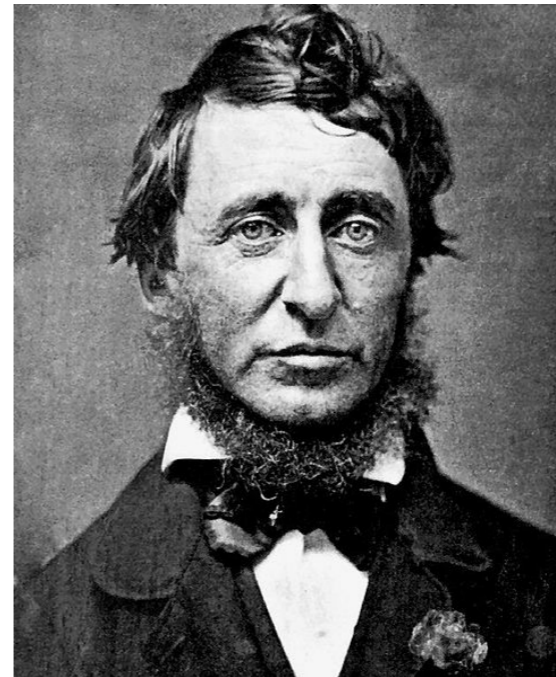


First, there is the power of the Wind, constantly exerted over the globe.... Here is an almost incalculable power at our disposal, yet how trifling the use we make of it! It only serves to turn a few mills, blow a few vessels across the ocean, and a few trivial ends besides. What a poor compliment do we pay to our indefatigable and energetic servant!

