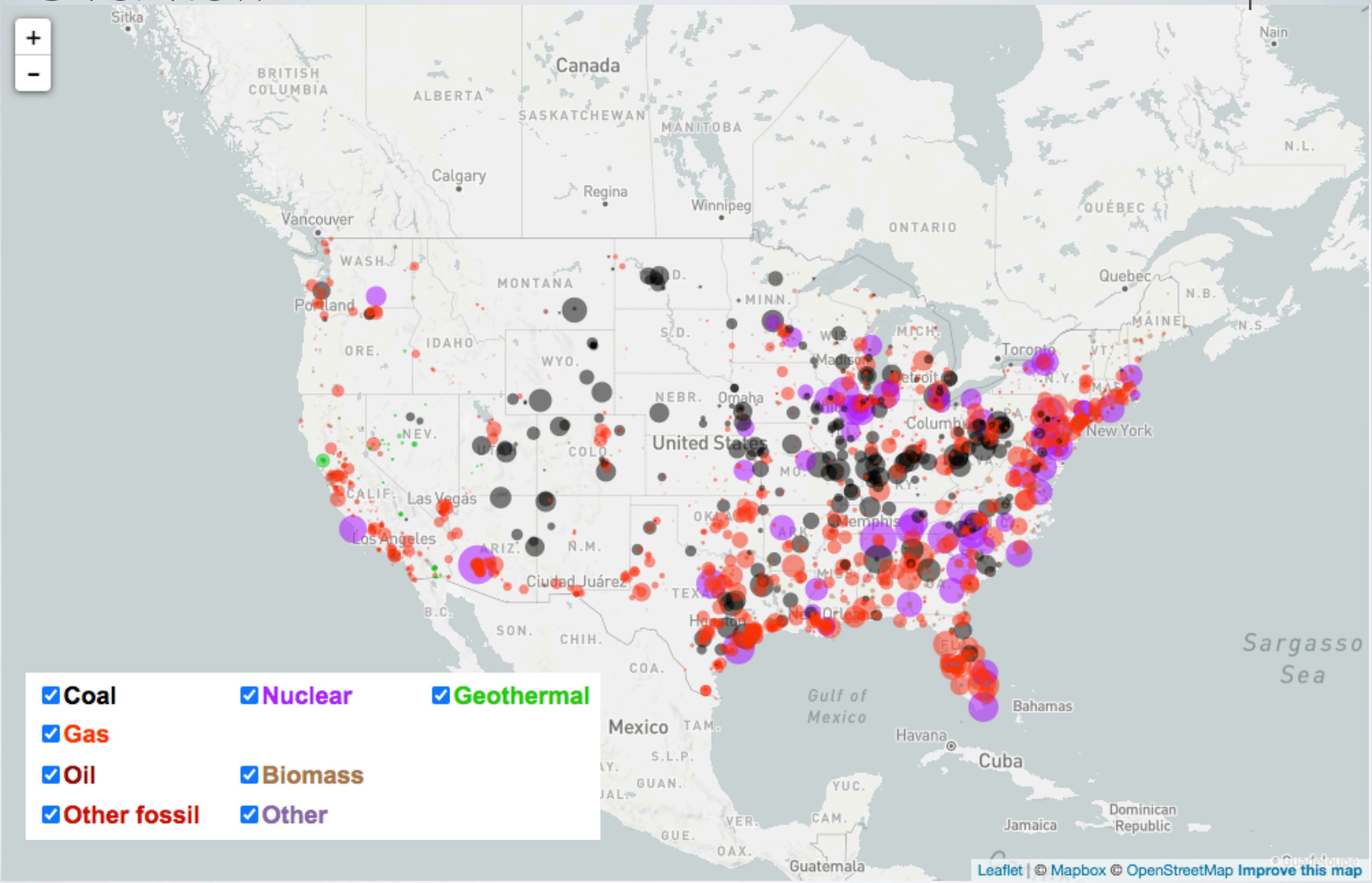
Big Kinetic

ITP Feddersen/Energy

Overview

Thermal-kinetic-electrical plants

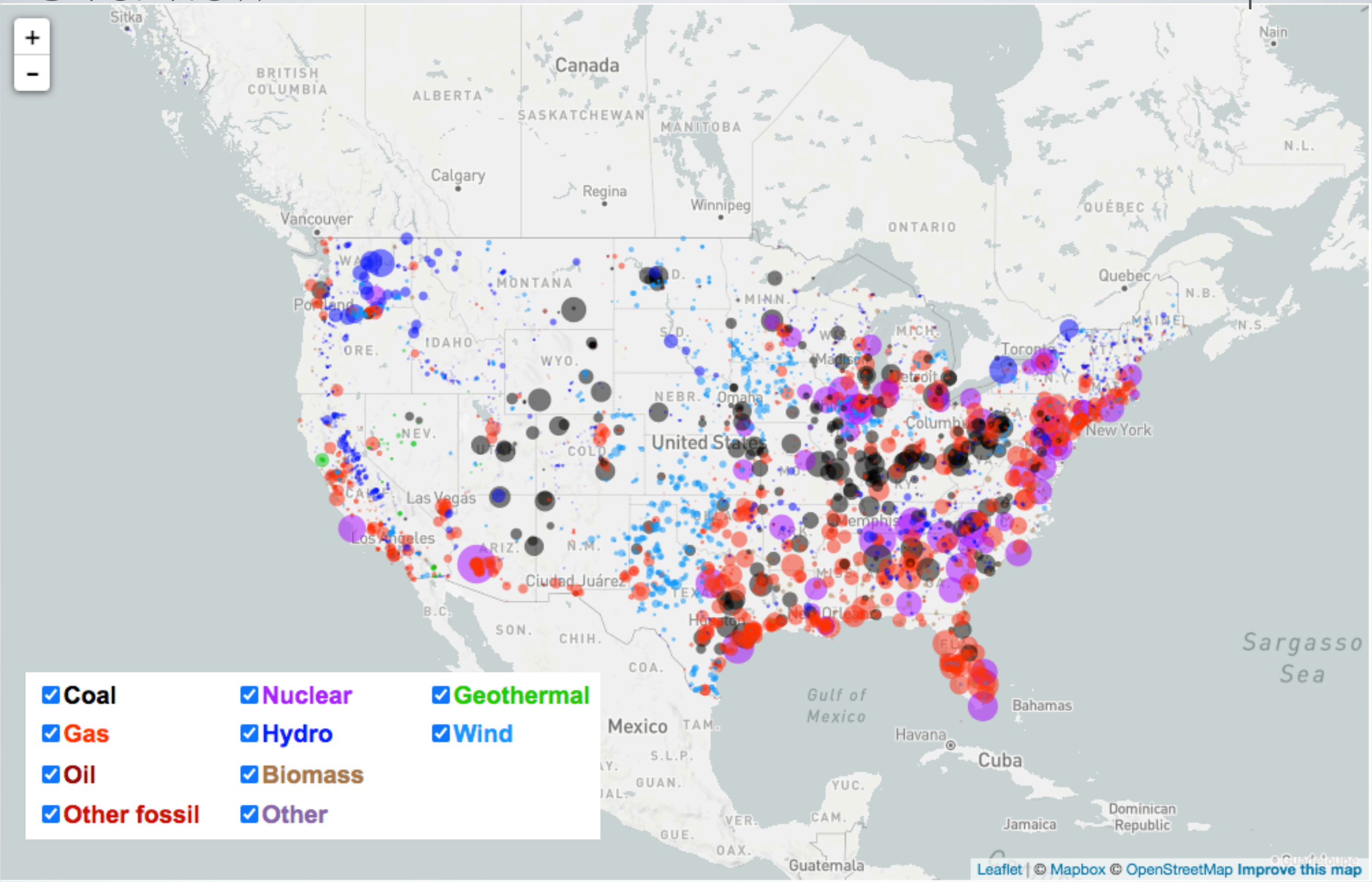


2019

Really awesome map of US electrical generation: https://physics.weber.edu/schroeder/energy/PowerPlantsMap.html

