ENVIROPLAN CONSULTING

# Economic Opportunities of Locating Wind Energy Facilities in the Vicinity of Existing Electric Power Plants

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# Overview

- Purpose of Study
- The Need: State Renewable Portfolio Requirements
- How Sites for New Wind Energy Facilities are Selected

**Photo simulation of a wind farm in Texas**

# Overview

- Data and Procedures
- Results
- Conclusions

Photo simulation of a wind farm in New York

# Purpose of Study

- More than half of all states have adopted Renewable Portfolio Standards (RPS) requiring up to 20% or more of electric energy to be generated by renewable energy sources by 2020

# Purpose of Study

- The most prevalent form of new renewable energy currently being developed is wind power

# Purpose of Study

**Key Requirement for a New Wind Energy Facility:**

- Adequate wind resources
- Proximity to electric power grid connections
- Available land

# Purpose of Study

- Electric power company property at or near their power plants are prime locations for new wind energy facilities

# Purpose of Study

- **Purpose:**

  Examine the economic costs and benefits of locating new wind energy facilities near existing electric power stations given the Renewable Portfolio Standard requirements to provide renewable energy in the future

# The Need: State Renewable Portfolio Requirements

- A renewable portfolio standard is a state policy that requires electricity providers  to obtain a minimum percentage of their power from renewable energy resources by a certain date

# The Need: State Renewable Portfolio Requirements

- Currently there are 25 states plus the District of Columbia with renewable portfolio standards

- There are another three states with renewable energy portfolio voluntary goals

# The Need: State Renewable Portfolio Requirements

| STATES WITH RENEWABLE PORTFOLIO STANDARDS AS OF 2007 | | |
|---|---|---|
| **State** | **Amount** | **Year** |
| **Arizona** | 15% | 2025 |
| **California** | 20% | 2010 |
| **Colorado** | 20% | 2020 |
| **Connecticut** | 23% | 2020 |
| **District of Columbia** | 11% | 2022 |
| **Delaware** | 20% | 2019 |
| **Hawaii** | 20% | 2020 |
| **Iowa** | 105 MW | |
| **Illinois** | 25% | 2025 |
| **Massachusetts** | 4% | 2009 |
| **Maryland** | 9.50% | 2022 |
| **Maine** | 10% | 2017 |
| **Minnesota** | 25% | 2025 |
| **Missouri*** | 11% | 2020 |
| **Montana** | 15% | 2015 |

## STATES WITH RENEWABLE PORTFOLIO STANDARDS AS OF 2007

| State | Amount | Year |
|---|---|---|
| Arizona | 15% | 2025 |
| California | 20% | 2010 |
| Colorado | 20% | 2020 |
| Connecticut | 23% | 2020 |
| District of Columbia | 11% | 2022 |
| Delaware | 20% | 2019 |
| Hawaii | 20% | 2020 |
| Iowa | 105 MW | |
| Illinois | 25% | 2025 |
| Massachusetts | 4% | 2009 |
| Maryland | 9.50% | 2022 |
| Maine | 10% | 2017 |
| Minnesota | 25% | 2025 |
| Missouri* | 11% | 2020 |
| Montana | 15% | 2015 |

| STATES WITH RENEWABLE PORTFOLIO STANDARDS AS OF 2007 | | |
|---|---|---|
| **State** | **Amount** | **Year** |
| **New Hampshire** | 16% | 2025 |
| **New Jersey** | 22.50% | 2021 |
| **New Mexico** | 20% | 2020 |
| **Nevada** | 20% | 2015 |
| **New York** | 24% | 2013 |
| **North Carolina** | 12.50% | 2021 |
| **Oregon** | 25% | 2025 |
| **Pennsylvania** | 18% | 2020 |
| **Rhode Island** | 15% | 2020 |
| **Texas** | 5,880 MW | 2015 |
| **Vermont*** | 10% | 2013 |
| **Virginia*** | 12% | 2022 |
| **Washington** | 15% | 2020 |
| **Wisconsin** | 10% | 2015 |

* Voluntary goals

Reference: U.S. Department of Energy

# Data and Procedures

Wind Resource and Wind Farm Study

- Twelve months of meteorological data
  - 2006
- Two sites adjacent to coal-fired power plants
  - Near Lake Michigan