Henry David Thoreau



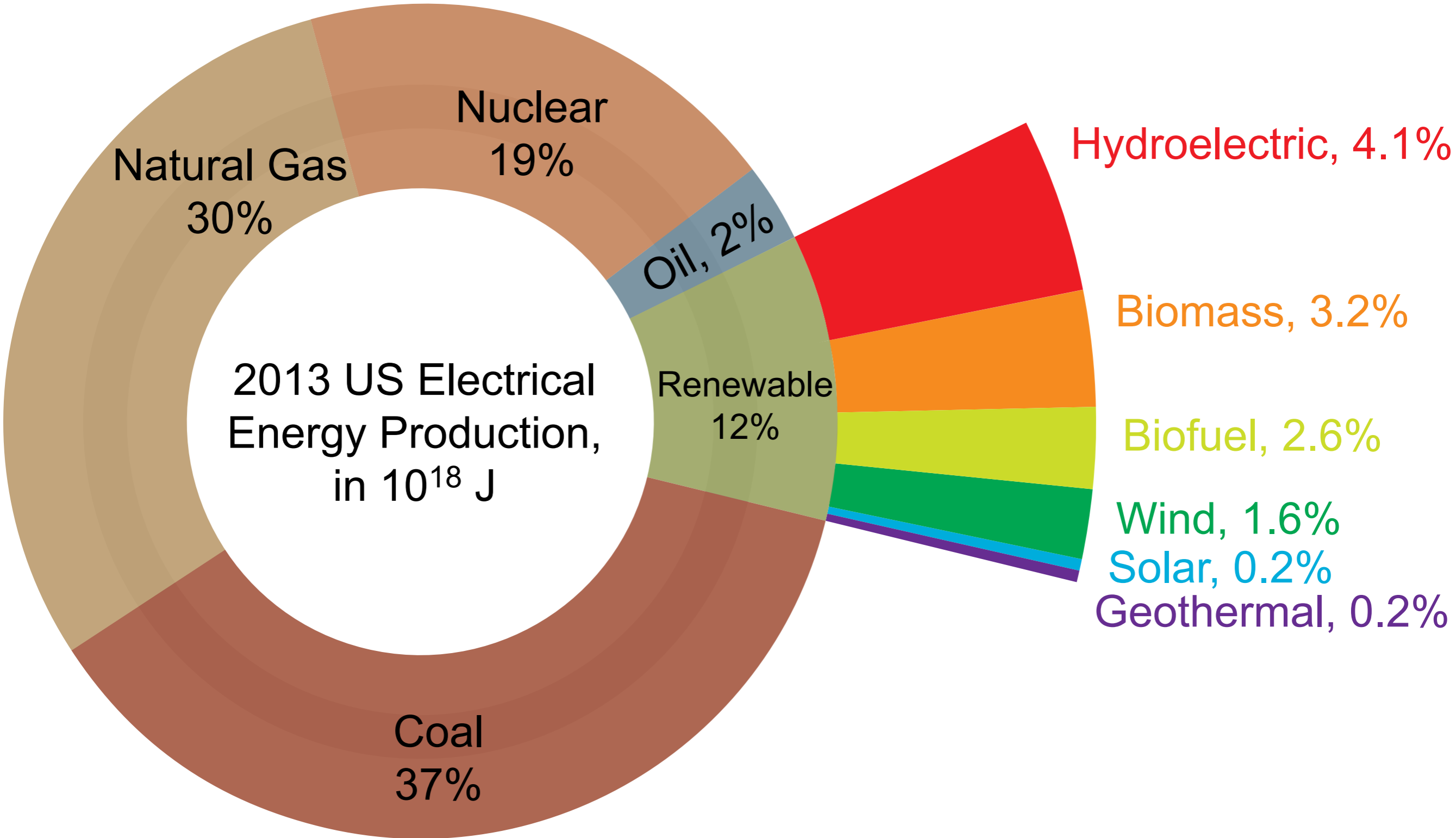
Arizona State University
SES 194

Energy in Everyday Life

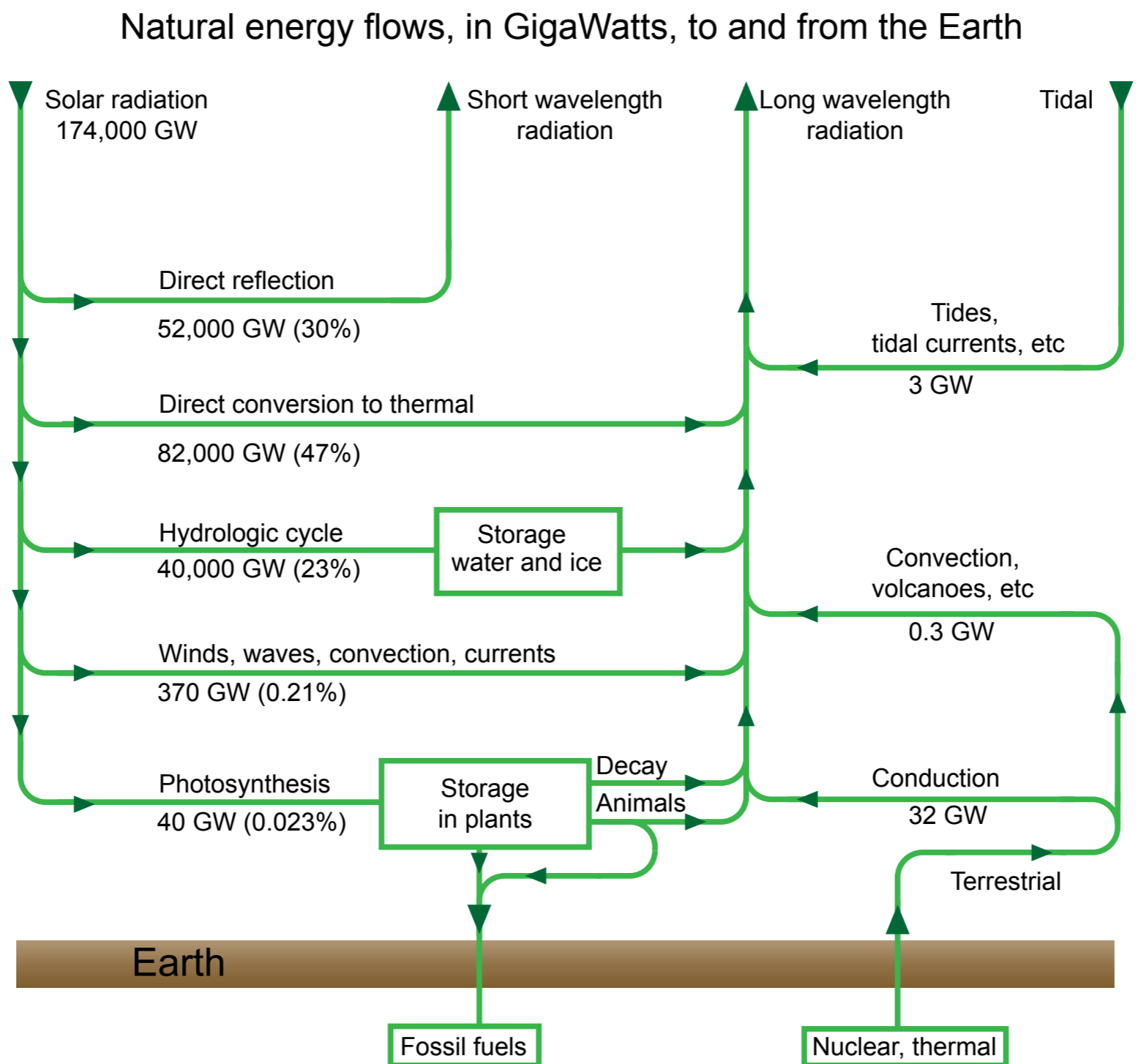