Overview

All kinetic-electrical plants



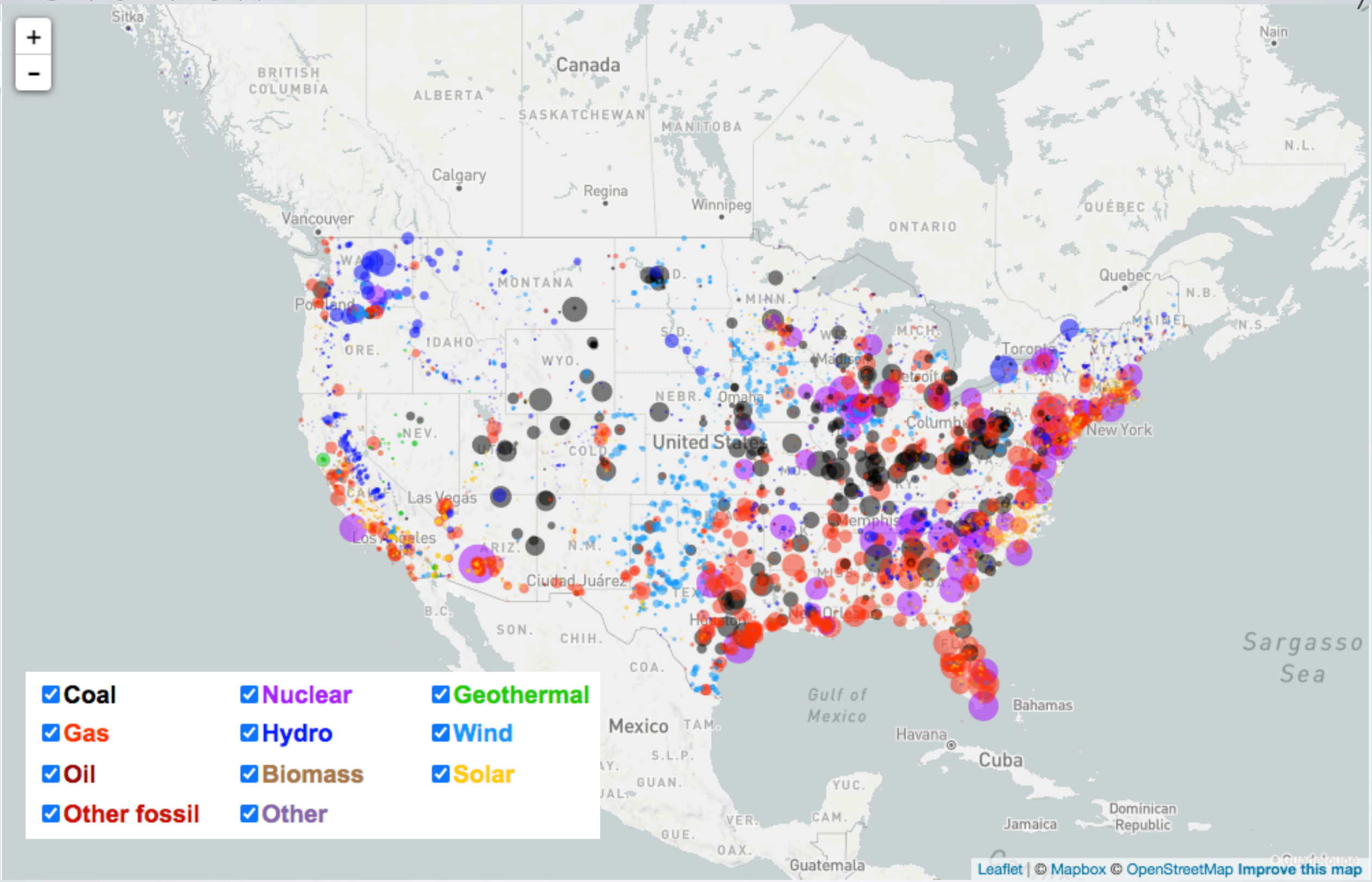
- [x] Coal
- [x] Nuclear
- [x] Geothermal
- [x] Gas
- [x] Hydro
- [x] Wind
- [x] Oil
- [x] Biomass
- [x] Other fossil
- [x] Other

2019

Really awesome map of US electrical generation: https://physics.weber.edu/schroeder/energy/PowerPlantsMap.html

Overview

All electricity



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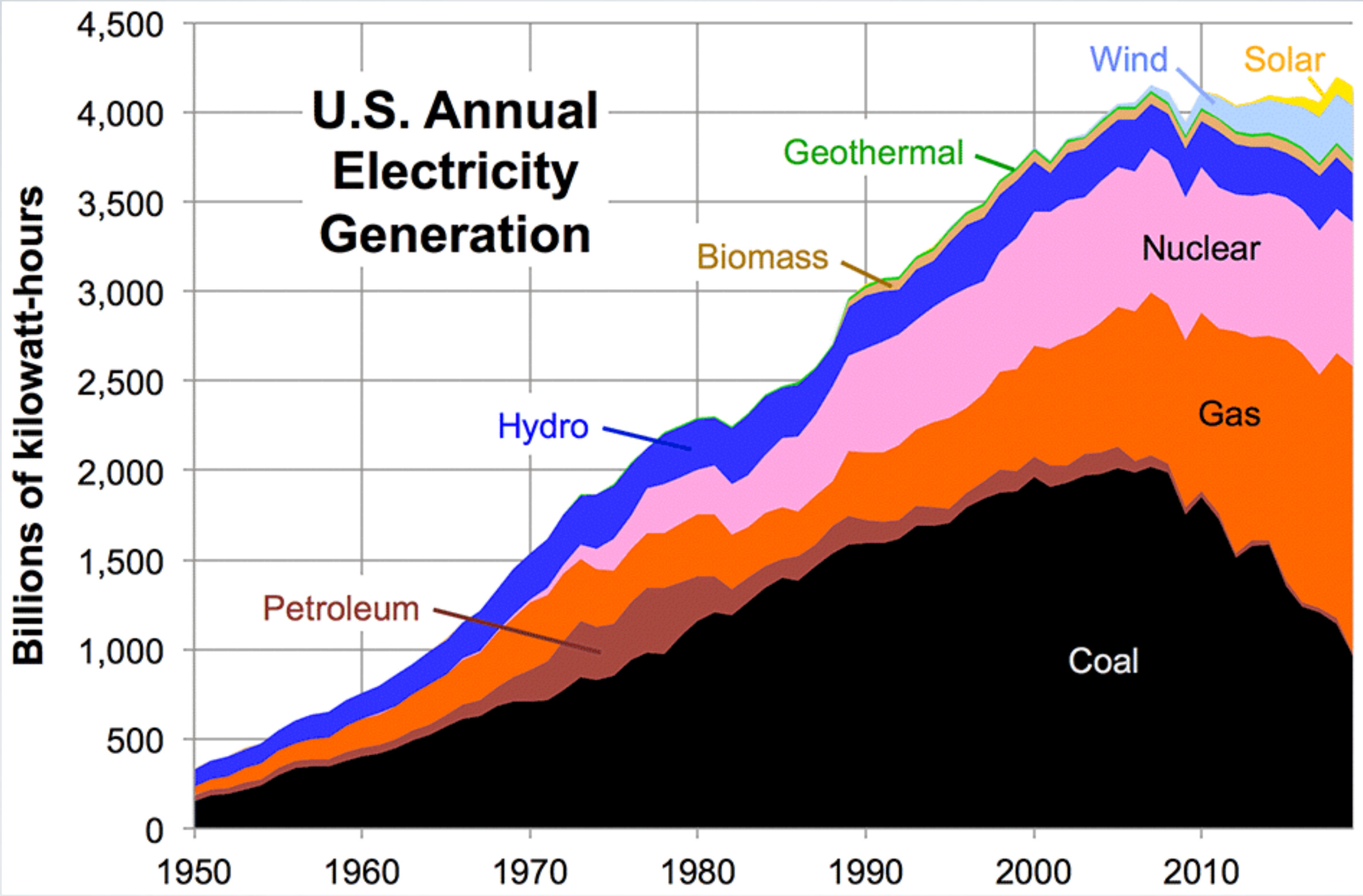
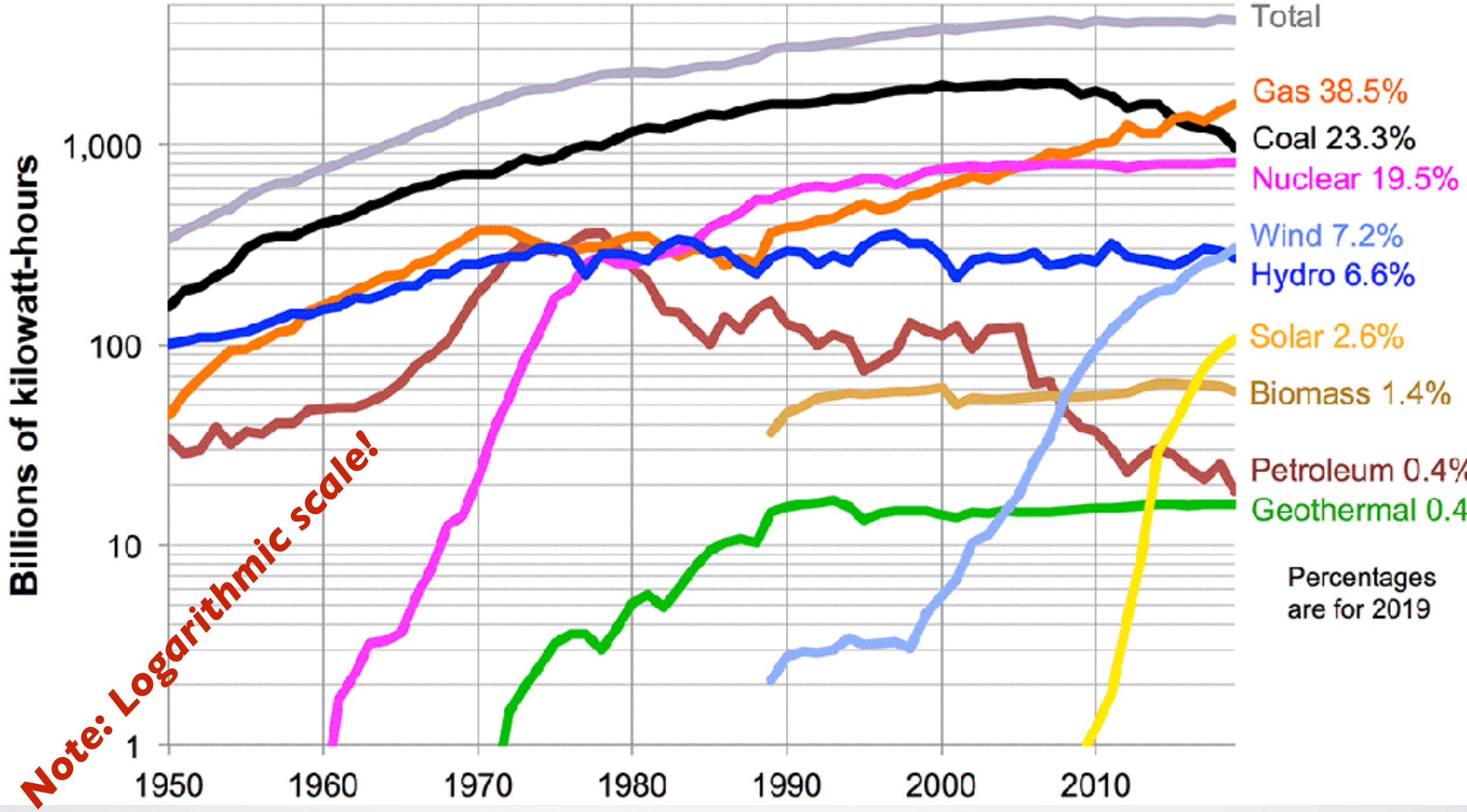


