Wind Energy in Iowa
Technical and Financial Considerations

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Wind Energy Science, Engineering and Policy

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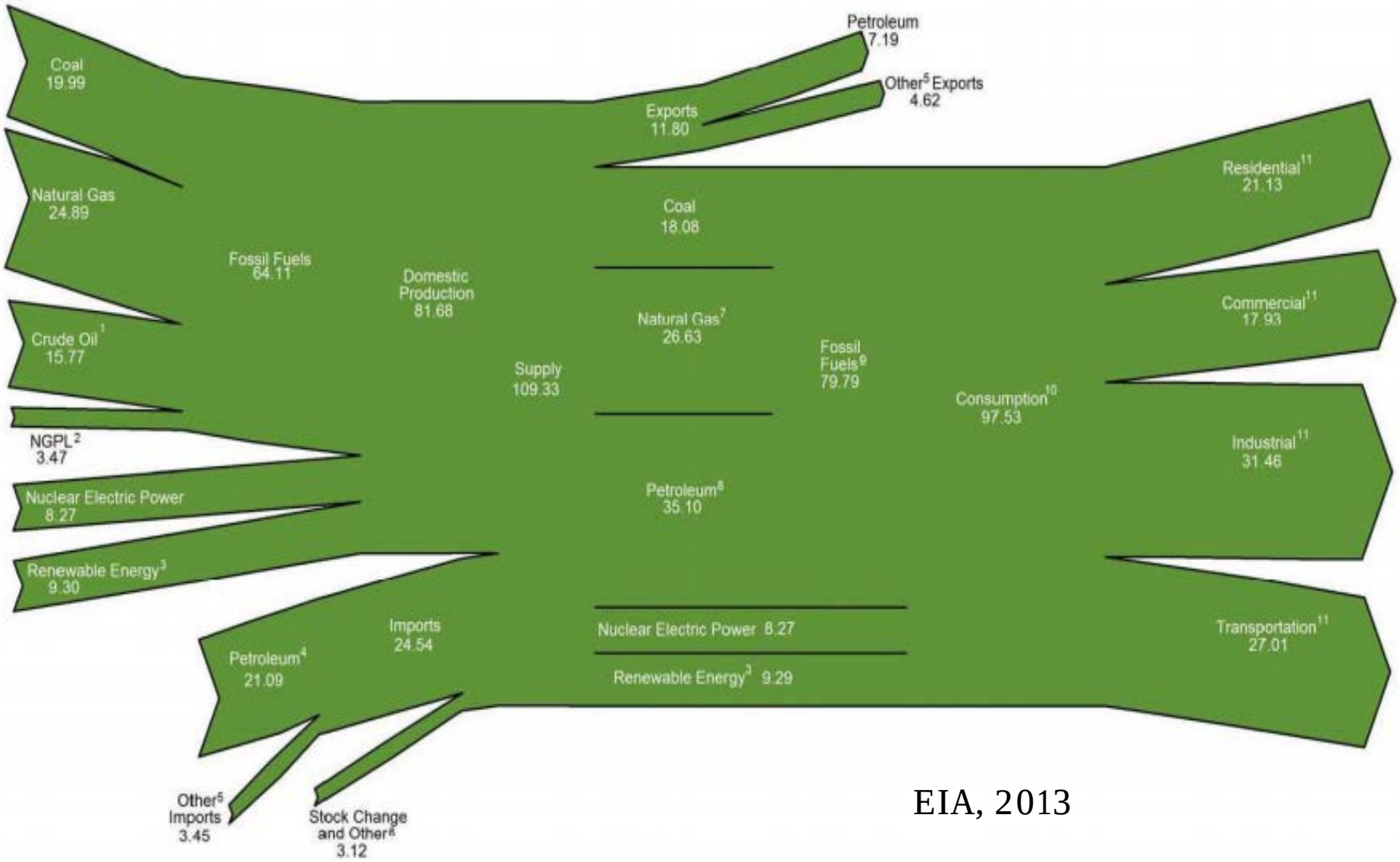
Who is the Iowa Energy Center?

- **A Little History**
  - Created by the 1990 Iowa Energy Efficiency Act
  - Funded by surcharge on intra-state electric & gas sales
    - 0.085% of gross revenues
    - ~ $3,900,000 annual budget
  - Administered by Iowa State University
  - Work with Iowa's colleges, universities & private nonprofits
  - Guided by a 13 member advisory council
- **Mission is to sponsor and conduct research, demonstration & information dissemination**
  - Energy efficiency
  - Alternate energy systems