Wind

Frank Timmes

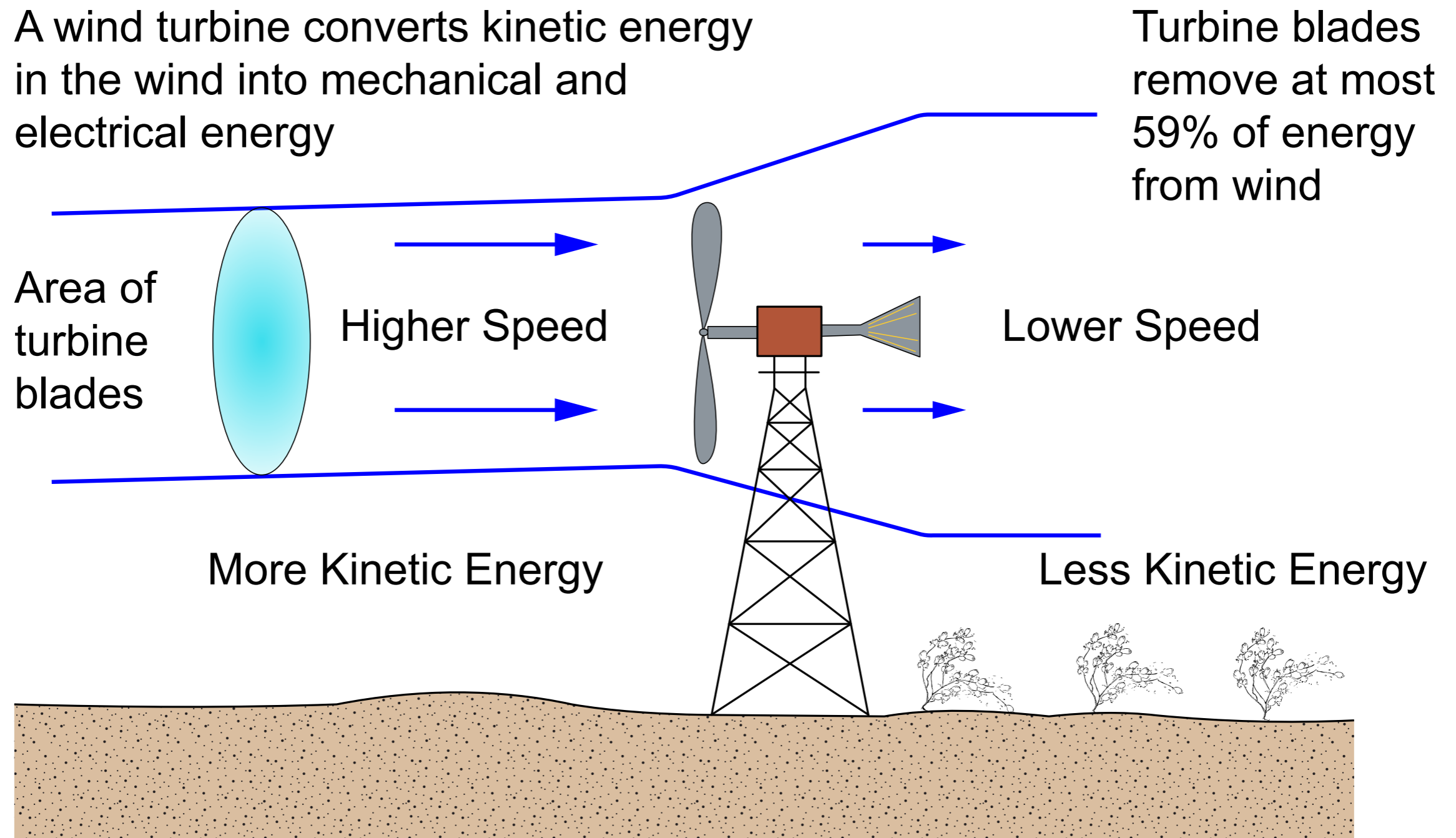
ftimmes@asu.edu



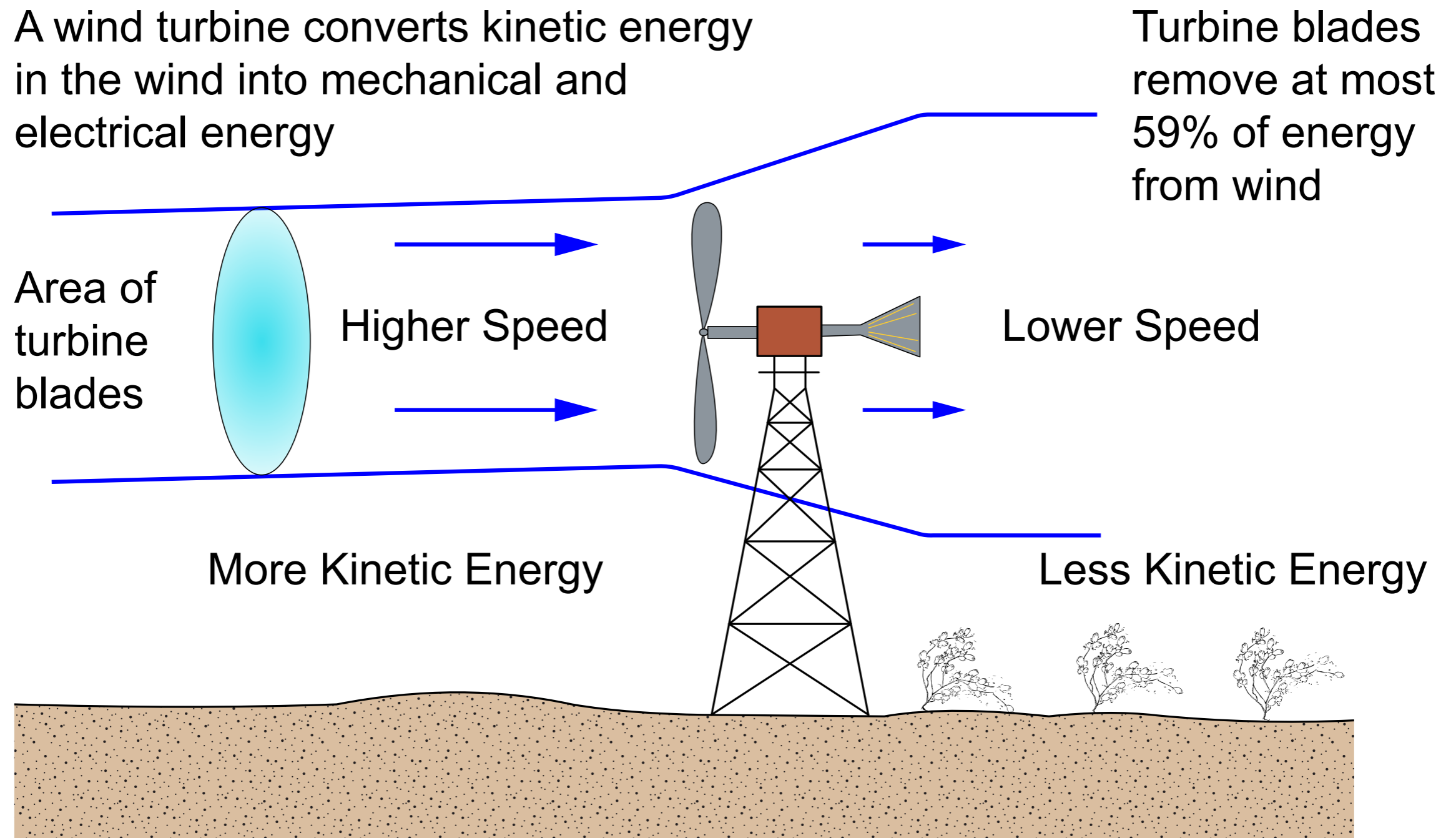
A small percentage of the incident energy heats the air/land, drives the weather, ocean currents and photosynthesis. Let's see what can be tapped from winds.