# Data and Procedures

- WindPRO, a comprehensive software package for planning and designing wind farms, was used to perform the analyses

# Data and Procedures

**Met Towers**

- Site A
  - Sensor Heights – 10, 45, and 91 m
- Site B
  - Sensor Heights – 10 and 60 m

# Data and Procedures

**Parameters Measured:**

- Wind Speed
- Wind Direction
- Date and Time

# Data and Procedures

Local Site Data Required:

- Local Wind Data
- Height Contours
- Surface Roughness
- Obstacles
- Turbine Make/Model

# Data and Procedures

## Wind Turbines

- **16 General Electric 2.5 MW Series**
  - Hub height = 80 m
  - Rotor Diameter = 88 m
  - Cut-in Speed = 3.5 m/s
  - Cut-out Speed = 25 m/s
  - Reliable and Commercially Available

**General Electric 2.5 MW Wind Turbine**

# Data and Procedures

- Medium Sized Wind Farm (40 MW)
  - Economies of Scale

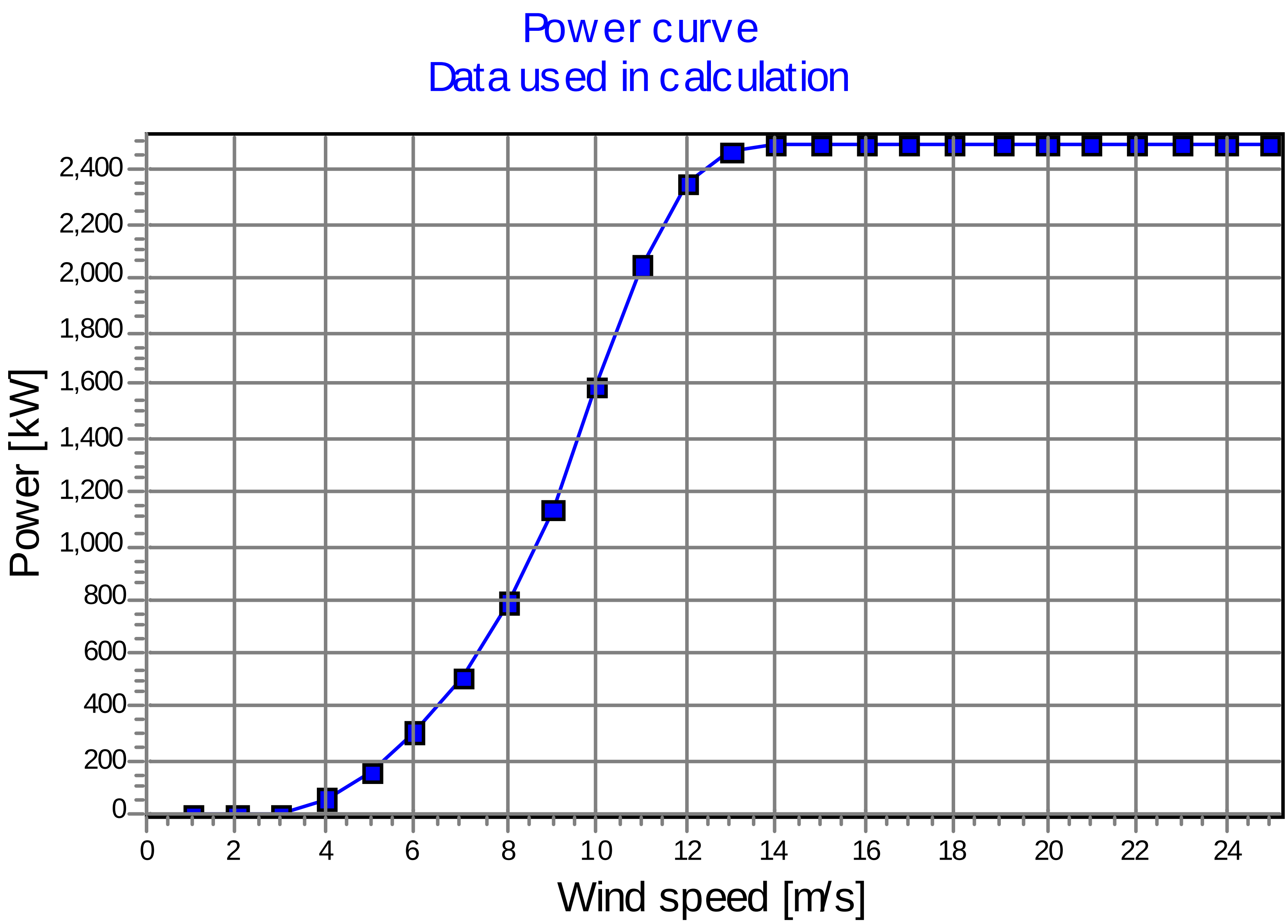
**General Electric 2.5 MW Wind Turbine**