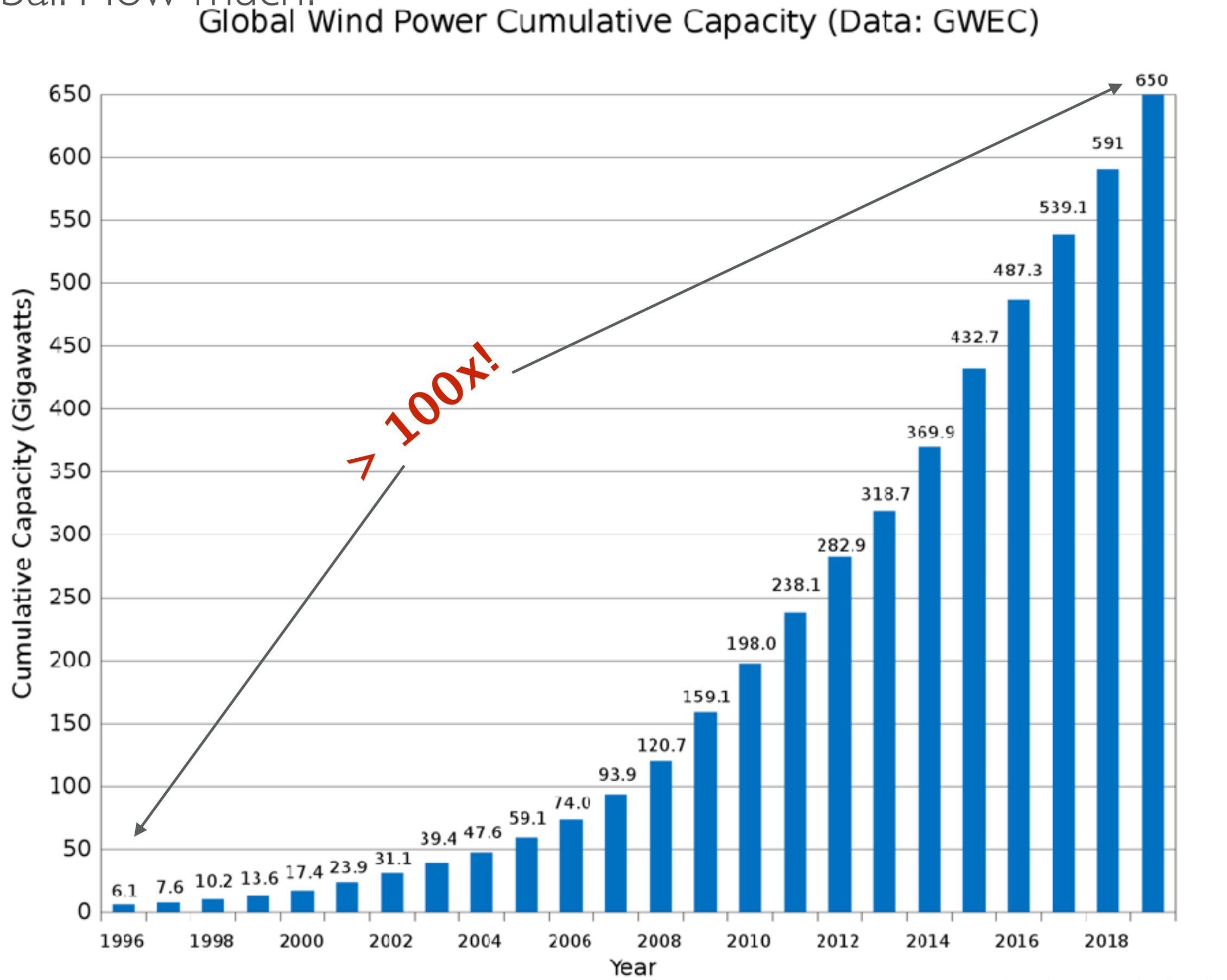
https://physics.weber.edu/schroeder/energy/PowerPlantsMap.html

U.S. Annual Electricity Generation



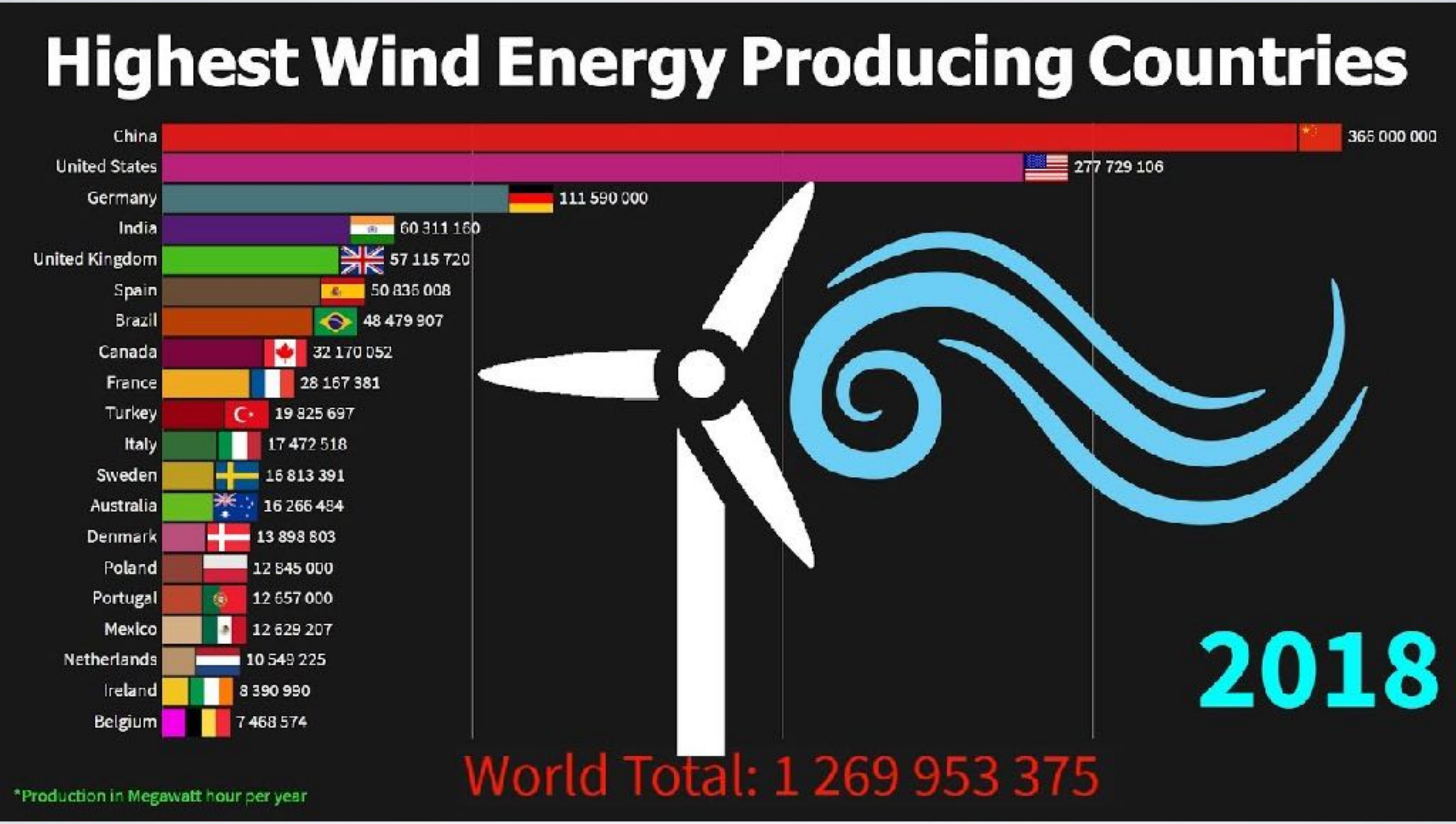
https://physics.weber.edu/schroeder/energy/PowerPlantsMap.html

Global: How much?