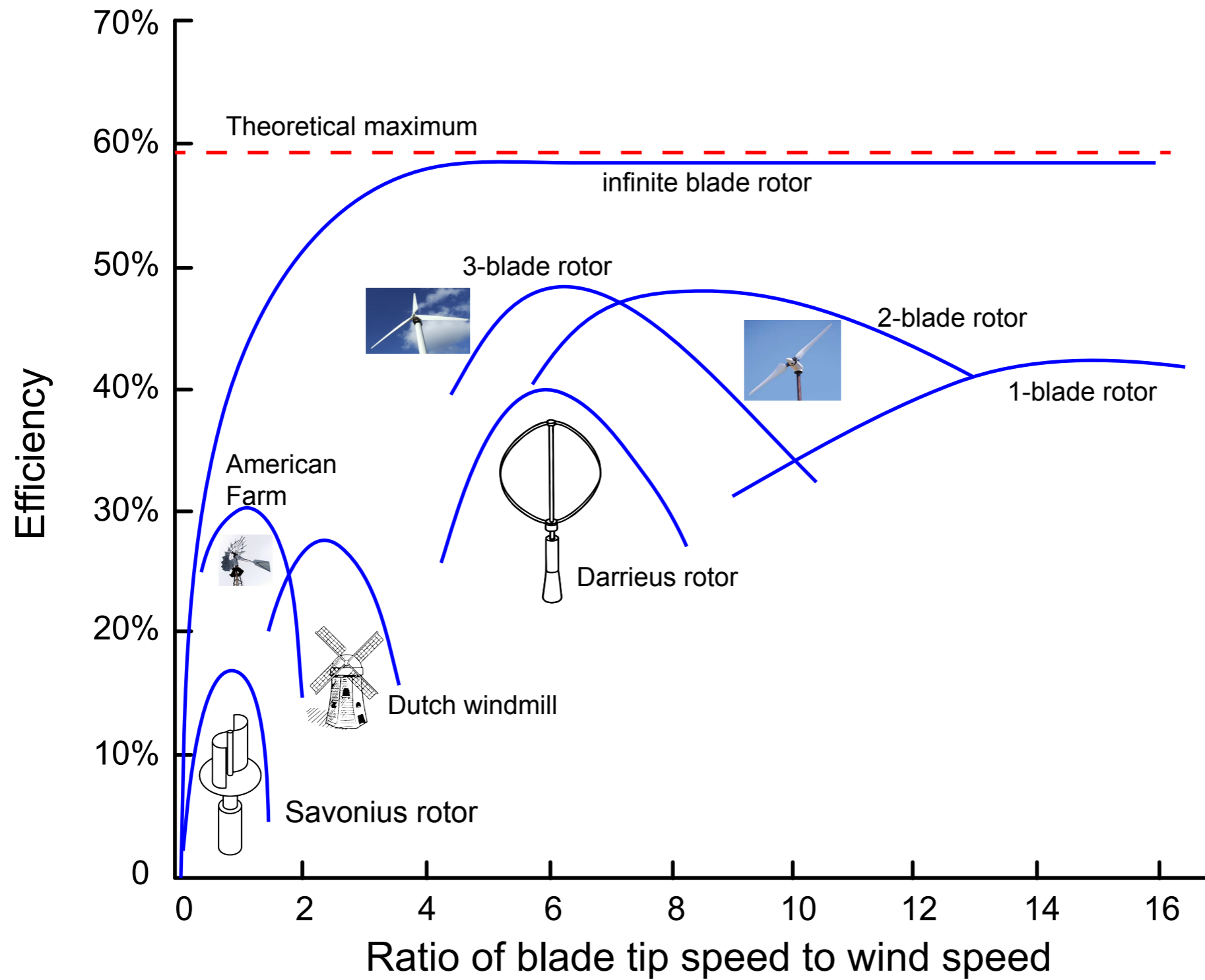
A windmill can't extract all of the wind's kinetic energy, because this would stop the wind, diverting oncoming wind around it, and the windmill would stop spinning.



