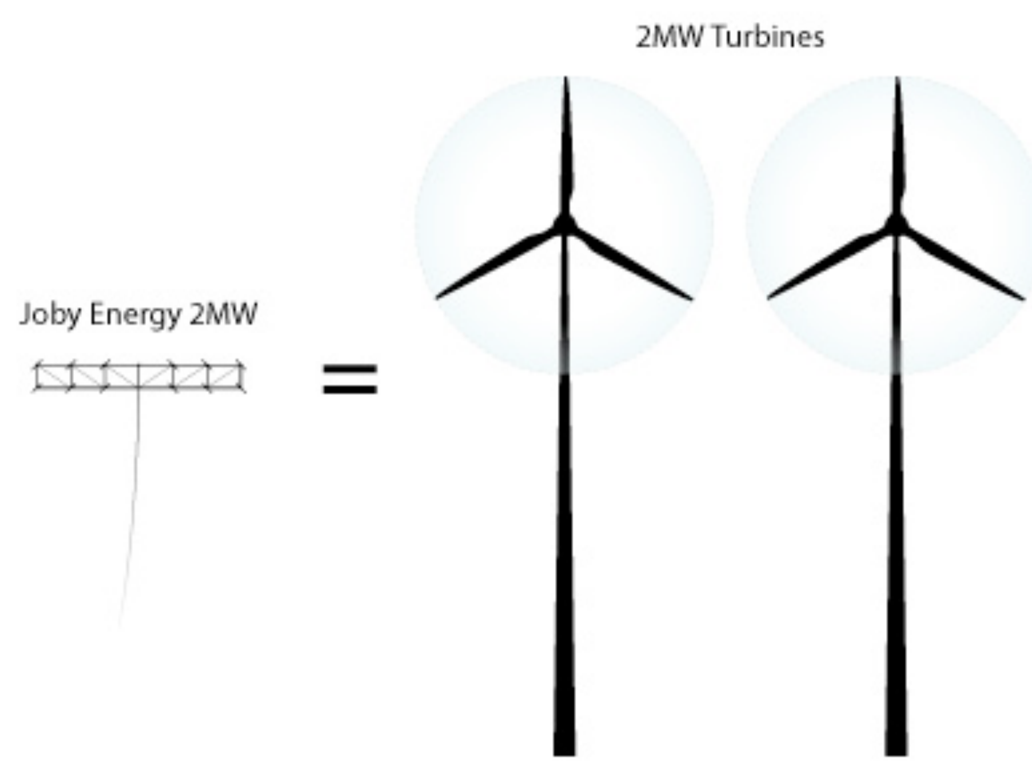
How It Operates

For launch, the turbines are supplied with power to enable vertical take-off. Upon reaching operating altitude, the system uses the power of the wind to fly cross-wind in a circular path. The high cross-wind speeds result in the turbines spinning the generators at high speeds, eliminating the need for gearboxes and increasing efficiency. The energy is transferred to the ground through the electrical tether. During occasional periods of low wind the turbines are powered to land the system safely.

Joby turbine data (predicted)








PETZL
www.petzl.com

- Phase 1 (2002 – 2006): Prototype Testing
- Phase 2 (2006 – 2009): Demonstration
- Phase 3 (Current): MW-Scale Build-Out

Verdant Power East River turbines

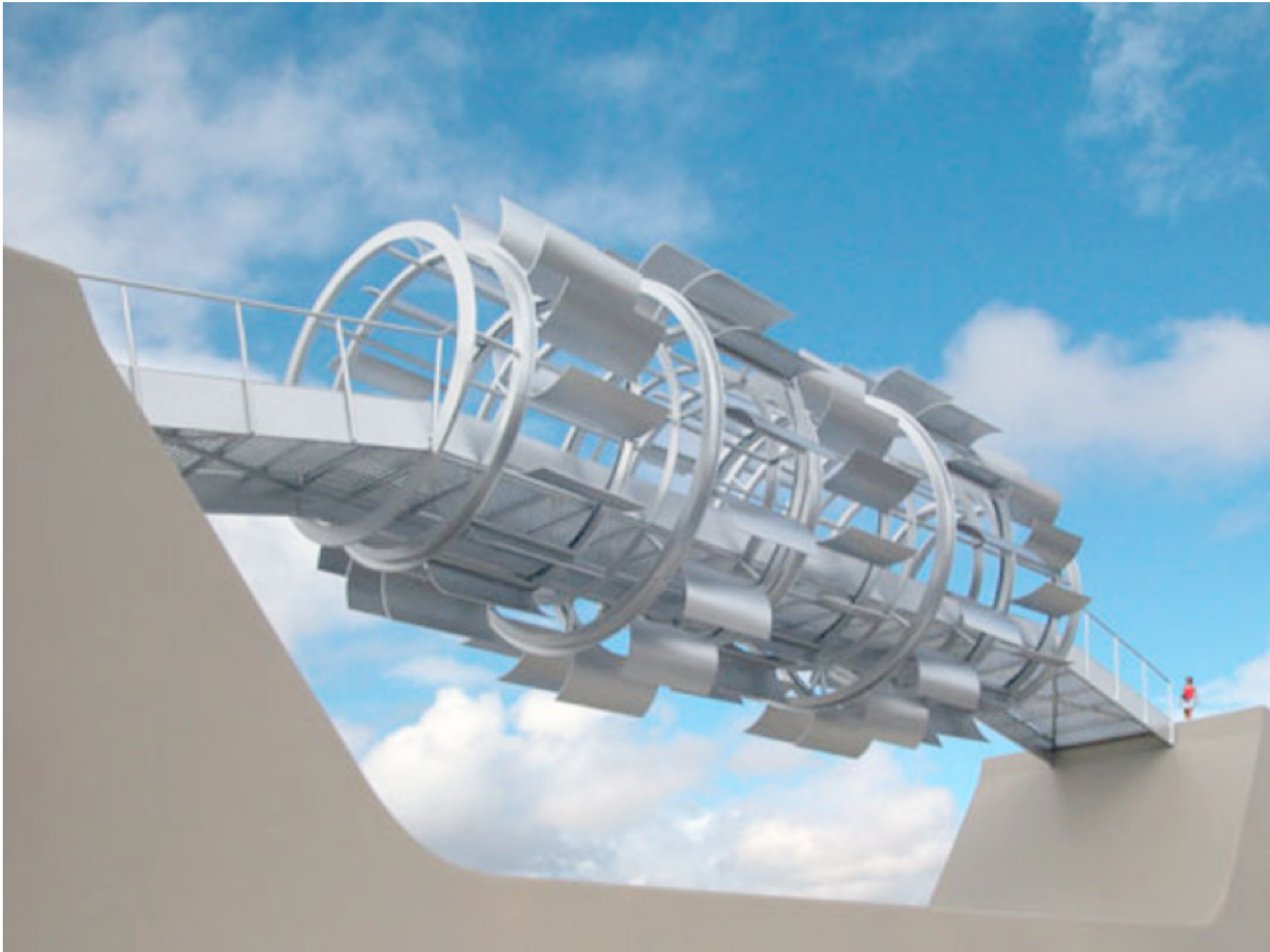
- Phase 1 (2002 – 2006): Prototype Testing
- Phase 2 (2006 – 2009): Demonstration
- ~~Phase 3 (Current): MW-Scale Build-Out~~
- Phase 4
- Currently testing "Gen5" turbines…

Verdant Power East River turbines


x 30 = 1 MW
Verdant Power East River
turbines

Source of wind?

Source of wind?



“Wind Powered Footbridge” www.michaeljantzen.com

Swept area?