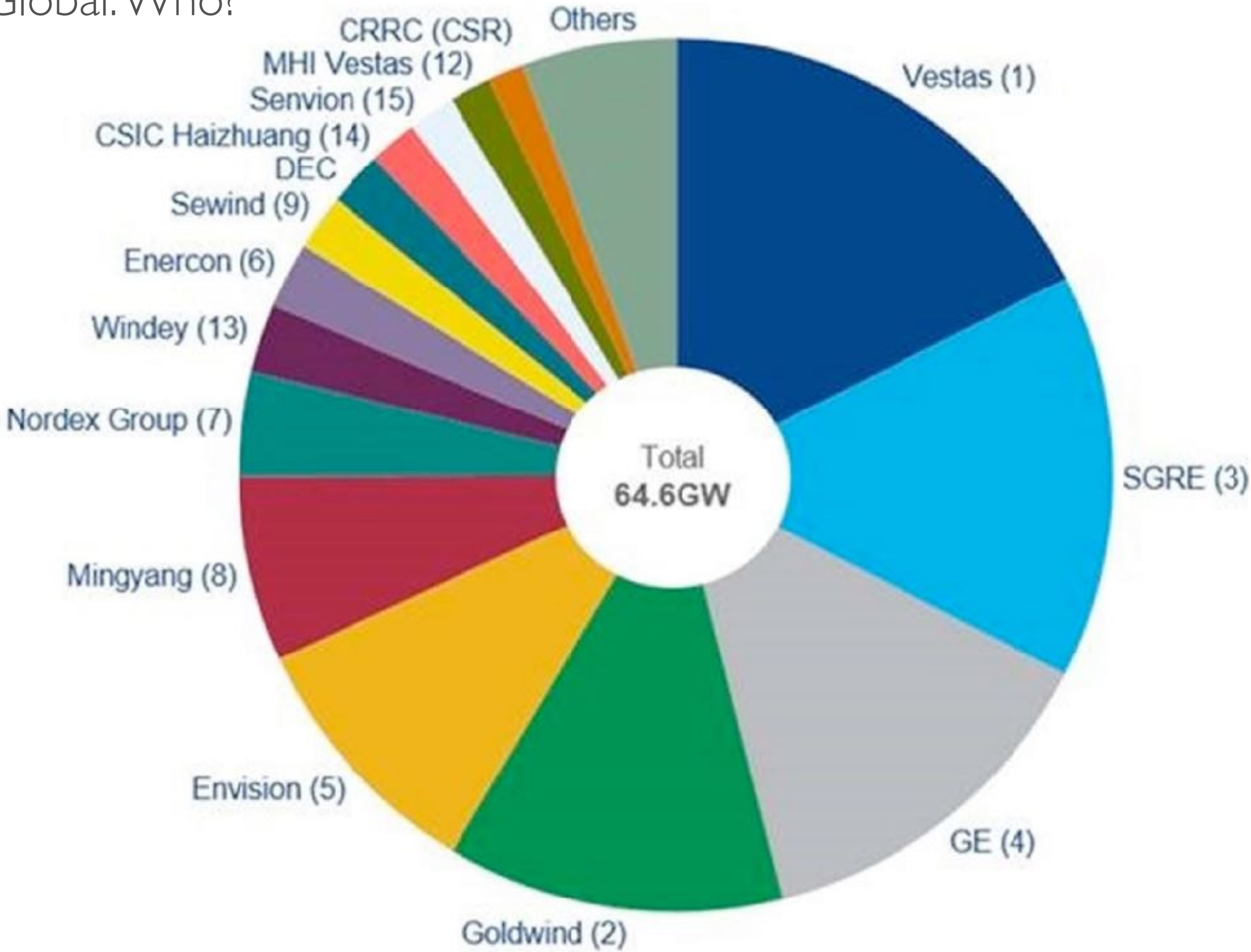
Source: https://gwec.net/ via wikipedia

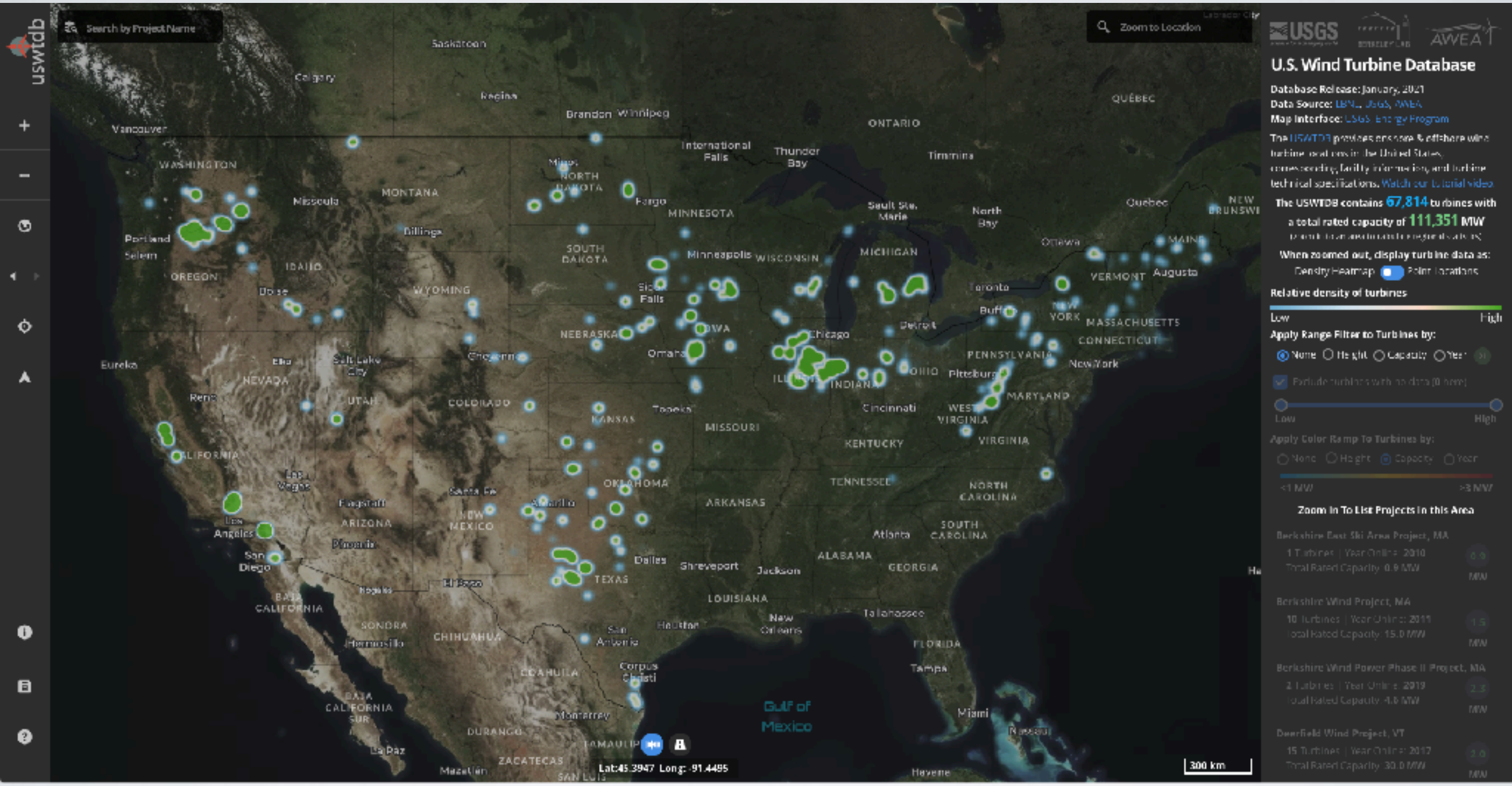
Global: Where?



Source: BP Statistical Review of World Energy (https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-e
via Animated Stats https://www.youtube.com/watch?v=Kso4Bj366vM

Global: Who?


Others
CRRC (CSR)
MHI Vestas (12)
Senvion (15)
CSIC Haizhuang (14)
DEC
Sewind (9)
Enercon (6)
Windey (13)
Nordex Group (7)
Mingyang (8)
Envision (5)
Goldwind (2)
GE (4)
SGRE (3)
Vestas (1)
Total
64.6GW



Another very cool map for wind in the US: https://eerscmap.usgs.gov/uswtdb/

Axis

"Vertical" (Perpendicular to wind)

"Horizontal" (Parallel to wind)