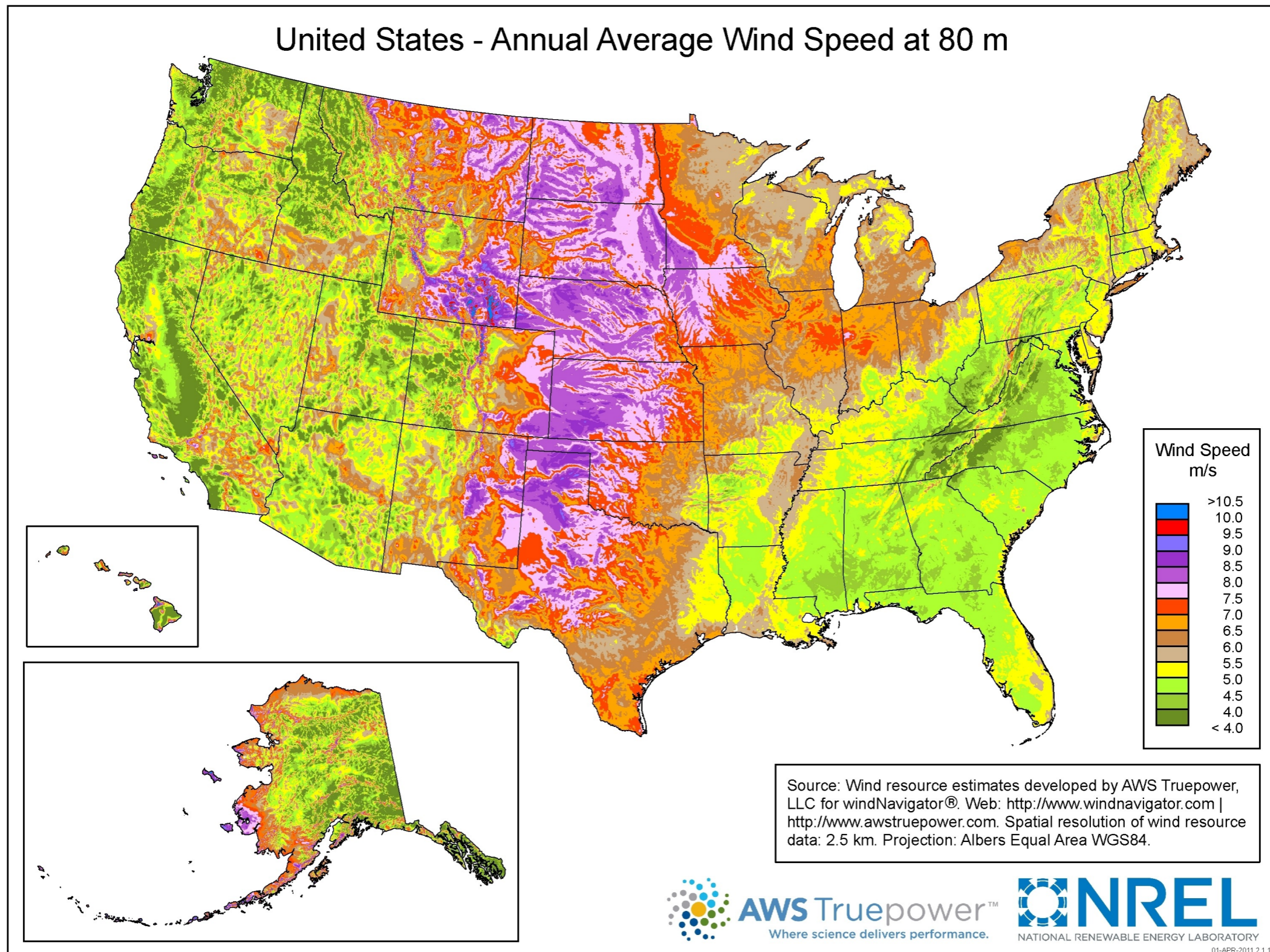
On the other hand, if you don't slow the wind down much you won't get much energy. The maximum efficiency is 59%, which corresponds to reducing wind velocity by 1/3.