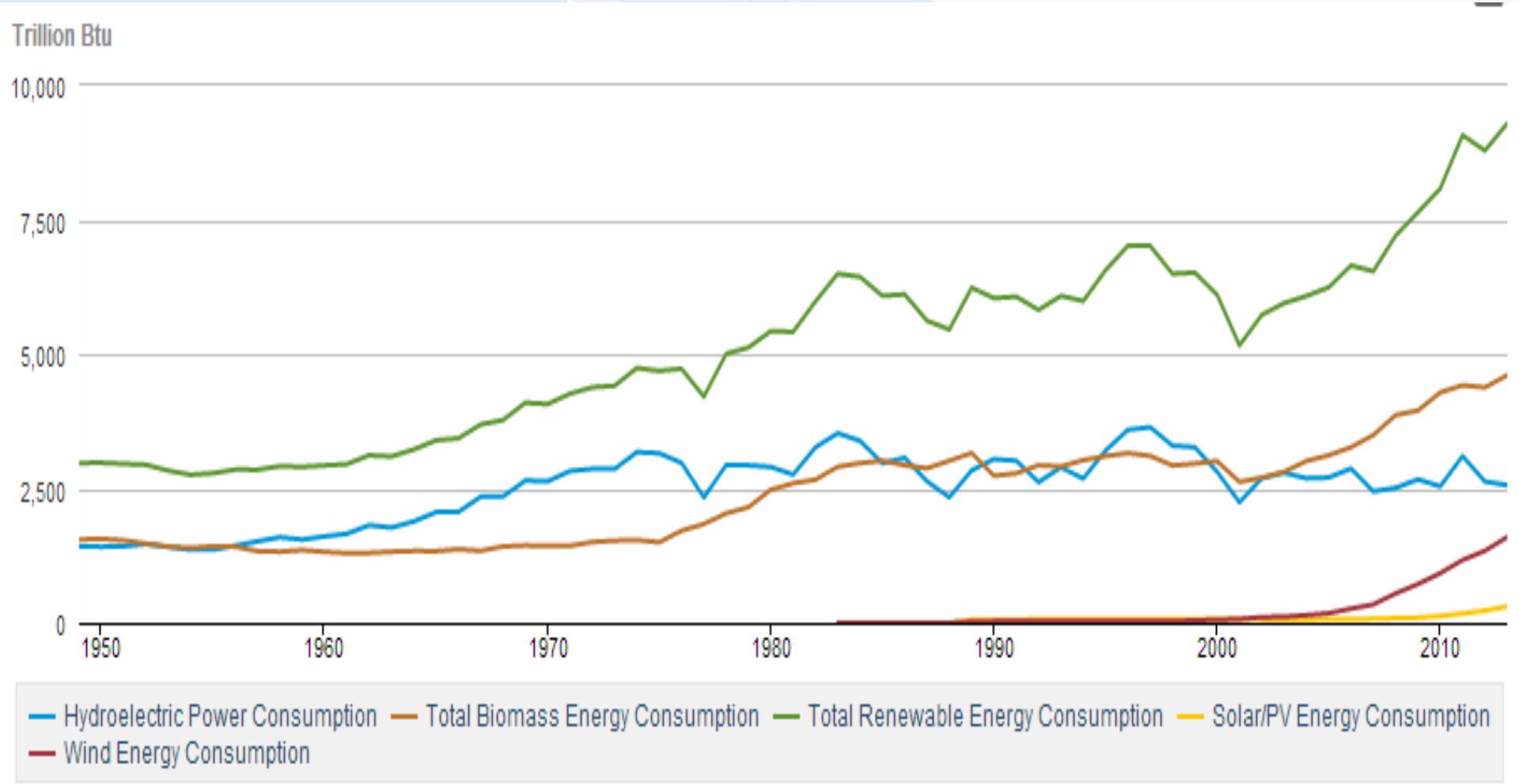
U.S. Energy Flow, 2013

(Quadrillion Btu)



EIA, 2013

U.S. Renewable Energy Usage, EIA 2013



Data source: U.S. Energy Information Administration

Status of Wind Energy in Iowa

- **Wind Facts**
  - Iowa is the nation's 7th windiest state and ranks 3rd in total wind energy capacity installed behind Texas & California
  - Approximately 5,708 MW installed capacity
    - 679 MW under construction
  - ~ 3,447 existing utility-scale turbines (>50 kW)
  - Percentage of Iowa electricity from wind in 2014: ~28.53%
    - **Iowa ranked first in the US in 2014 for percentage of electricity derived from wind.**
  - Iowa wind farms now online power the equivalent of more than 1.5 million homes
  - Many farm/residential units (400-500)

Wind Energy in Iowa

- **Wind energy industry accounts for over 6,000 jobs**
- **Over $10 billion of capital investment**
- **Over $17 million in annual land lease payments**
- **Home to 12 major turbine supply manufacturers**
  - Siemens (blade manufacturing facility)
  - TPI Composites (blade manufacturing facility)
  - Acciona (turbine manufacturing and developer)
  - Trinity Structural Towers (steel towers)

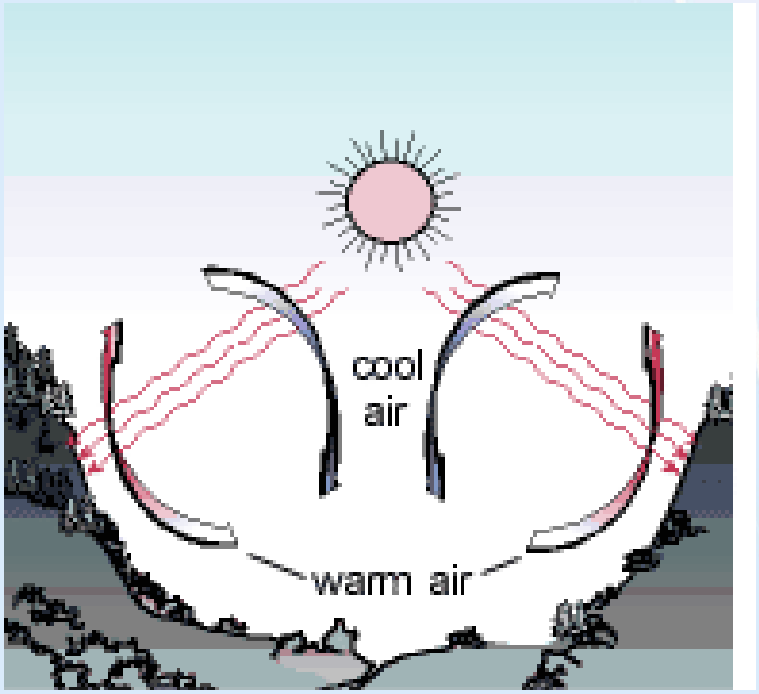
How does Iowa Compare?

	Wind Poten MW	Installed MW	Installed Rank	% of Load	No. of Turbines	Under Constr. MW	Manuf Facilty
Iowa	570,714	5,708	3	28.53	3,447	679	12
IL	249,882	3,667	5	4.98	2,245	425	39
MN	489,271	3,035	6	15.94	2,156	370	24
KS	952,371	2,967	9	21.67	1,729	1,072	5
SD	882,412	882	19	25.29	528	124	7
NE	917,999	812	20	6.91	475	74	1
WI	103,757	648	22	2.65	417	0	26
MO	274,355	459	24	1.28	252	0	10

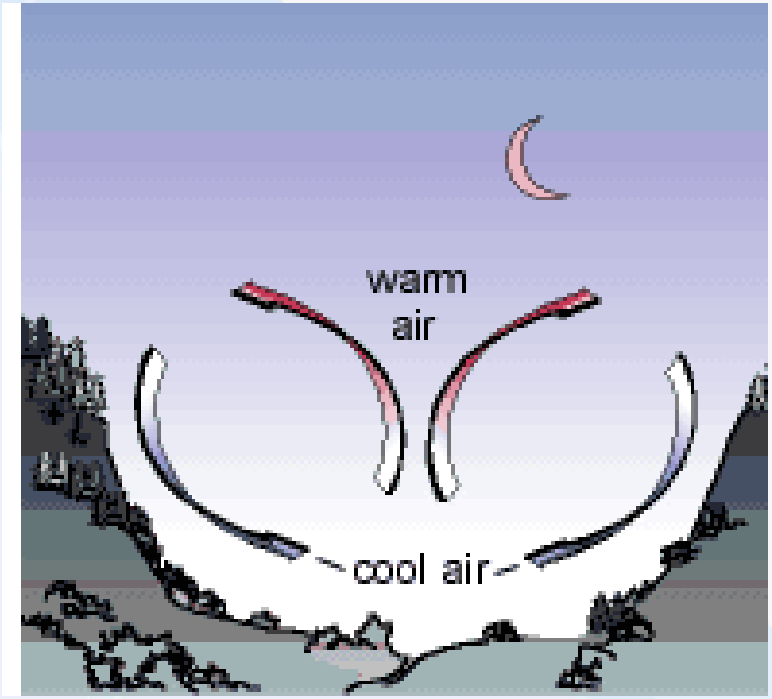
What is Wind?

