Kalamazoo: Windmill City

- Smith & Pomeroy Windmill Co.
- Phelps & Bigelow
- 1880’s annual production of 4,000
- Exported windmills Europe, South America, Africa, & Australia
Wind Power = Clean Power

(No smokestack and no tailpipe)

- No sulfur dioxide
- No nitrogen dioxides
- No carbon dioxide
- No particulates
- No mercury
- No water used
Evolution of U.S. Commercial Wind Technology

**The 1980's**
- Altamont Pass, CA
- Kenetech 56-100kW

**The 1990's**
- Altamont Pass, CA
- Kenetech 33-300kW
- Buffalo Ridge, MN
- Zond Z-750kW
- 500kW
- 300kW
- 100kW
- 50kW

**2000 & Beyond**
- Arklow, Scotland
- GE 3.6MW
- 2.5 MW
- 1.5 MW
- Medicine Bow, WY
- Clipper 2.5MW
- 93m blade

Rotor Diameter in meters

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</table>
Wind Generation in the US

Year

MW

2001 2002 2003 2004 2005 2006

0 2000 4000 6000 8000 10000 12000
Increased Turbine Size - R&D Advances - Manufacturing Improvements
**World View**

*Total Installed Wind Capacity*

1. Germany: 20952 MW
2. Spain: 12500 MW
3. United States: 12376 MW
4. India: 7093 MW
5. Denmark: 3136 MW

*World total July 2007: 78728 MW*

*Source: WindPower Monthly*
U.S. Leads World in Annual Capacity Additions
Third in Cumulative Capacity

Table 1. International Rankings of Wind Power Capacity

<table>
<thead>
<tr>
<th>Cumulative Capacity (end of 2006, MW)</th>
<th>Incremental Capacity (2006, MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>20,652</td>
</tr>
<tr>
<td>Spain</td>
<td>11,614</td>
</tr>
<tr>
<td><strong>US</strong></td>
<td><strong>11,575</strong></td>
</tr>
<tr>
<td>India</td>
<td>6,228</td>
</tr>
<tr>
<td>Denmark</td>
<td>3,101</td>
</tr>
<tr>
<td>China</td>
<td>2,588</td>
</tr>
<tr>
<td>Italy</td>
<td>2,118</td>
</tr>
<tr>
<td>UK</td>
<td>1,967</td>
</tr>
<tr>
<td>Portugal</td>
<td>1,716</td>
</tr>
<tr>
<td>France</td>
<td>1,585</td>
</tr>
<tr>
<td>Rest of World</td>
<td>11,102</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>74,246</strong></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: BTM, 2007; AWEA/GEC dataset for U.S. cumulative capacity.
U.S. Lagging
Wind % of Electricity Consumption

Projected Wind Production as % of Electricity Consumption (approximate, end of 2009)

- Denmark: 21.4%
- Spain: 8.8%
- Portugal: 7.0%
- Germany: 7.0%
- India: 1.7%
- UK: 1.5%
- Italy: 1.3%
- US: 0.8%
- France: 0.7%
- China: 0.2%
- TOTAL: 0.9%

Source: Berkeley Lab estimates based on data from BTM and elsewhere.
United States - Current Installed Wind Power Capacity (MW)

Total: 22,813 MW
(As of 9/30/06)

Wind Power Capacity
Megawatts (MW)
- 1,000 - 4,500
- 100 - 1,000
- 20 - 100
- 1 - 20

Data from the American Wind Energy Association (AWEA) and Global Energy Concepts (GEC) database.

U.S. Department of Energy
National Renewable Energy Laboratory

15-OCT-2006 1:13
Nationally, Wind Has Been Competitive with Wholesale Power Prices in Recent Years

- Wind projects built from 1998-2006 have, in aggregate, been competitive relative to conventional wholesale prices over the 2003-06 timeframe.
- Wholesale price range reflects a flat block of power across 26 pricing hubs in the U.S.