Blade Type

Lift

Drag


2.3 MW
~ 2MW typical turbine size

2.3 MW

x 11,500*

*200 watt output

2.3 MW

x 22*

*140 hp output

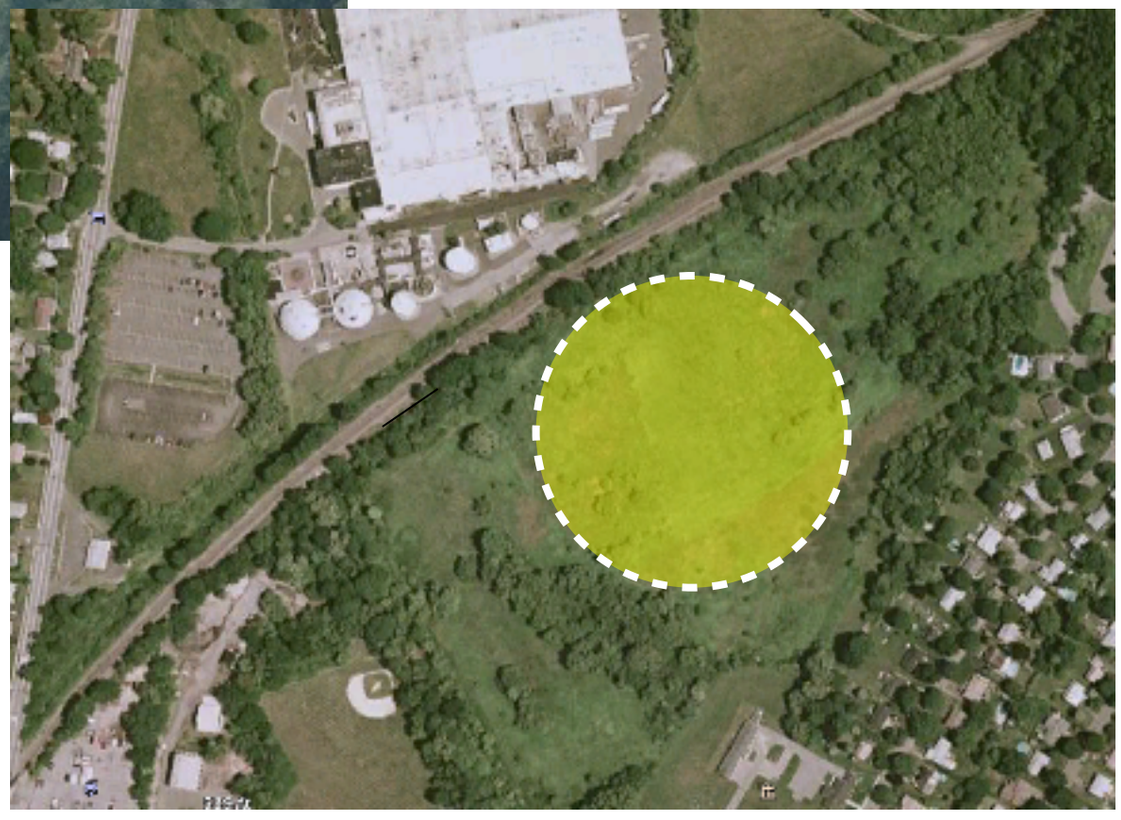
2.3 MW

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:

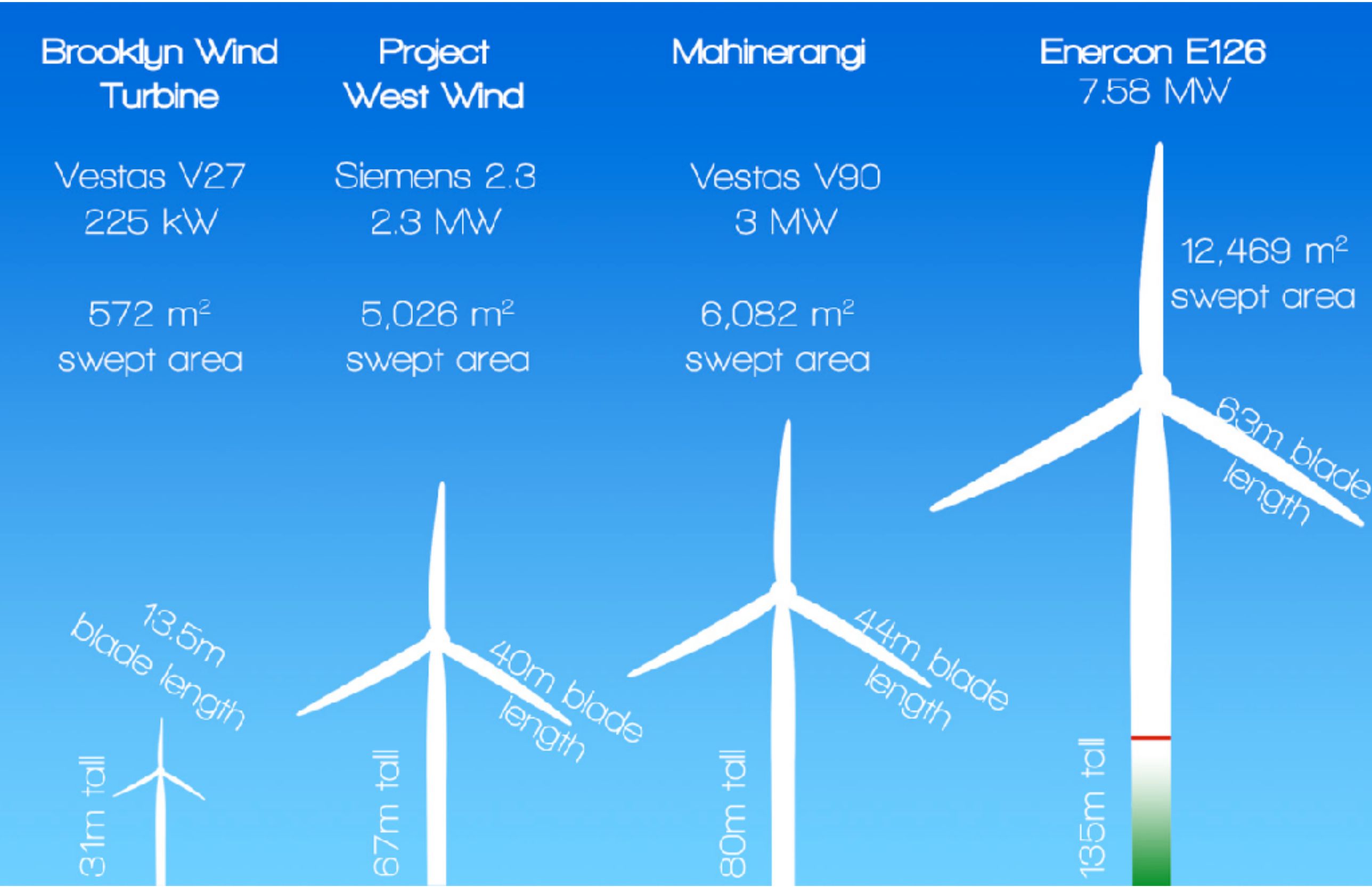
Swept area, and thus power, increases with ***square*** of radius (πr^2) **Bigger is better**

Kinetic energy increases with ***square*** of velocity ($\frac{1}{2} mv^2$) **Faster is better**

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

Consistent is better

Bigger is better



“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.