- **Wind is a byproduct of solar energy**
- **Approximately 2% of solar energy reaching the earth is converted to wind**
- **Wind results from**
  - uneven heating & cooling of earth
  - creates atmospheric pressure gradients
  - gradients force air movement from areas of high pressure to low pressure

Physics of Wind



Daytime

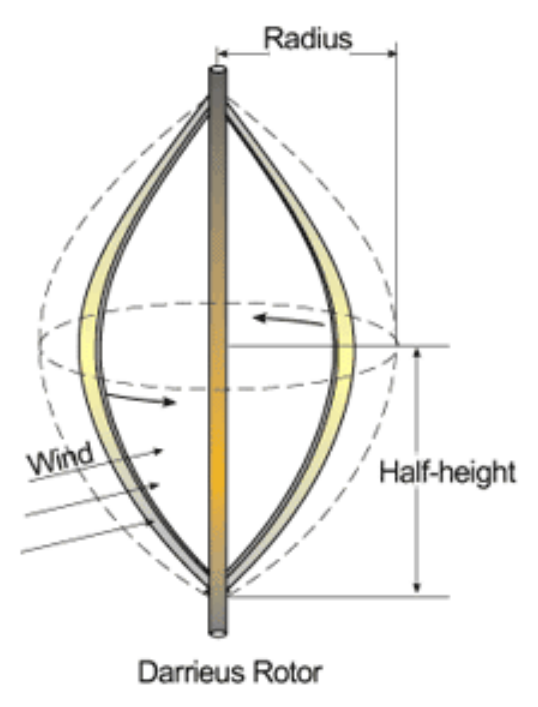


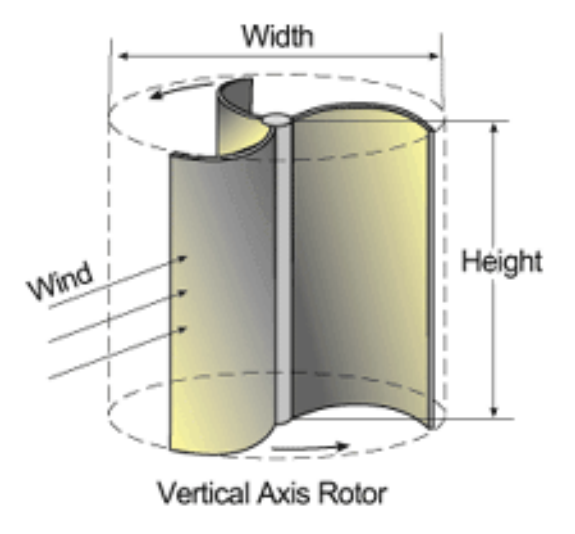
Nighttime

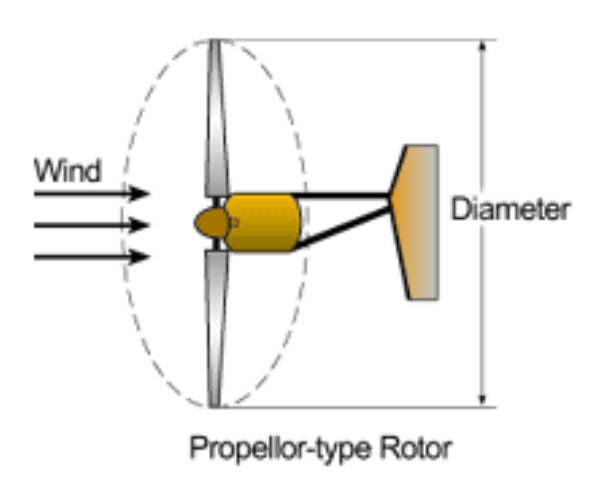
Physics of Wind Power

- **Power = ½ ρAv^3η**
  - ρ = specific gravity of air
    - function of air temperature and elevation
  - A = cross sectional area of swept blades
  - v = wind velocity
    - function of height above ground
      - $V_2 = V_1 (H_2 / H_1)^{0.2}$
  - η = loss factor
    - function of wind direction relative to turbine orientation
    - function of ground turbulence effects
    - function of turbine design