# Data and Procedures

## Wind Classes:

- Area has low-end International Electrotechnical Commission (IEC) Class I to Class II wind resources

- Average wind speed of between 0.0 and 6.4 m/s with power density of between 0 and 300 watts/meter at 50 meter height




**Source: Manufacturer data for General Electric 2.5 MW Wind Turbine**

## Classes of Wind Power Density at 10 m and 50 m[a]

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

(a) Vertical extrapolation of wind speed based on the 1/7 power law

(b) Mean wind speed is based on the Rayleigh speed distribution of equivalent wind power density. Wind speed is for standard sea-level conditions. To maintain the same power density, speed increases 3%/1000 m (5%/5000 ft) of elevation.
(from the Battelle Wind Energy Resource Atlas)

# Wind Resource Analyses Results

## Site A

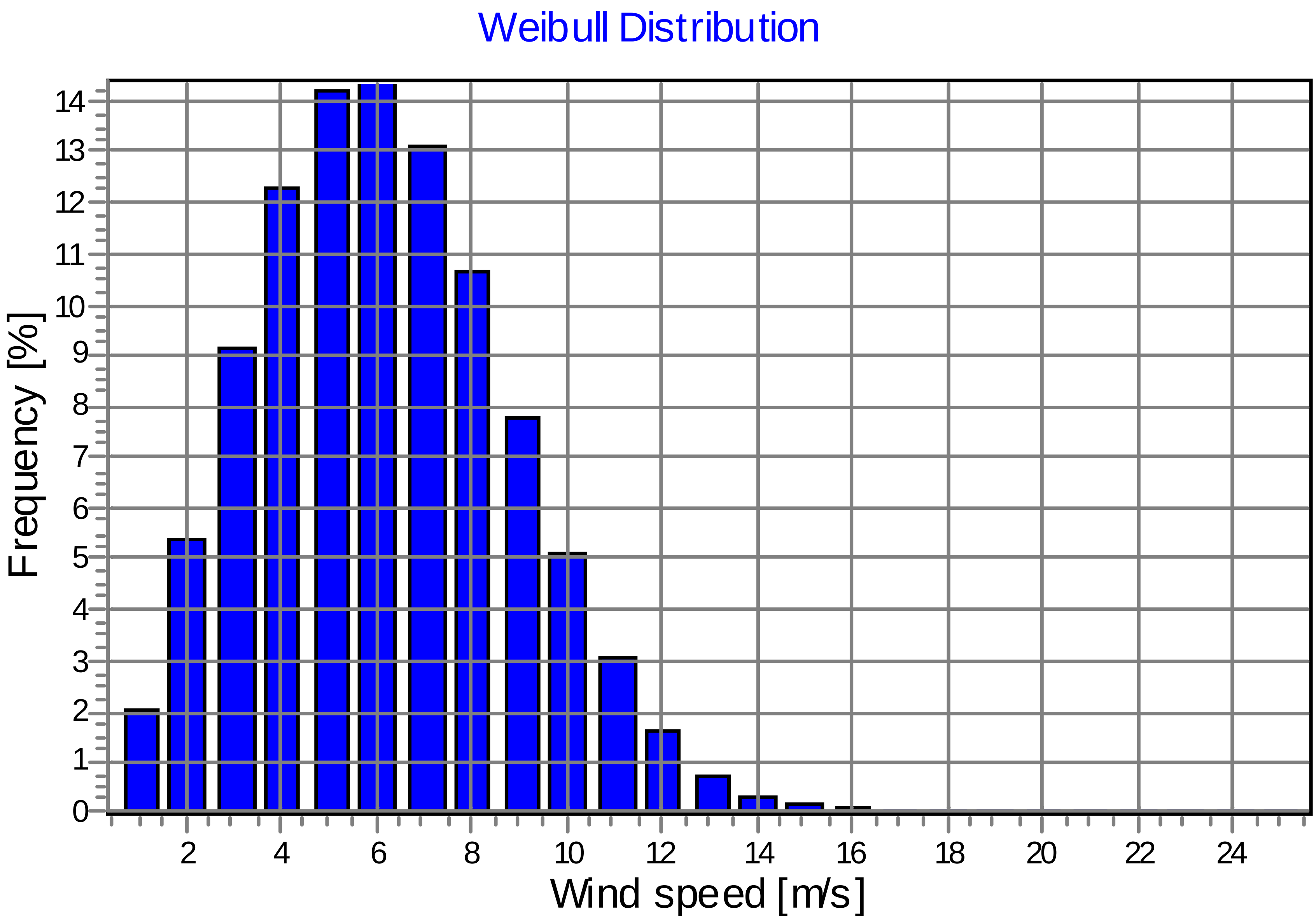
- Average Wind Speed at Turbine Hub Height Adjusted from Met Tower Data = 6.0 m/s
- Capacity Factor = Actual Annual Output/Rated Output = 17.8%
- Actual Annual Output = 62,569.6 MWh/yr
- Rated Output = 350,400 MWh/yr
- Average Annual Energy Output = 3,910.5 MWh per Turbine