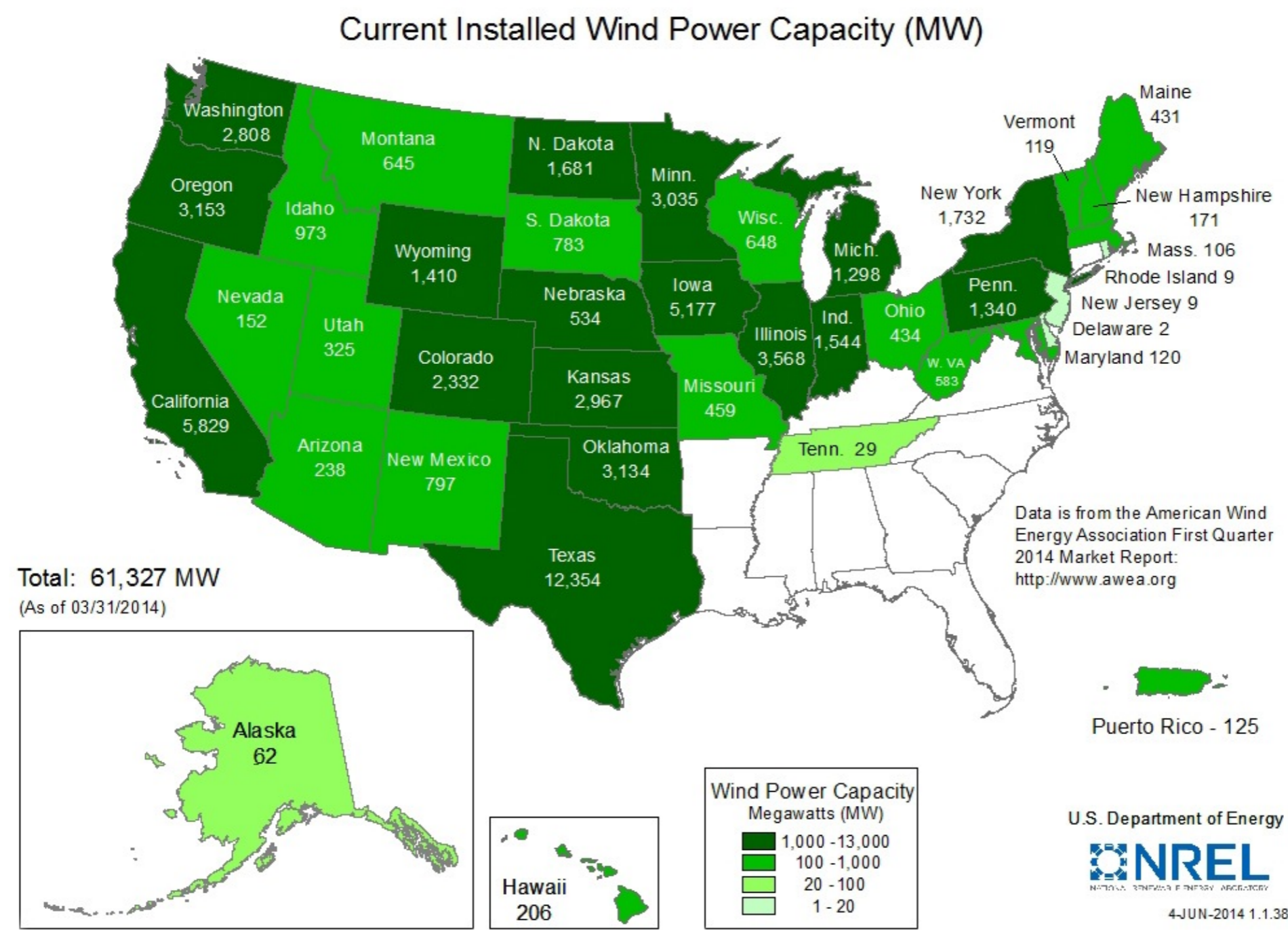
Modern windmills attain ~50% efficiency. Conversion from the rotary mechanical motion to electrical is 90% efficient, for a final efficiency of ~45%.