Swept Area for Turbine Blades





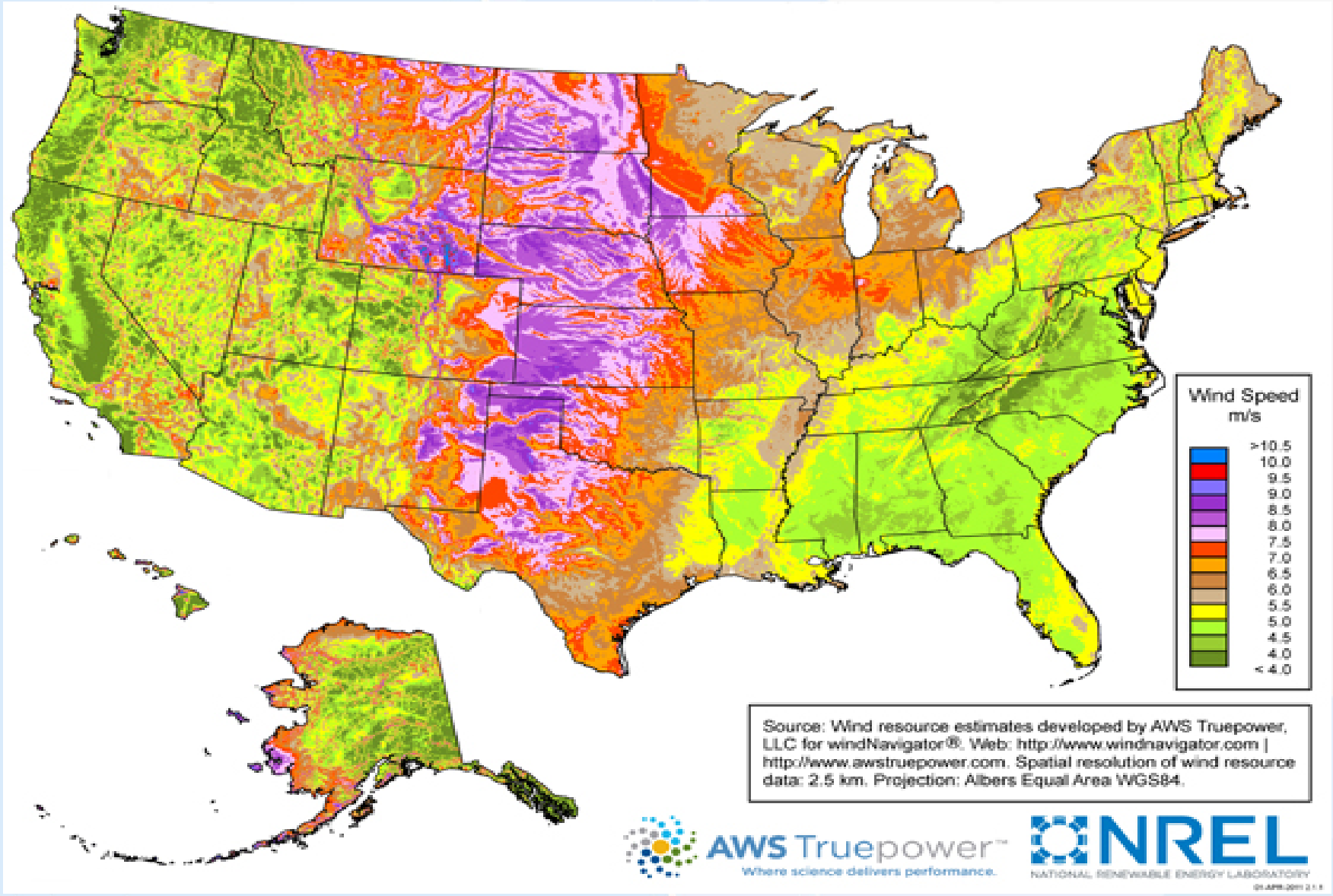


Propeller Bladed Wind Turbines

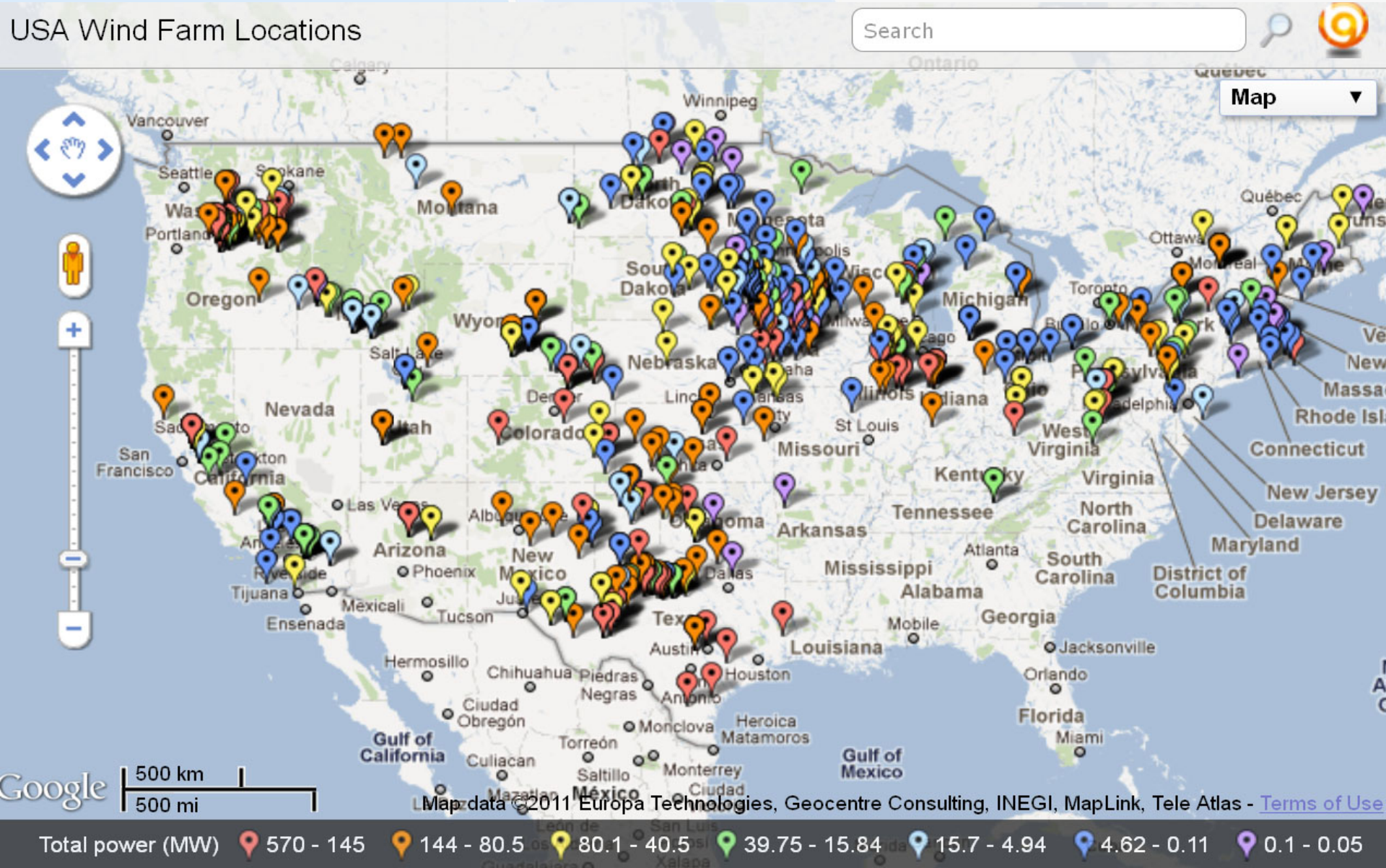
Key Elements For Wind Development

- **Location, Location, Location**
  - Within a good wind regime
  - Favorable terrain features
  - Close proximity to utility grid
  - Permitting and “good neighbor” barriers
    - Tower height restrictions
    - Liability considerations
    - Flicker/Shadowing
    - Zoning requirements / setbacks, property lot size, tower type, paint color
    - FAA approval
- **Power Consumer vs. Power Supplier Viewpoint**
  - Retail vs. wholesale vs. avoided cost value of power
  - Load profile consistent with wind turbine generation
- **Favorable Utility Contracts**
  - Interconnection and Power Purchase Agreements
  - Net Metering
- **Favorable Financing Package**
  - Property and production tax credits
  - Grants and loans