Great Lakes, Great Winds

- Now – 55.5 MW
- Includes Harvest Wind Farm – 52.8
- On-Shore Potential 15,000 – 25,000 MW
- Off-Shore Potential > 40,000 MW
100 meter map Michigan
Buy Local/Buy Wind

• Out of State

• 100% coal
• 96% oil
• 75% natural gas

$20 billion leaves MI each year
Wind Power = Jobs

- Harvest Wind Farm
- 32 turbines, ~ 50 MW
- 80 construction jobs
- 6-10 permanent jobs
- $90 million investment
Michigan – Economic Impacts
from 1000 MW of new wind development

Wind energy’s economic “ripple effect”

**Direct Impacts**

Payments to Landowners:
- $2.7 million/year

Local Property Tax Revenue:
- $18.6 million/year

**Construction Phase:**
- 1426 new construction jobs
- $188.5 M to local economies

**Operational Phase:**
- 230 new long-term jobs
- $21.2 M/yr to local economies

**Indirect Impacts**

**Construction Phase:**
- 560 new jobs
- $53.5 M to local economies

**Operational Phase:**
- 60 local jobs
- $6.6 M/yr to local economies

**Induced Impacts**

**Construction Phase:**
- 844 new jobs
- $83.4 M to local economies

**Operational Phase:**
- 217 local jobs
- $21.5 M/yr to local economies

**Totals (construction + 20 yrs)**

Total economic benefit to Michigan = $1.3 billion
New local jobs during construction = 2830
New local long-term jobs = 507
Michigan Results

Total economic impacts from new wind and coal plants in Michigan
(direct, indirect and induced)
Construction + 20 yrs of operation

<table>
<thead>
<tr>
<th></th>
<th>Millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind (715 MW)</td>
<td></td>
</tr>
<tr>
<td>Wind (2.5% tax)</td>
<td></td>
</tr>
<tr>
<td>Coal (250 MW)</td>
<td></td>
</tr>
</tbody>
</table>

- **Landowner revenue**
- **Property taxes**
- **Operations**
- **Construction**
Wind Power = Manufacturing Jobs

- Nov 2006 study by Renewable Energy Policy Project
- MI ranked 4th for potential activity
- Over 900 potential firms
- 8,000-24,000 jobs depending on state & national policies

K&M Machine Fabricating
Cassopolis
Wind Industry Suppliers in Michigan

1. ADCO Circuits – Controls
2. American Chemical Technologies
3. Ann Arbor Machine Company – Gear and Gear Boxes
5. Axson North America – Lubricants/Chemicals
6. Cascade Engineering – Engineering and System Integrator
7. Citation Corporation – Machined, Cast, and Forged Components
8. Cobasys – Batteries
9. Danotek Motion Technology – Generators
10. Diversified Sales and Service, Inc. – Installers
11. Dowding Industries – Tower Construction and Machining Transmission Housings
12. Freedom Power – Installers
13. Goertz – Schiele – Gear and Gear Boxes
14. Great Lakes Gear Technologies, Inc. – Gear and Gear Boxes
15. K&M Machine Fabricating, Inc. – Machined, Cast, and Forged Components
16. Kaydon Corporation – Bearings
17. Hov-Aire – Rotor and Blade Fabrication
18. Kurdziel Industries – Machined, Cast, and Forged Components
19. Merrill Fabricators – Generators
22. NSK Corporation – Gear and Gear Boxes
23. Pernetic Generator Group – Technology Developers
24. Ricardo Engineering – Engineering and System Integrator
25. Siemens VDO Electric Drives – Controls
26. Simrit, Division of Freudenberg–NOK – Lubricants/Chemicals
27. Steel Industries, Inc. – Machined, Cast, and Forged Components
28. Su-Dan Corporation – Machined, Cast, and Forged Components
29. Three M Tool & Machinery – Gear Boxes and Machined Components
30. Tool North, Inc. – Machined, Cast, and Forged Components
31. Trenton Forging – Machined, Cast, and Forged Components
32. Triad Services Group – Machined, Cast, and Forged Components
33. Wahoo Composites – Machined, Cast, and Forged Components
34. Williams Form Engineering Corporation – Fasteners
35. Wind to Energy – Technology Developers
Industry Value Chain Map: WIND