# Wind Resource Analyses Results

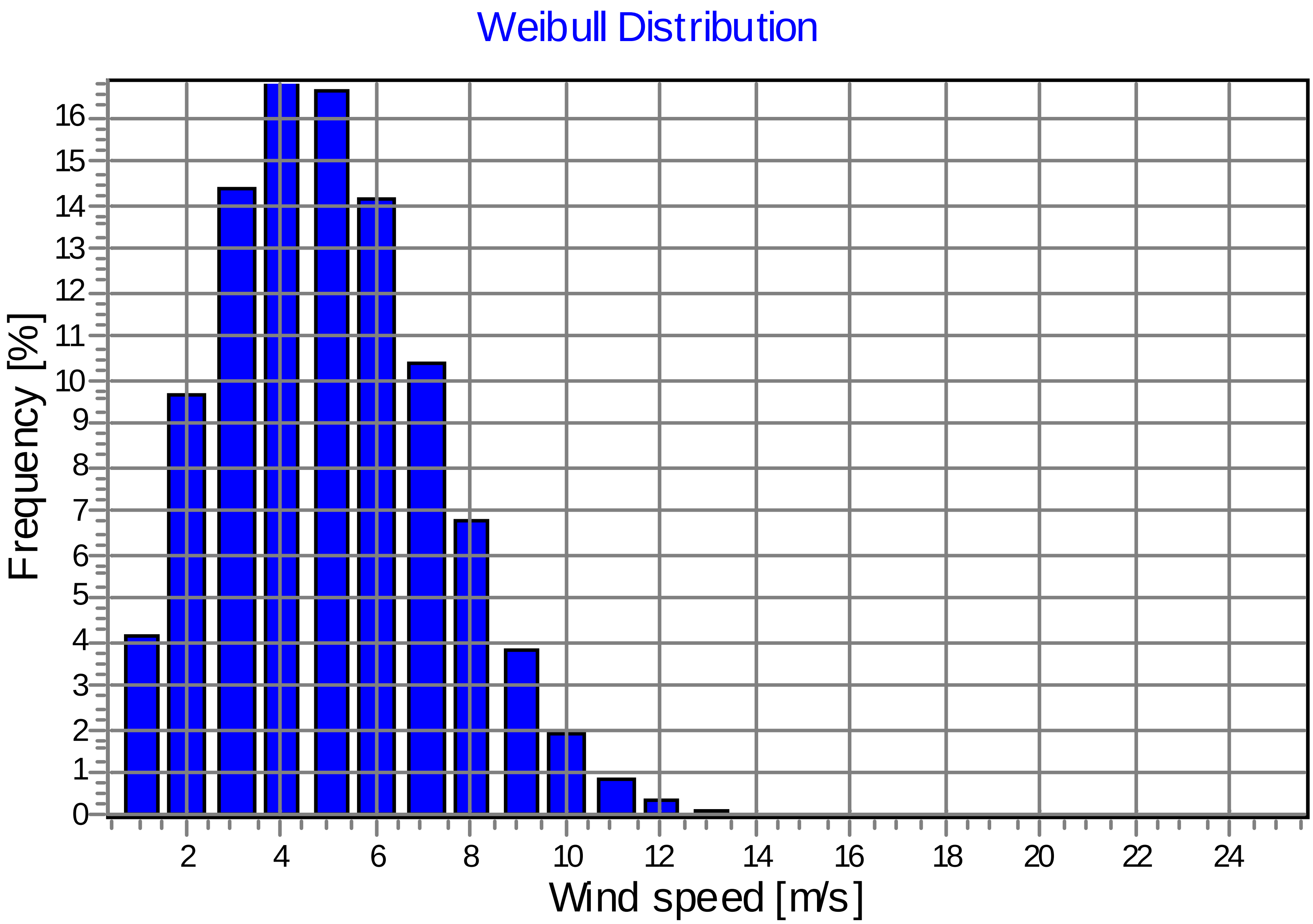
**Site B**

- Average Wind Speed at Hub = 5.2 m/s
- Capacity Factor = 18.2%
- Actual Annual Output = 63,814 MWh/yr
- Rated Output = 350,400 MWh/yr
- Average Annual Energy Output = 3,988.4 MWh per turbine