U.S. Wind Resources, 80 m

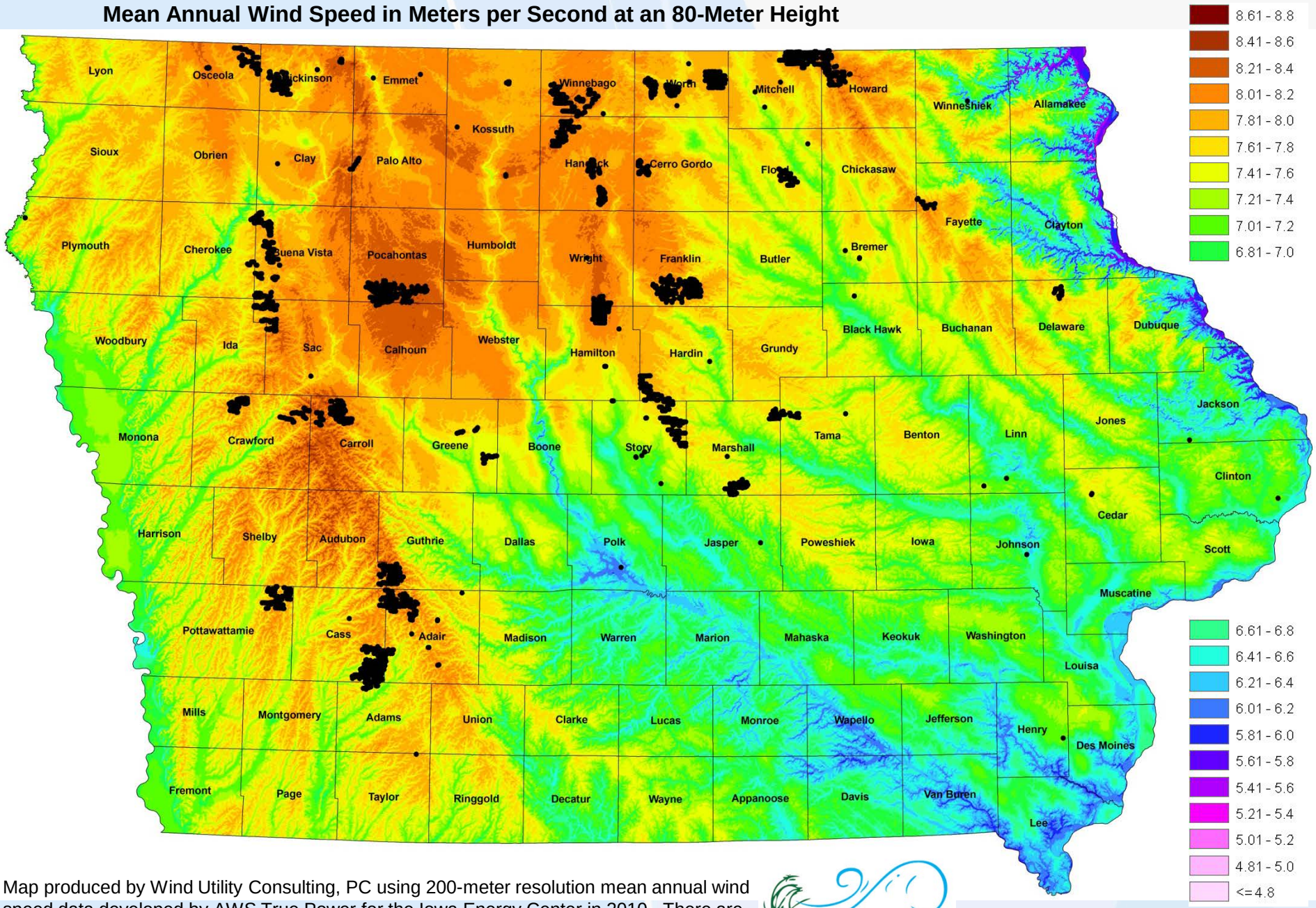


US Wind Farm Locations



3,200 Large Wind Turbines in Iowa

Mean Annual Wind Speed in Meters per Second at an 80-Meter Height



Map produced by Wind Utility Consulting, PC using 200-meter resolution mean annual wind speed data developed by AWS True Power for the Iowa Energy Center in 2010. There are approximately 3,200 large wind turbines plotted on the map

Wind Utility Consulting, PC March 2015

Andrew T. Coil & Thomas A. Wind

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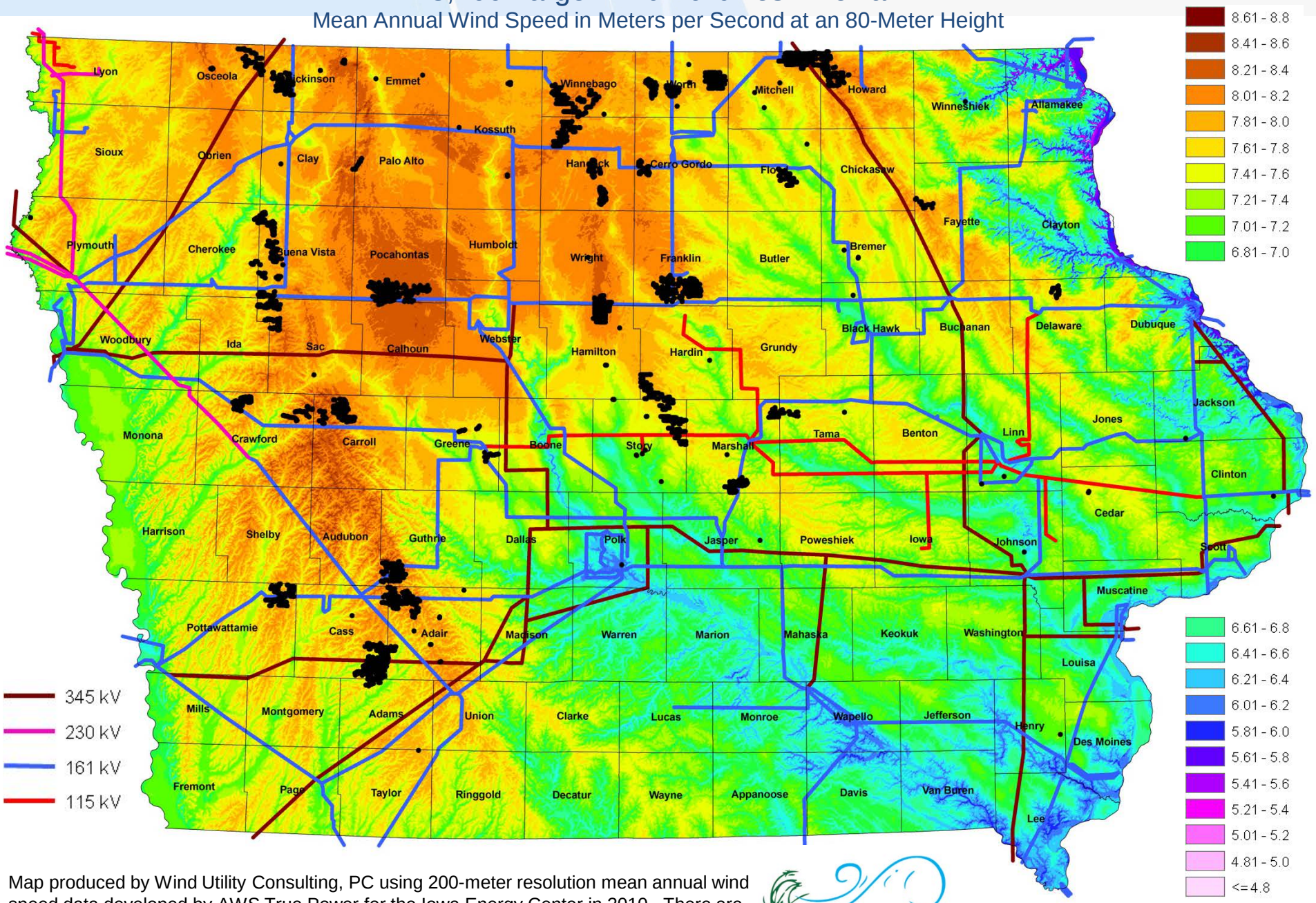