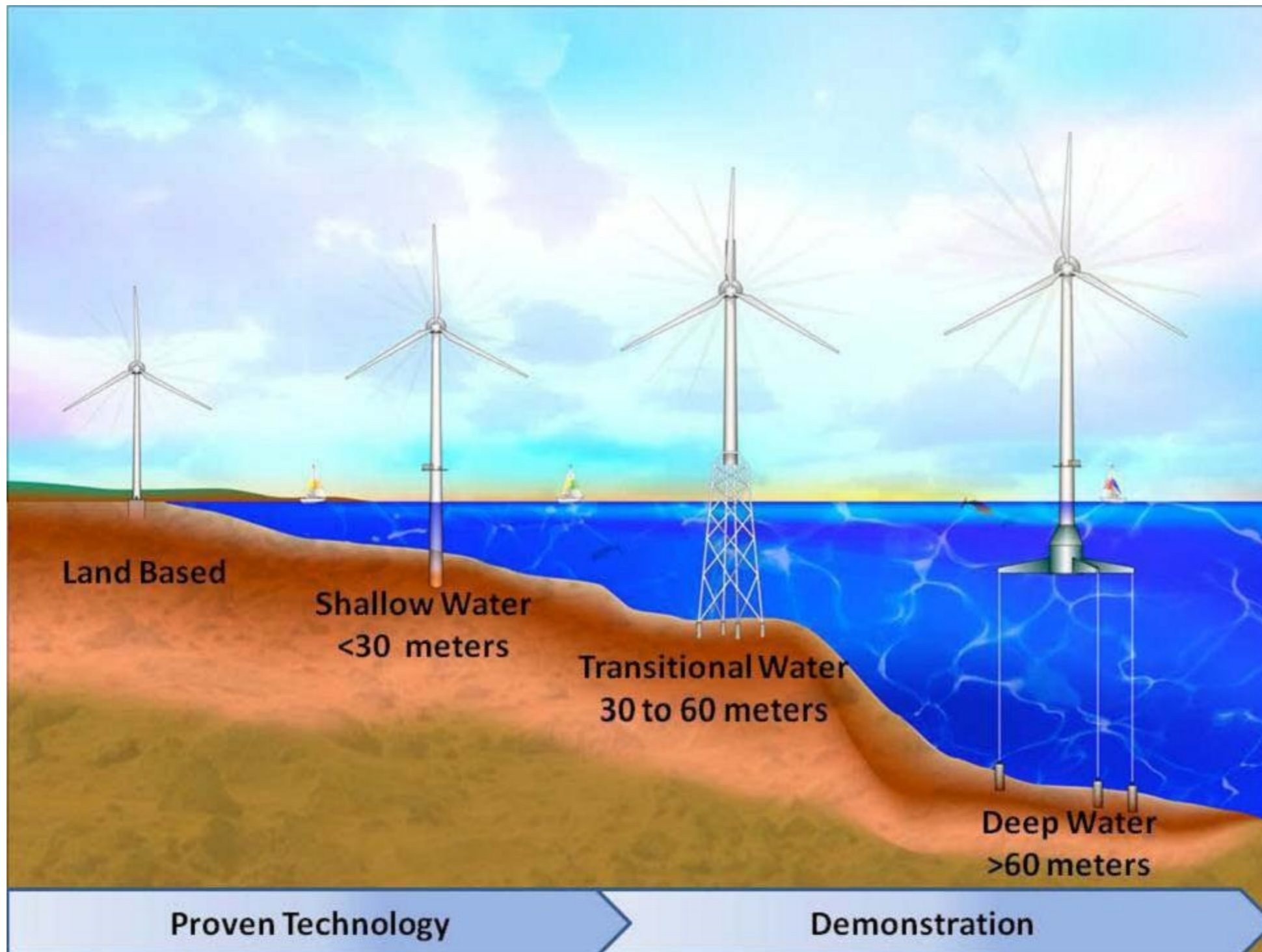
Wind is a rapidly developing resource, with 6.4 GW in 2003 to 62 GW by end of 2014 and growing at ~25% per year, with a cost of ~\$0.05/kW-hr that is very competitive.



It doesn't pay to space windmills too closely - one robs the other. Typical arrangements have rotors 10 diameters apart in direction of prevailing wind, 5 diameters apart in the cross-wind direction for a filling factor of ~2%.



As a result of this filling factor, plus faster winds, there is a lot of action in offshore wind energy production.



The Nysted Wind Farm is a Danish offshore wind farm close Gravity based foundations are used rather than pillars due to ice conditions. Annual generation is ~1300 GW.



The Vestas 164 in the North Sea is the largest wind turbine in the world.

Its 164 m blade length is larger than the wingspan on modern airplanes.

It went online in 2014 and is expected to generate ~30 GW-hrs annually.



If fully developed, “industrial wind” could generate an average power almost equal to our current electrical capacity.

The essential challenge with wind is intermittency - the wind doesn't blow all the time - and our current electrical grid has a limited tolerance for intermittent sources.

Secondary challenges, or primary depending on your point of view, include land/ocean real estate, serious noise pollution, and migratory birds.