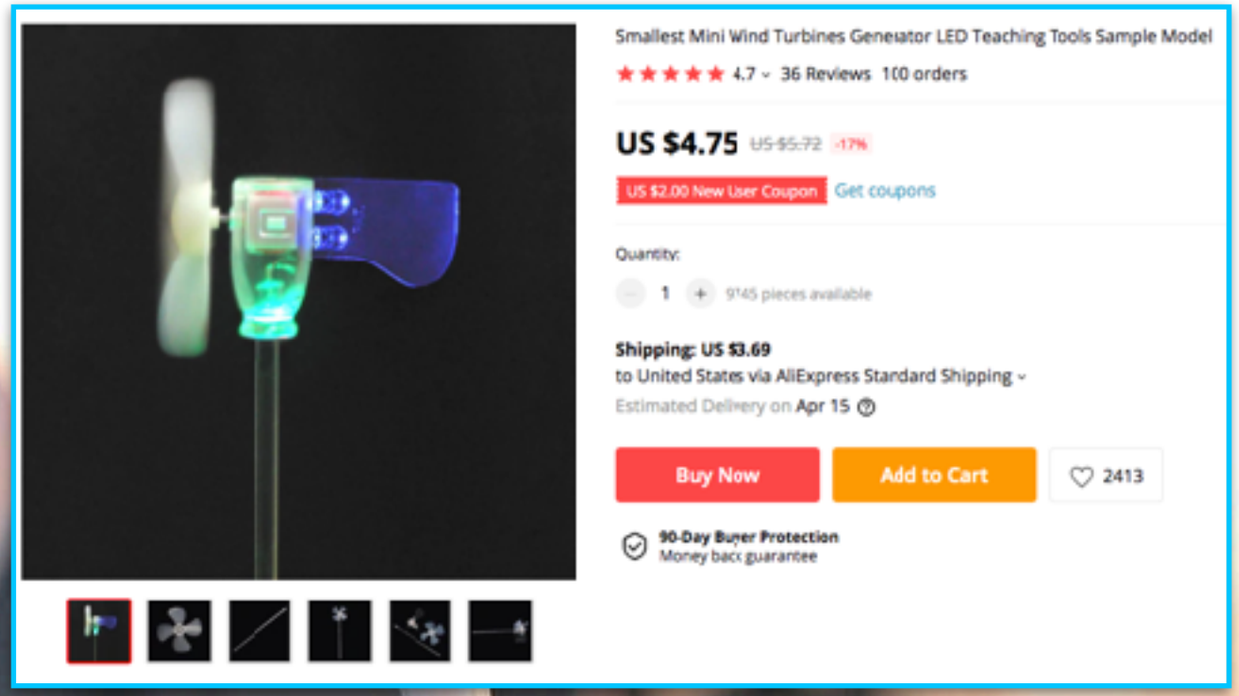
http://aeroscraft.com

Patrick Marold "Windmill Project" 2001-ongoing

https://www.patrickmarold.com/

Jason Bruges “Wind to Light” 2007

https://www.jasonbruges.com/art#/wind-to-light/



Jason Bruges "Wind to Light" 2007

https://www.jasonbruges.com/art#/wind-to-light/

Faster/Consistent is better

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/

Faster/Consistent is better

Capacity factor: 20 - 40%

2.3 MW × 365 days × 30% = 6 GWh

Wikipedia

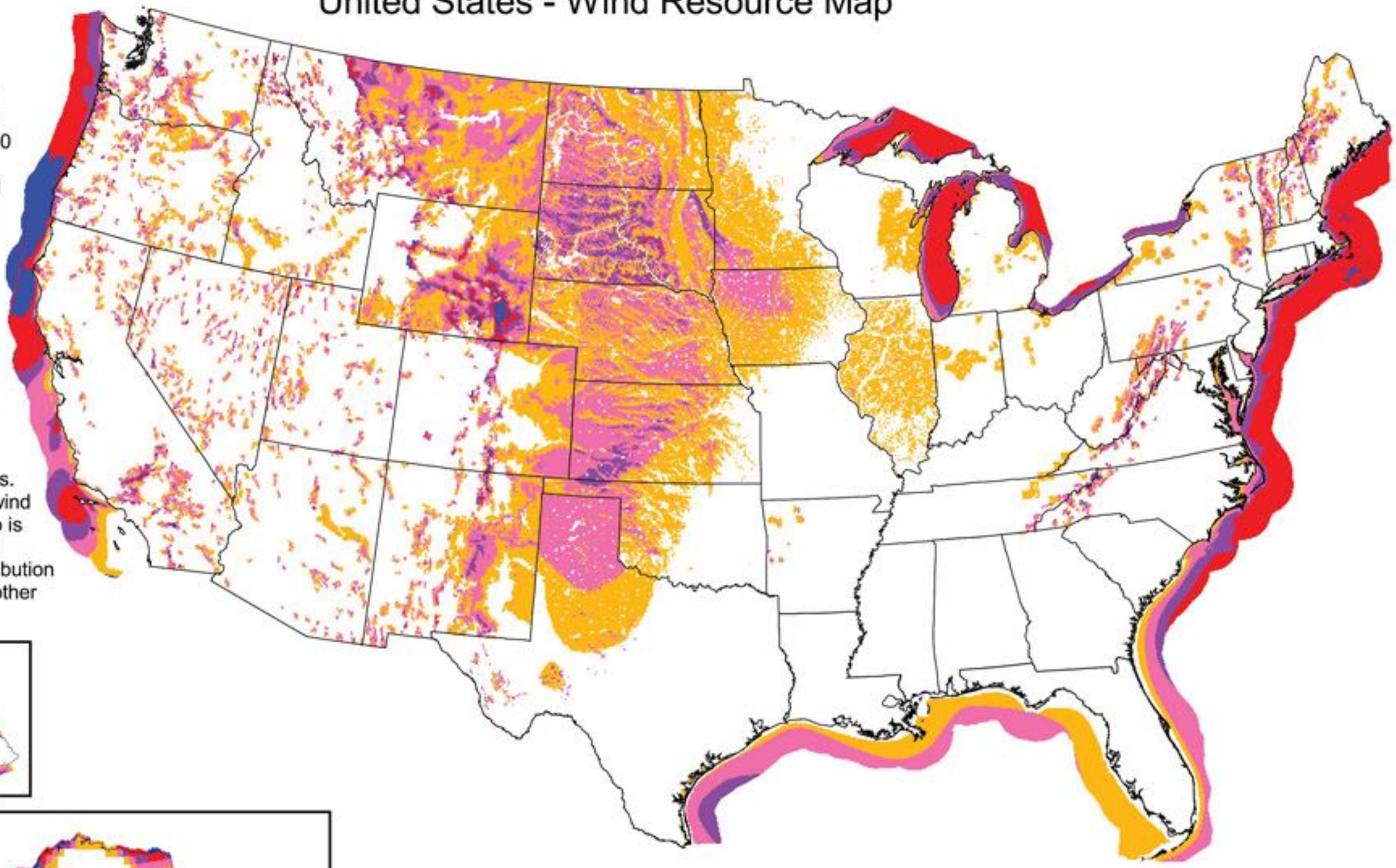
Offshore wind

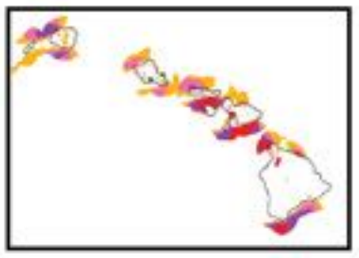
Vestas V164/V174
9.5MW record in 2017

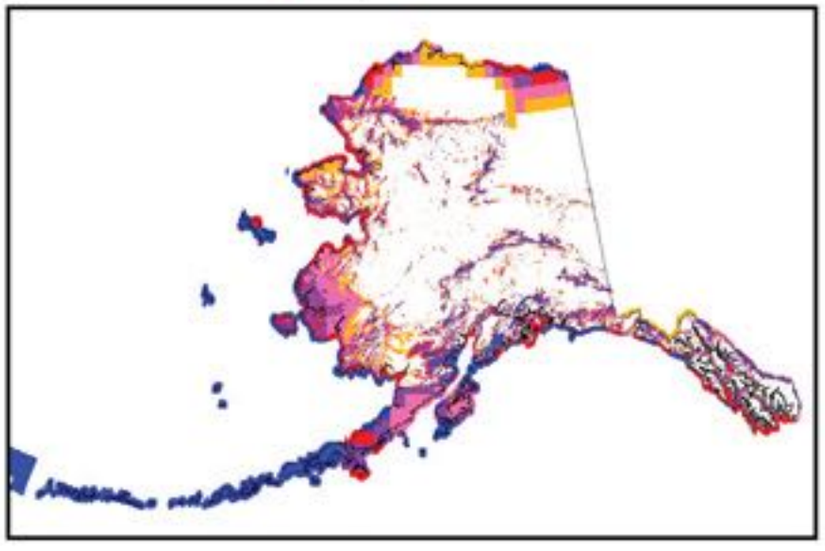
Vestas V236
15MW, 236m diameter, 2022

United States - Wind Resource Map

This map shows the annual average wind power estimates at 50 meters above the surface of the United States. It is a combination of high resolution and low resolution datasets produced by NREL and other organizations. The data was screened to eliminate areas unlikely to be developed onshore due to land use or environmental issues. In many states, the wind resource on this map is visually enhanced to better show the distribution on ridge crests and other features.







Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m^2	Wind Speed [a] at 50 m m/s	Wind Speed [a] at 50 m mph
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	800 - 1600	8.8 - 11.1	19.7 - 24.8

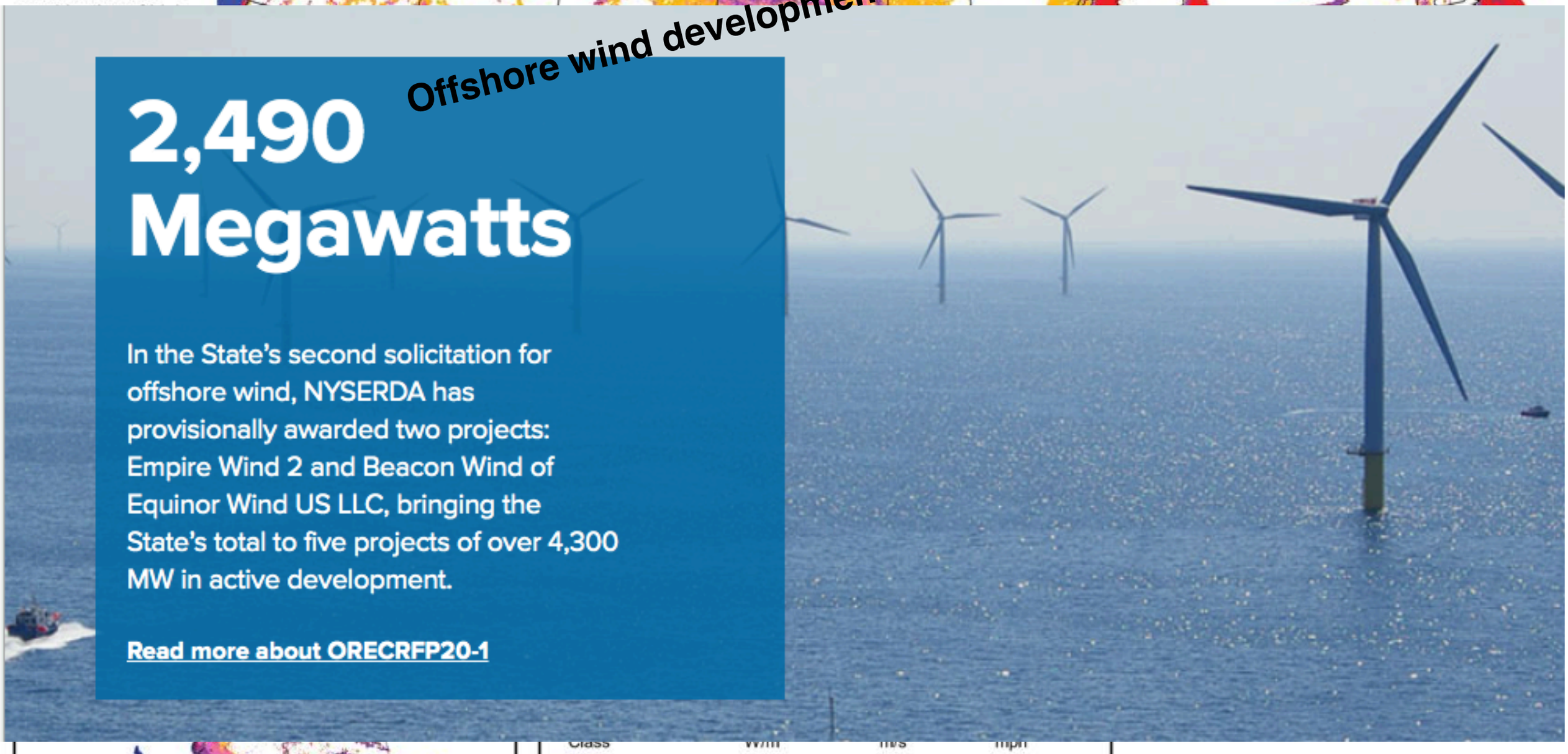
[a] Wind speeds are based on a Weibull k value of 2.0