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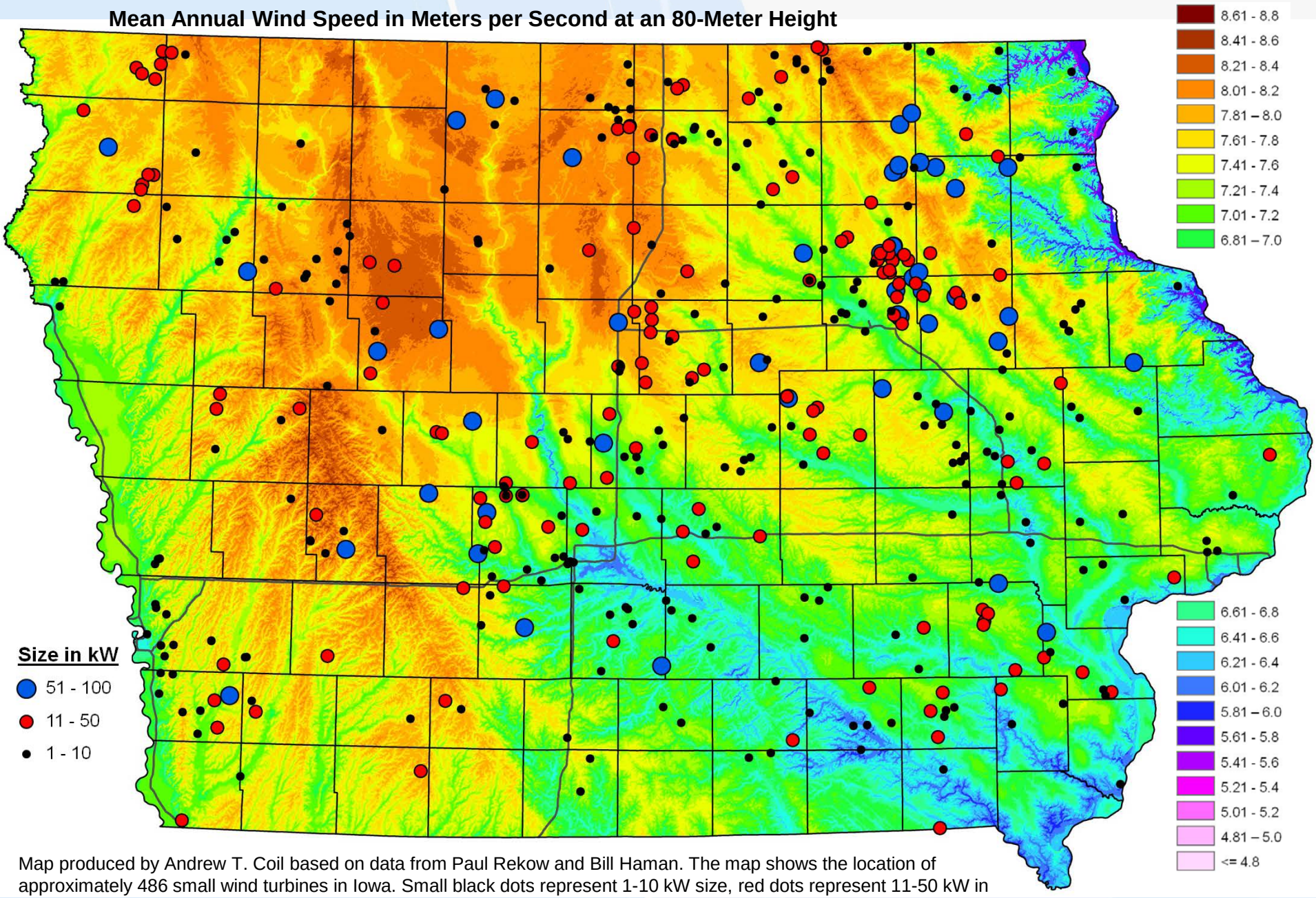
Location of Small and Midsized Wind Turbines in Iowa