# Site A Wind Resource Analyses Results

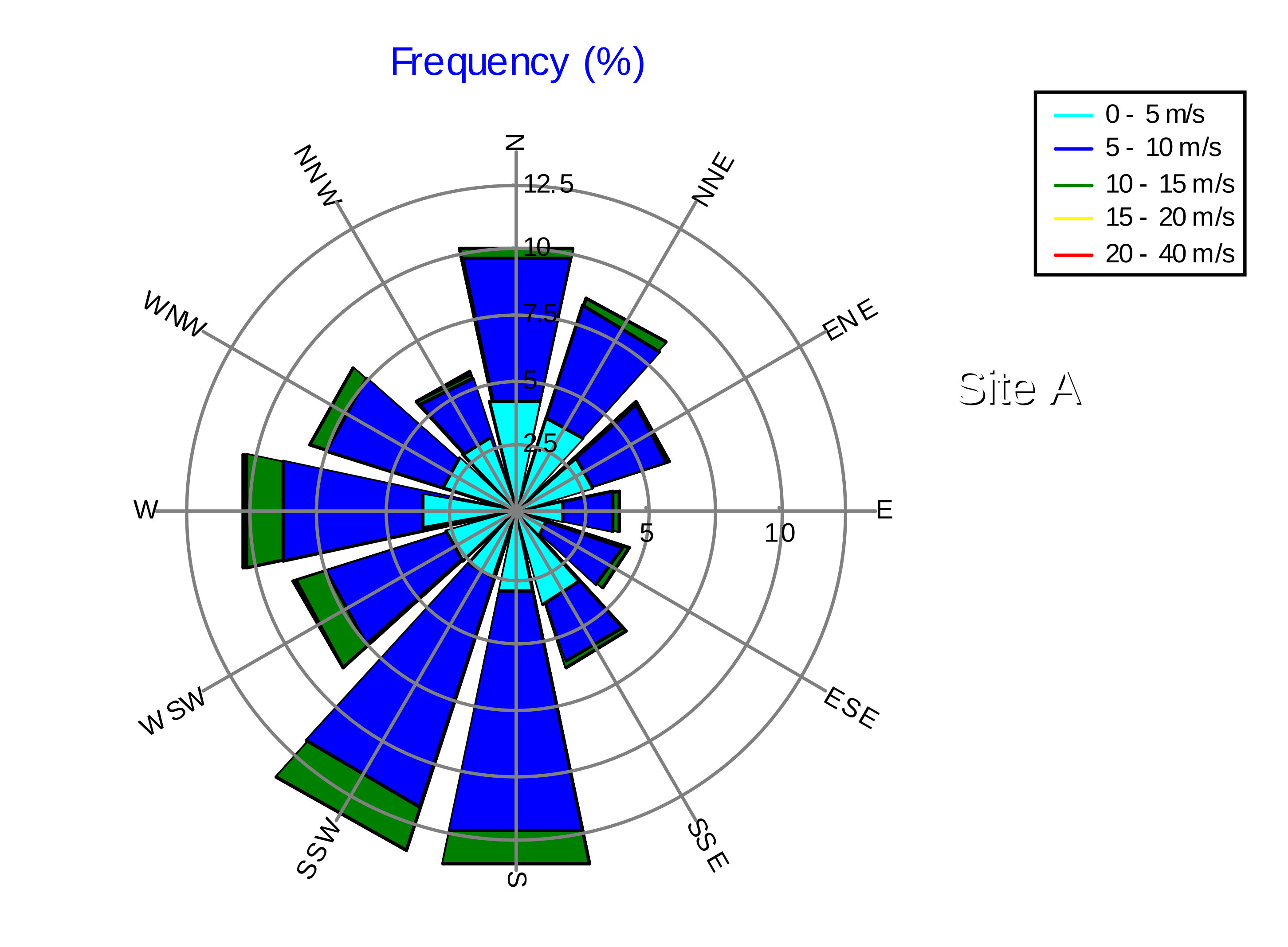


# Site B Wind Resource Analyses Results



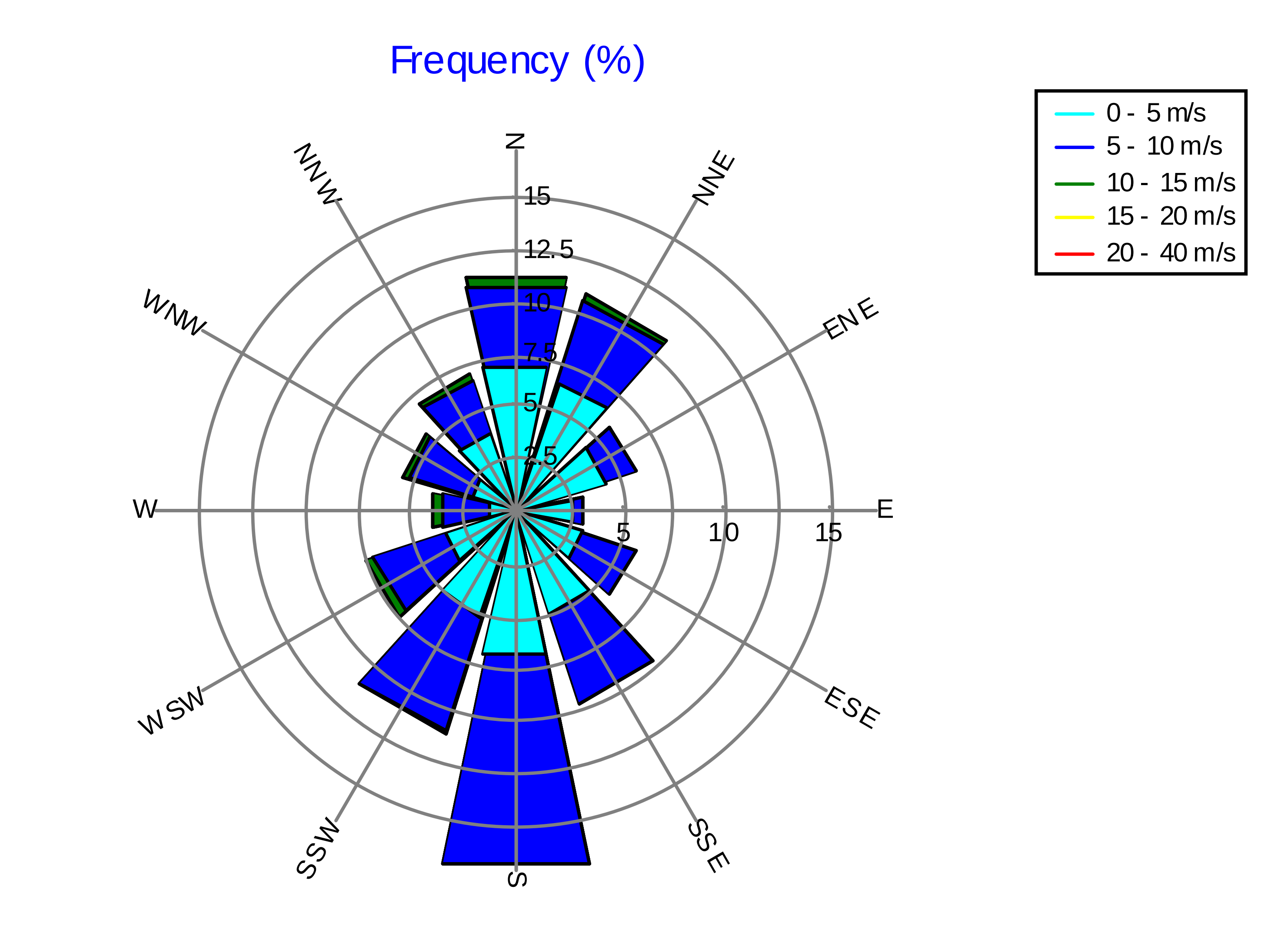
# Wind Resource Analyses Results

**Predominant Wind Direction: S to SSW (Site A)**



# Wind Resource Analyses Results

## Predominant Wind Direction: S (Site B)



# Economic Feasibility Results

Following project costs are based mainly on an National Renewable Energy Laboratory model in a technical report entitled Wind Turbine Design Cost and Scaling Model

# Economic Feasibility Results

The capital costs of the project (per turbine) include:

- Turbine cost - $2,000,000
- Electrical interface/connection costs - $191,000
- Transportation costs - $150,000
- Roads and civil work costs - $118,000

# Economic Feasibility Results

The capital costs of the project (per turbine) also include:

- Insurance (pre-pay 5 yrs) - $100,000
- Other costs - $182,000
  - Foundation costs
  - Assembly and installation costs
  - Engineering and permitting costs

# Economic Feasibility Results

Total Estimated Capital Costs are:

- $2,741,000 per turbine
- $43,856,000 for 16 turbines