U.S. Department of Energy
National Renewable Energy Laboratory
03-MAR-2009 1.1.5

United States - Wind Resource Map

This map shows the annual average wind power estimates at 50 meters above the surface of the United States. It is a

Offshore wind development happening in NY, now



Class		W/m²	m/s	mph
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U.S. Department of Energy
National Renewable Energy Laboratory

03-MAR-2009 1.1.5


PETZL
(c) Jean Paul Cano / Hoos Partner
www.petzl.com

Makani 2006 – 2020
(patents opensourced)

https://x.company/projects/makani/

Makani M30 30kW
prototype airborne turbine

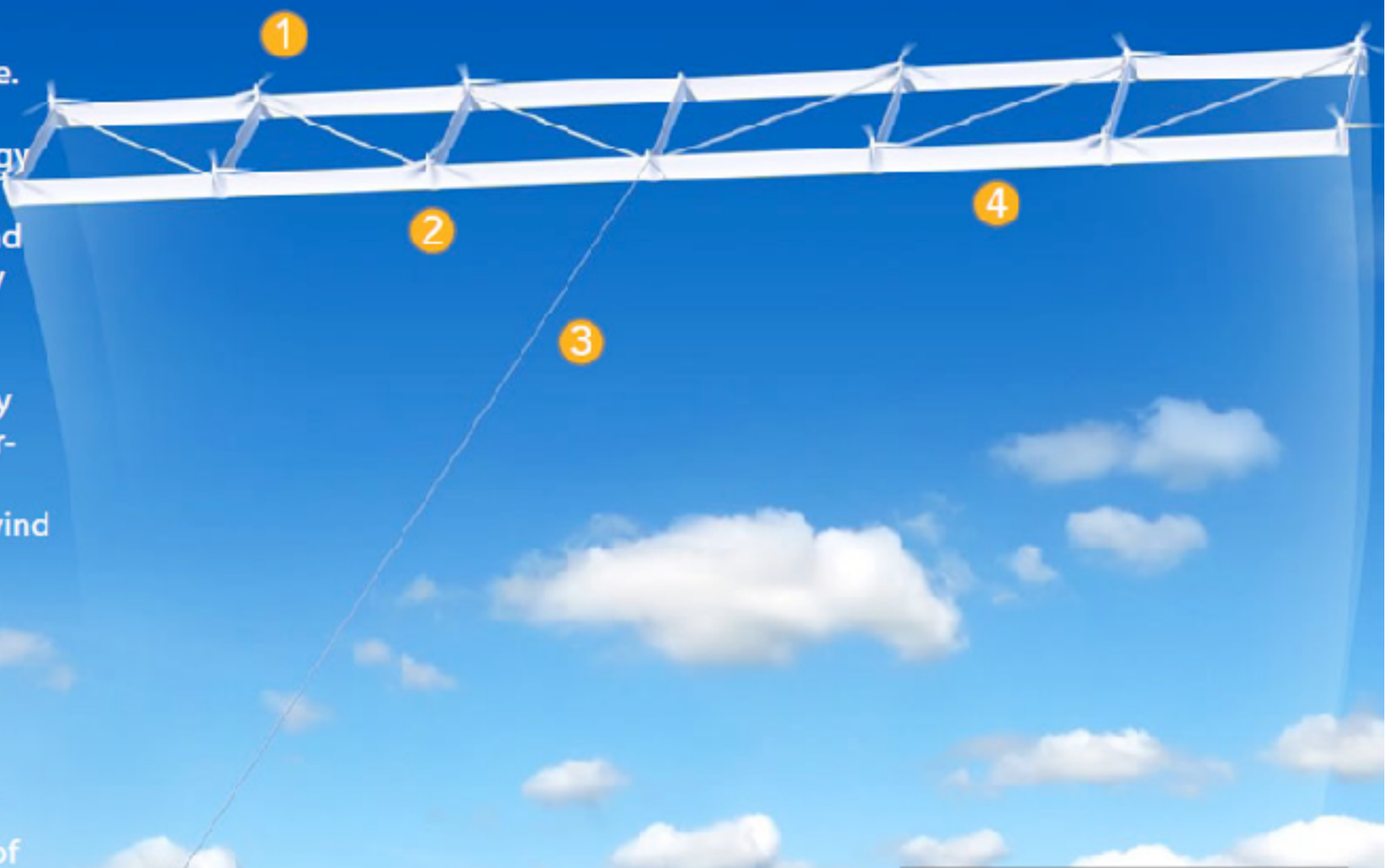
Airborne Wind Turbines

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.

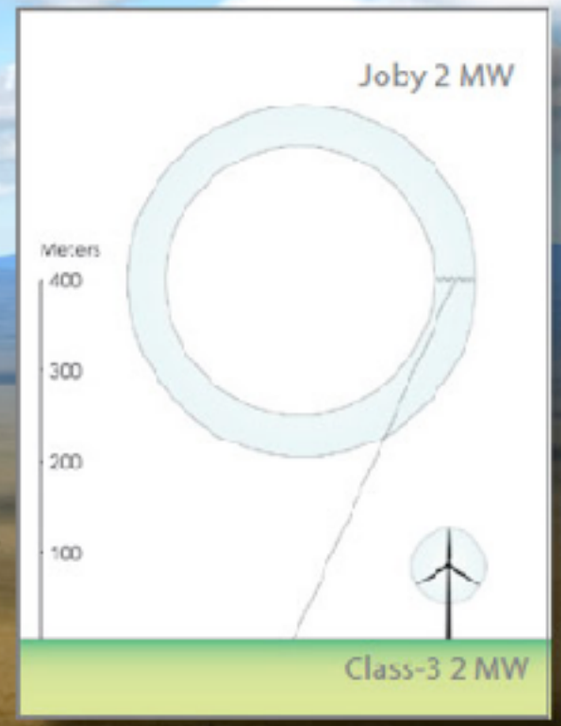
Our multi-wing structure supports an array of turbines. The turbines connect to motor-generators which produce thrust during takeoff and generate power during crosswind flight. Orientation in flight is maintained by an advanced computer system that drives aerodynamic surfaces on the wings and differentially 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.