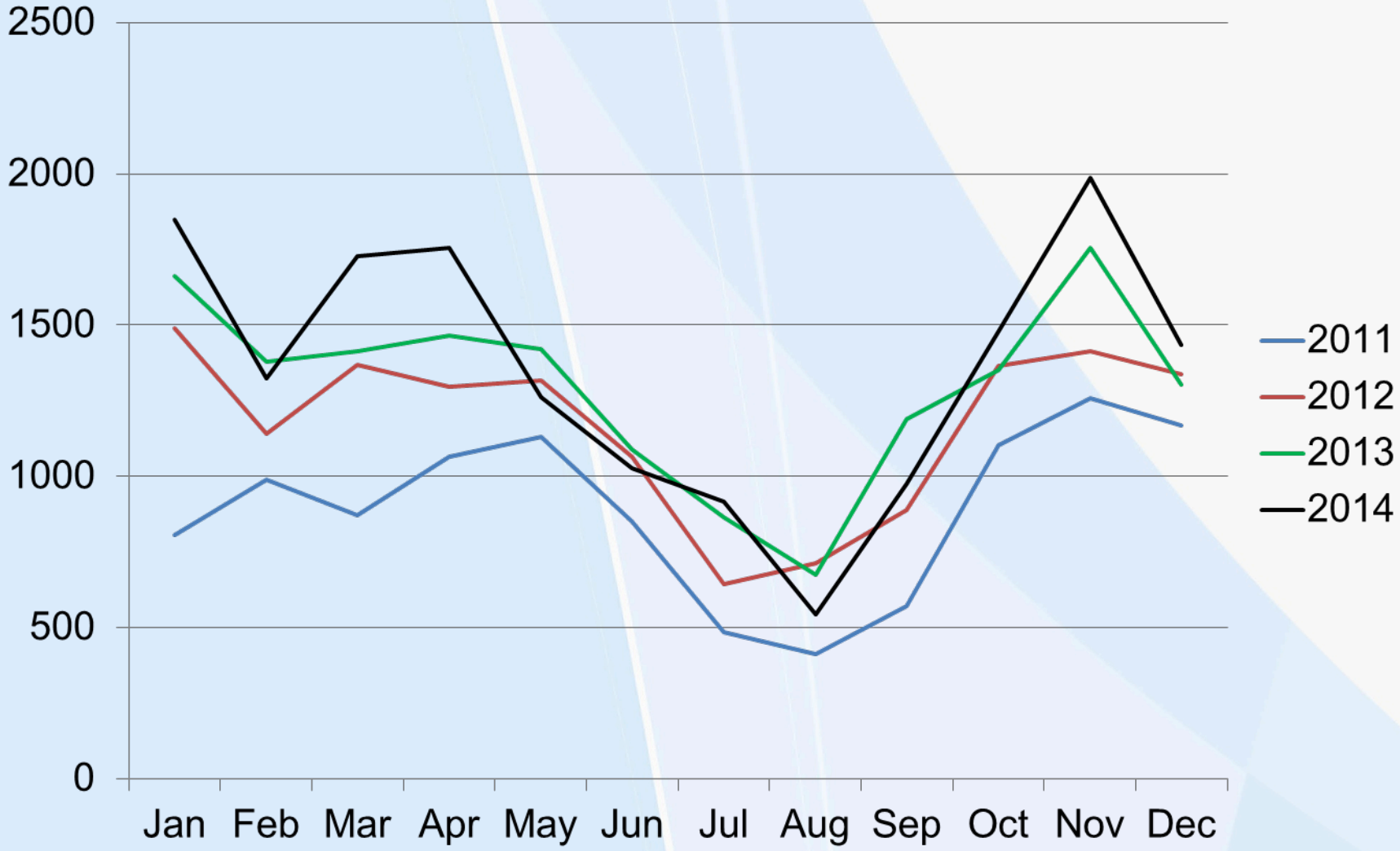
Mean Annual Wind Speed in Meters per Second at an 80-Meter Height



Map produced by Andrew T. Coil based on data from Paul Rekow and Bill Haman. The map shows the location of approximately 486 small wind turbines in Iowa. Small black dots represent 1-10 kW size, red dots represent 11-50 kW in size, and blue dots represent 51 to 100 kW in size. The background is the 200-meter resolution mean annual wind speed map developed by AWS True Power for the Iowa Energy Center in 2010.