# Economic Feasibility Results

The annual operating and maintenance costs include:

- Warranty
- Service and maintenance
- Insurance
- Levelized replacement cost – fund for major overhauls

# Economic Feasibility Results

## Assumptions:

- Land lease fees not included (property assumed to be owned by the electric power company)

- Environmental impacts and mitigation costs not considered

# Economic Feasibility Results

## Assumptions:

- Revenue streams from Renewable Energy Certificates (RECs) not considered
- An REC is a tradable environmental commodities that represent proof that 1 megawatt-hour (MWh) of electricity was generated from an eligible renewable energy source
- Current market prices of RECs are $5 to $90 per MWH

# Economic Feasibility Results

## Assumptions:

- Revenue streams from wind energy Production Tax Credits (PTCs) are included for 2008 but excluded for future years since the PTC expires on 12/31/08

- A PTC in 2008 provides a 2.0 cent-per-kilowatt-hour (kWh) tax credit for electricity generated with wind turbines over the first ten years of a project's operations

# Economic Feasibility Results

**Assumptions:**

- 20 year lifespan for turbines
- Constant 2008 wholesale electricity price of $0.035/kWh adjusted for inflation at rate of 2% per year

Source:

# Economic Feasibility Results for Site A

# Economic Feasibility Results for Site B

# Economic Feasibility Results

| Site | Payback Time |
|---|---|
| A | |
| B | |
| Turbine Lifespan: | 20 years |

# Conclusions

Wind farms at each power plant site are not economically feasible based on current assumptions

# Conclusions

Wind farms at each power plant site may become economically feasible:

- If the Federal Production Tax Credit is extended beyond 2008
- As the market develops for Renewable Energy Credits

# Conclusions

As electric power companies increasingly become subject to Renewable Portfolio Standards, economic feasibility will no longer be the condition for deciding whether to build a wind energy facility

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As electric power companies increasingly become subject to Renewable Portfolio Standards, economic feasibility will no longer be the condition for deciding whether to build a wind energy facility