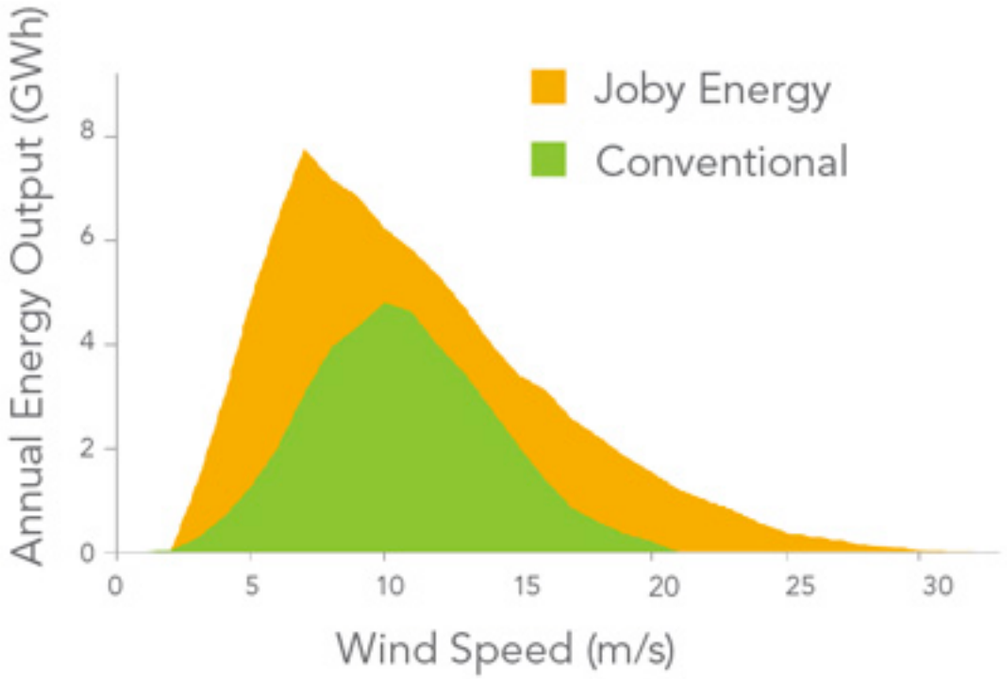
How It Operates

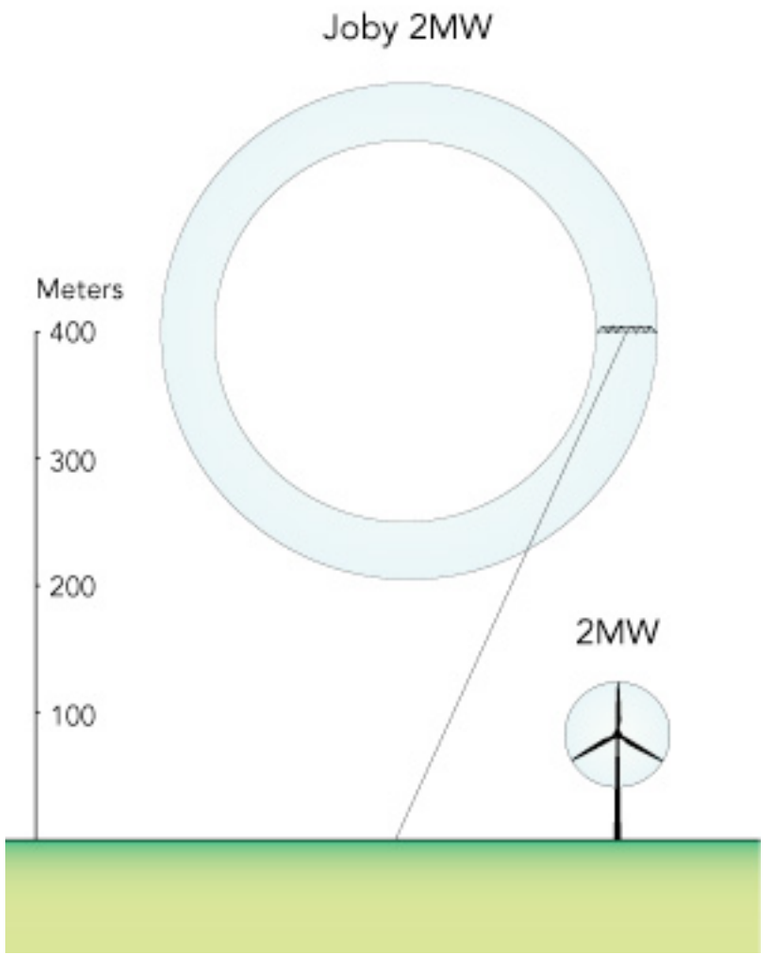
Joby turbine

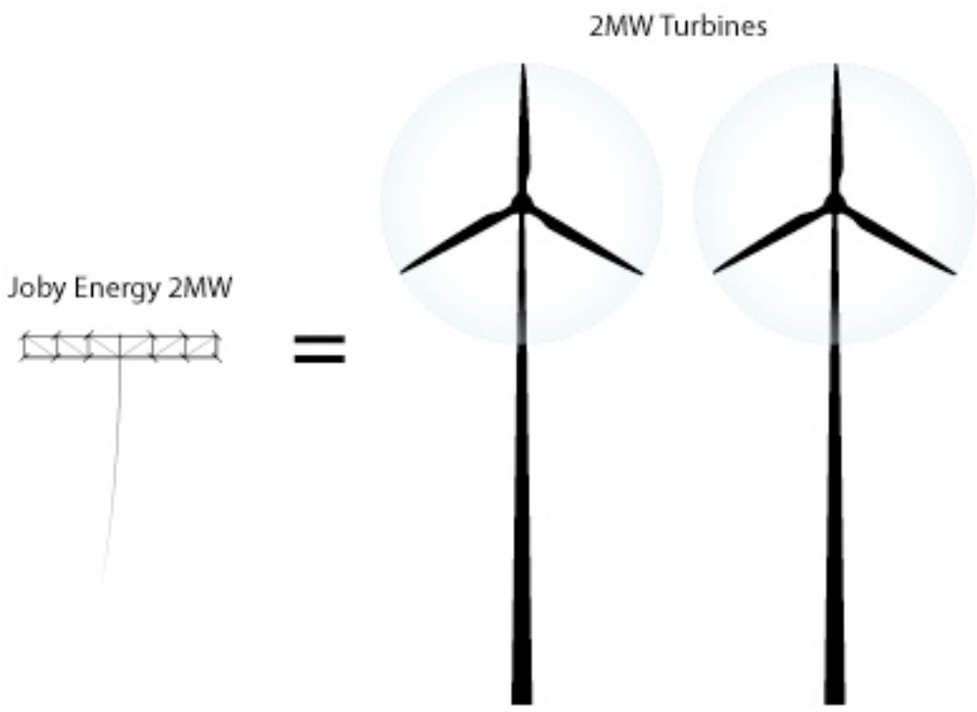
For launch, the turbines are supplied with power to enable vertical take-off. Upon reaching operating altitude, the system uses the power of the wind to fly cross-wind in a circular path. The high cross-wind speeds result in the turbines spinning the generators at high speeds, eliminating the need for 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)





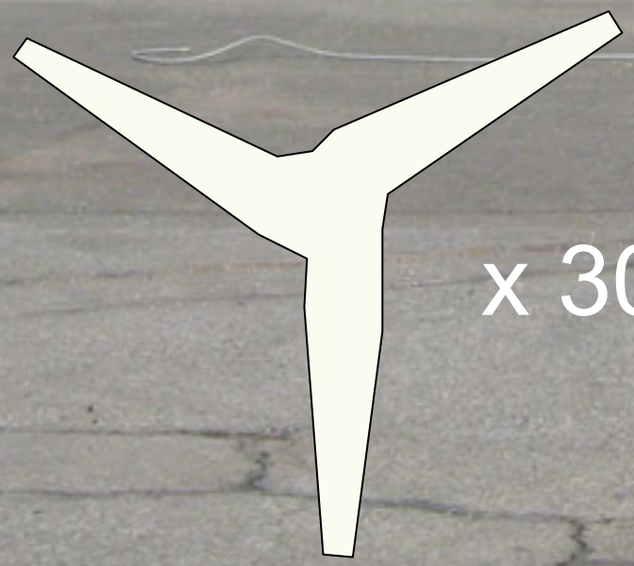


- Phase 1 (2002 – 2006): Prototype Testing
- Phase 2 (2006 – 2009): Demonstration
- Phase 3 (Current): MW-Scale Build-Out

Verdant Power East River turbines

Verdant Power East River turbines

- Phase 1 (2002 – 2006): Prototype Testing
- Phase 2 (2006 – 2009): Demonstration
- ~~Phase 3 (Current): MW-Scale Build-Out~~
- “Gen5” turbine (~2017)
- **October 2020: three tidal power turbines form the Roosevelt Island Tidal Energy (RITE) Project site in the East River, the first U.S. licensed tidal power project.**

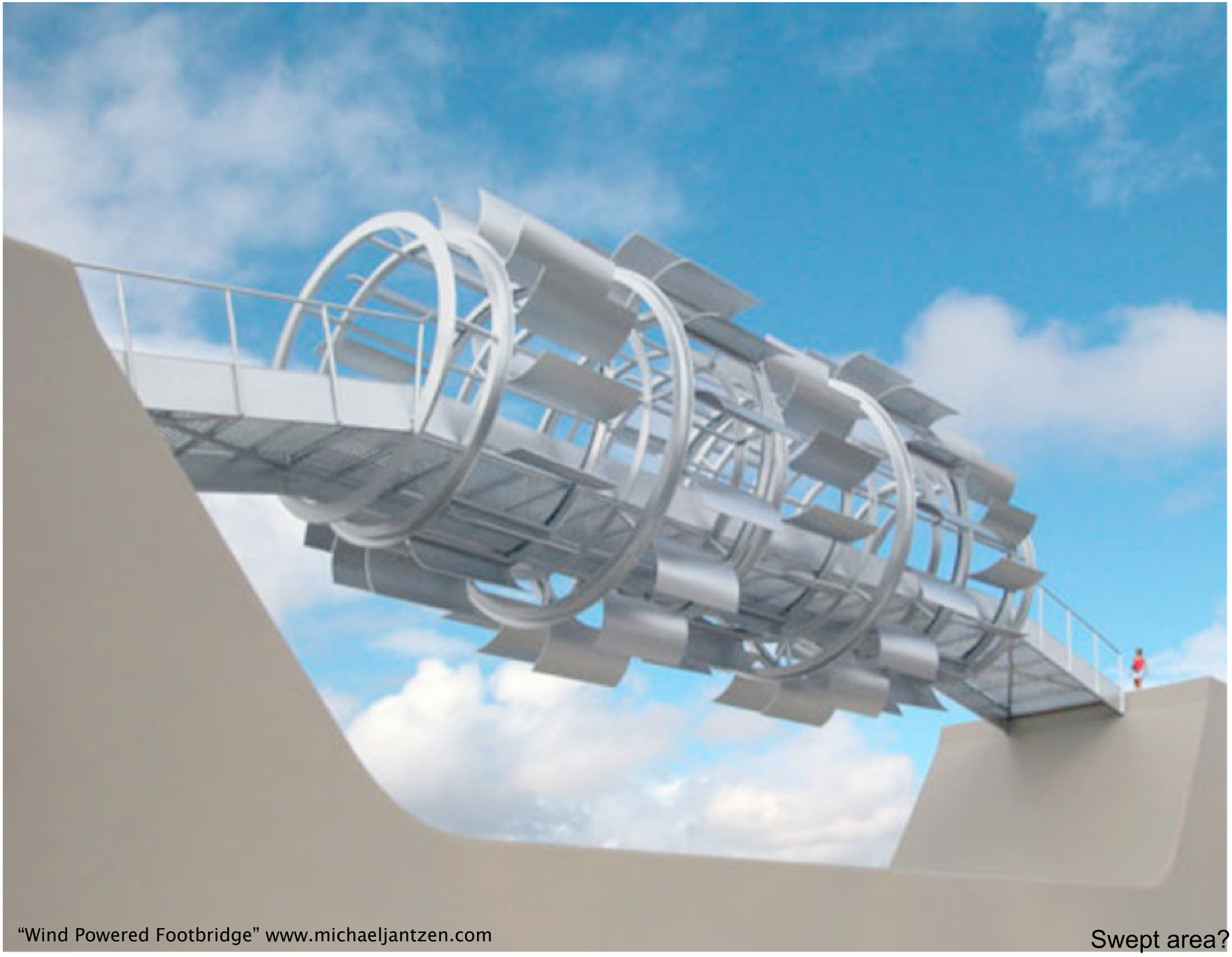


x 30 = 1 MW

Verdant Power East River turbines

Source of wind?

Source of wind?



"Wind Powered Footbridge" www.michaeljantzen.com

Swept area?