March 2015

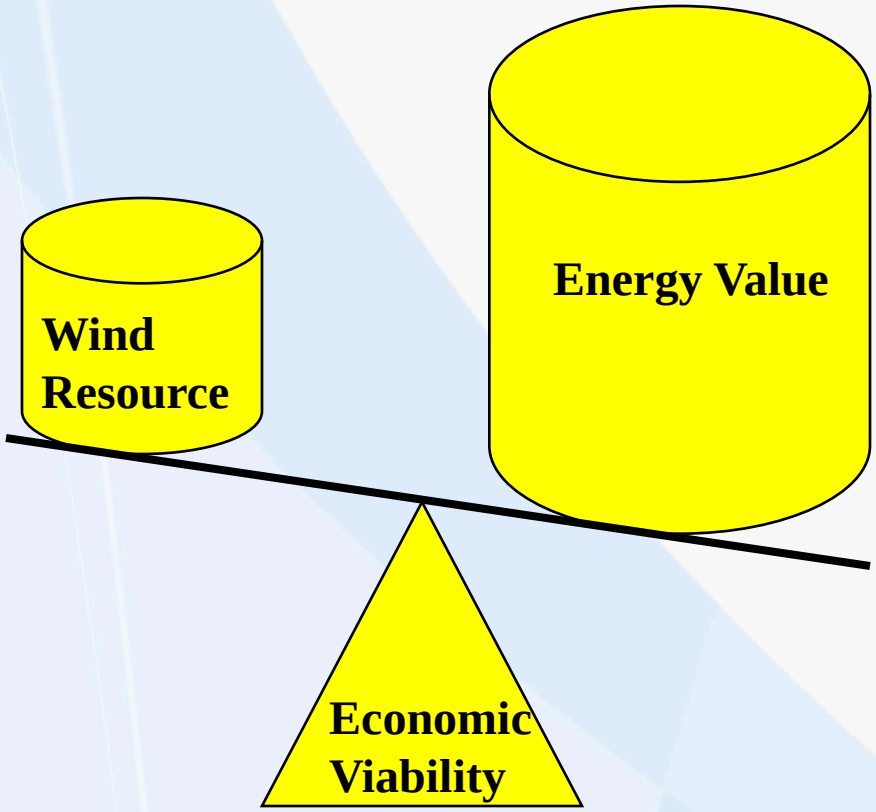
Annual Wind Generation in Iowa, GWh



EIA, 2015

Wind Power Economic Viability

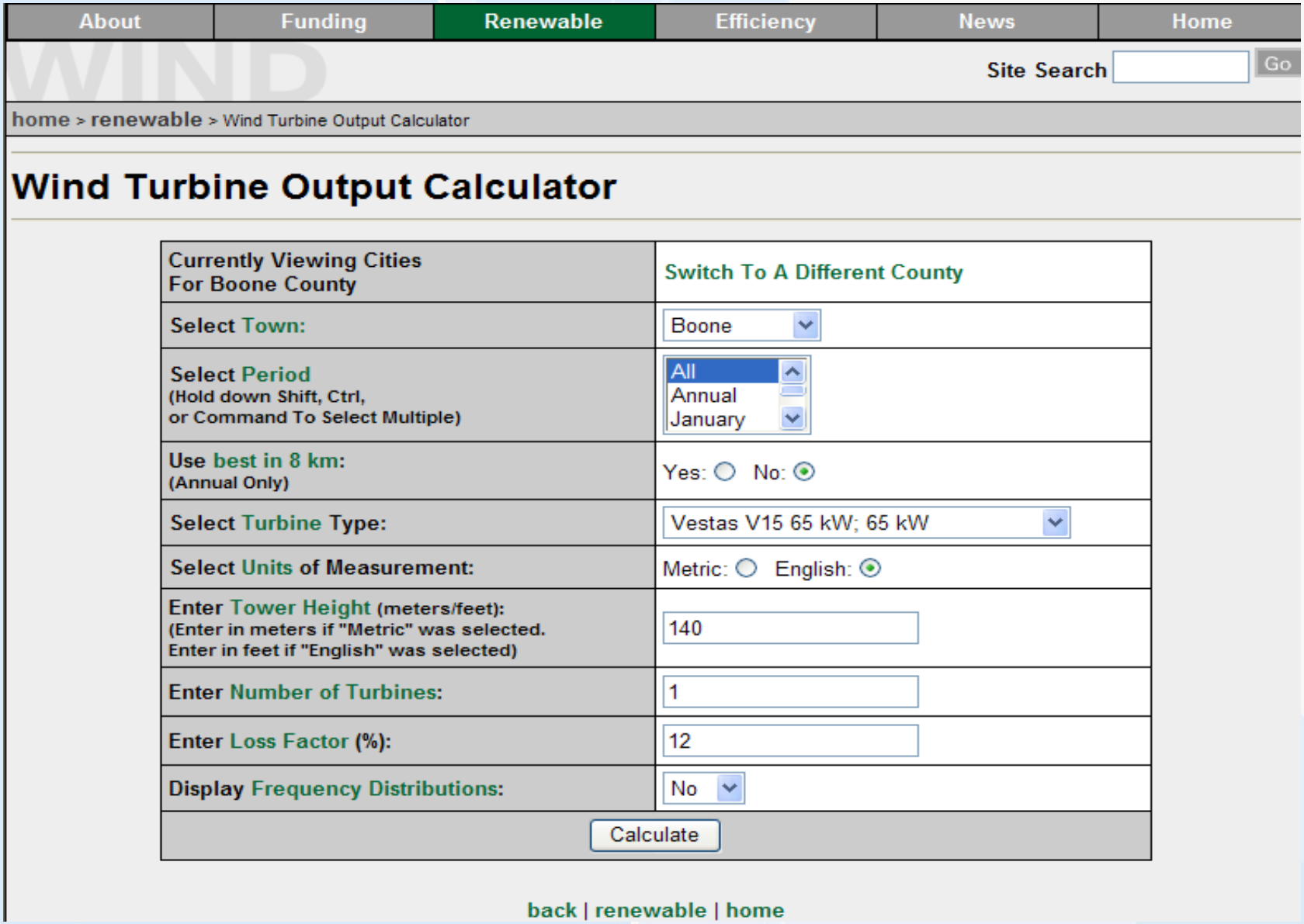
- **Economic viability is a function of:**
  - wind resource (mph)
  - value of energy ($/kWh)
- **Multiple scenarios**
  - high wind resource + high energy value
  - high wind resource + low energy value
  - low wind resource + high energy value
  - average wind resources + average energy value
- **Cost-to-Benefit Analysis**



IEC Wind Calculator

- **Demonstrate monthly variation in wind speeds**
- **Use with turbine power curve to help determine if site has minimum required wind resource**
- **Estimate electricity production for a given site under varying conditions**
  - different turbine models
  - turbine hub heights
  - loss factors
- **Model will not account for local obstructions**
  - these must be determined on a case-by-case basis

Wind Turbine Calculator Input



Wind Energy Costs

- **Capital costs**
  - technology advancements
  - economies of scale
  - utility scale wind farms are competitive with new fossil fuel power plants ($0.041 - 0.045/kWh)
- **Installed costs**
  - very small/hobby (<2.5 kW) = $8,200/kW
  - small/residential (2.5 - 10 kW) - $7,200/kW
  - medium/commercial (11 – 100 kW) - $6,000/kW
  - large/utility scale (101 – 2,500 kW) - $6,000 - $1,500/kW
- **Maintenance costs**
  - $0.005 - $0.01/kWh
  - increases with age of turbine

Renewable Energy Incentives

- **Alternate Energy Revolving Loan Program**
  - Zero-interest financing through Iowa Energy Center
- **Federal wind production tax credit (expired Dec 31, 2014)**
  - 2.3 cent/kWh inflation adjusted production tax credit over 10 years for electricity produced by turbine owner
- **Federal Investment Tax Credit (expires Dec 31, 2016)**
  - 30% for solar and small wind (<100 kW)
- **Local sales and property tax incentives**
- **USDA Grants & Loans – Renewable Energy Systems and Energy Efficiency Improvements Program**
  - Farm and Rural Investment Act of 2007
  - 25% cost share ($2,500 minimum and $500,000 maximum)
  - 50% share guaranteed loans (up to $10 million)
- **Iowa Wind Energy Production Tax Credit (expires Jan 1, 2017)**
  - $0.01/kWh or $0.015/kWh, 1st come 1st
- **Database of State Incentives for Renewables & Efficiency**
  - www.dsireusa.org – Source for Federal & State Incentives

Challenges/Opportunities for Small Wind Energy

- **General lack of equipment standardization**
  - Small Wind Certification Council (established in 2009)
    - Third party independent testing
    - Only 9 turbines have been performance certified (7 manufacturers)
- **General lack of specialized contractors**
  - North American Board of Certified Energy Practitioners (NABCEP)
    - No certified professionals in Iowa
- **Urban based permitting issues**
  - Property setback requirements
  - FAA authorization
  - Noise levels

Guidelines for Customers

- **The Iowa Attorney General has issued an advisory with these key points:**
  - Be aware of potentially misleading claims and information regarding the suitability and expected payback period of alternative energy equipment
  - Obtain a detailed written proposal that fully describes key items that are necessary for the success of your project.
  - Consult your electric utility about safety requirements, net billing, and interconnecting costs.
  - Ask the dealer about their training and experience.
  - Ask about whether the turbine is certified by the Small Wind Certification Council.
  - Consult authorities about any local zoning laws.
  - Seek a second opinion as to the cost and economics of the turbine project.
  - http://www.state.ia.us/government/ag/working_for_farmers/farm_advisories/Renewable_energy.html

Endurance E-3120, 50 kW

Windmatic 15S Remanufactured

Jacobs, Model 31-20
20 kW

Aeroman Model 41
Reman, to Next Gen 12-5
33 kW

Northern Power Systems Model 100, 100 kW

Enertech Model 44
40 kW

Xzeres Model 442SR
10 kW

? Questions ?

Iowa Energy Center

www.iowaenergycenter.org

515-294-8819