# Conclusions

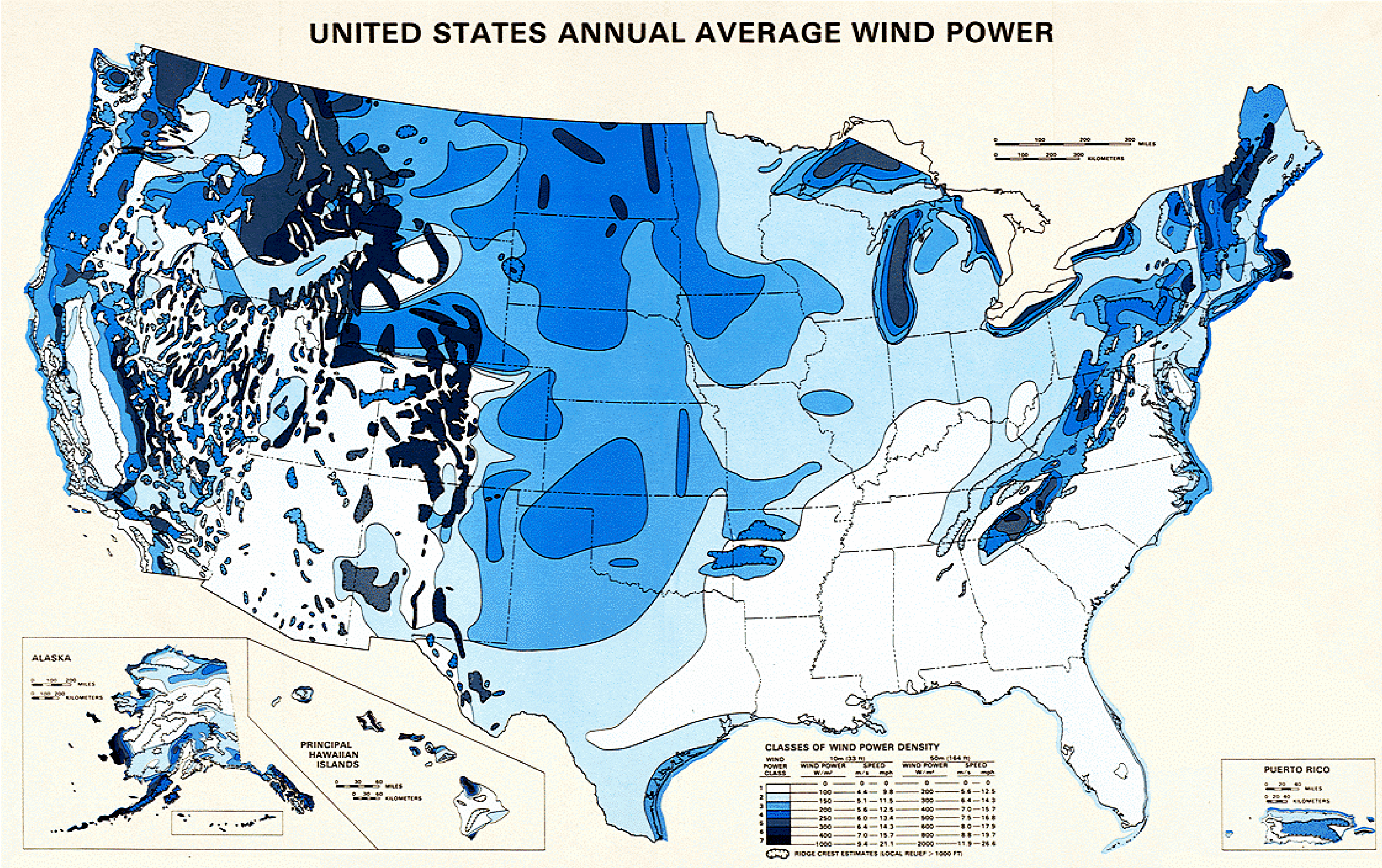
Instead the condition will be:

Is this the least costly way of satisfying my Renewable Portfolio Standard requirements?

# Conclusions

Many areas in the U.S. are suitable for wind energy development

# Conclusions



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