From Raw Material-to-Installation

Raw Material & Machinery Suppliers
- Steel
- Carbon Fiber
- Balsa Wood
- Fiberglass
- Other materials

Manufacture Services
- Design
- Engineering
- University Research
- Machining
- Automation
- Assembly

Component Suppliers
- Gear Boxes
- Bearing
- Tower
- Generators
- Blades
- Electronics

Wind Turbine Companies
- OEMs
- Large Utility Scale
- Small Wind
- New Wind Energy Designers

Wind Developers
- Feasibility Analysis Firms
- Project Developers
- Utilities

Construction & Installation Services
- Engineering & Procurement (EPC)
- Construction Companies
- Transportation Services
- Operation & Maintenance

Wind Turbine Companies
- GE
- Clipper
- Vestas
- Bergey
- SW Wind
- ADSC
- Aerotecture
- Watts

Raw Material & Machinery Suppliers
- Ricardo*
- K&M
- Allegheny/ATI

Component Suppliers
- Williams Forum
- Kaydon
- SKF
- Danotek*
- FlexSys*

Wind Turbine Companies
- Mackinaw Power
- Noble Power
- FES Surveyors
- DTE
- Consumers Energy

Construction & Installation Services
- Walbridge
- High Rise Escape
- Buist Electric
- Industrial Control Repair
- Hov-aire

*NEC New Venture Clients
Want a Job in the Wind Industry

• Research
  American Wind Energy Assoc. [www.awea.org](http://www.awea.org)
  Great Lakes Renewable Energy Assoc. [www.glrea.org](http://www.glrea.org)
  North American Windpower Magazine – Wind Jobs

• Network, Network, Network
  Calendar of Events
  Michigan Wind Working Group [www.michigan.gov/energyoffice](http://www.michigan.gov/energyoffice)
DOE 20% by 2030

300 GW (nationally)
20 GW for Michigan
≈10,000 2-MW turbines
20% Wind Vision
20% of U.S. Electricity by 2030

Installed Wind Nameplate Capacity by State (2030)

Wind Capacity
Total Installed (2030) (GW)

- 0.0 - 0.1
- 0.1 - 1
- 1 - 5
- 5 - 10
- 10 - 20
- > 20

The black square in the center of a state represents the land area needed for a single wind farm to produce the projected installed capacity in that state. The white square represents the actual land area that would be dedicated to the wind turbines (2% of the black square).
What does 20% Wind look like?

Source: AWEA 20% Vision
Total Cumulative Manufacturing Jobs Created by Scenario that Meets 20% of U.S. Electricity Needs From Wind (2007 - 2030)


Major component assumptions: 50% of blades are manufactured in U.S. in 2004 increasing to 80% in 2030; 26% of towers are from the U.S. in 2004 increasing to 50% in 2030 and 20% of turbines are made in the U.S. increasing to 42% by 2030.
Potential Michigan Suppliers to the Wind Industry
**Manufacturing Potential to Serve U.S. Growth in Renewables (Michigan)**

<table>
<thead>
<tr>
<th>Michigan</th>
<th># U. S. MW</th>
<th>Number of Firms</th>
<th>Millions $ Investment</th>
<th>New FTE Jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>124,900</td>
<td>967</td>
<td>$3,453</td>
<td>24,350</td>
</tr>
<tr>
<td>Solar</td>
<td>23,150</td>
<td>360</td>
<td>$1,256</td>
<td>6,644</td>
</tr>
<tr>
<td>Geothermal</td>
<td>15,190</td>
<td>129</td>
<td>$272</td>
<td>1,502</td>
</tr>
<tr>
<td>Biomass</td>
<td>21,760</td>
<td>594</td>
<td>$349</td>
<td>2,281</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>185,000</strong></td>
<td><strong>2,050</strong></td>
<td><strong>$5,328</strong></td>
<td><strong>34,777</strong></td>
</tr>
</tbody>
</table>

* Assumes 18,500 installed per year for 10 years in U.S. (“Climate Stabilization Case”, REPP, 11/06)
20% Vision Conclusions

• 20% wind energy penetration is possible
• 20% penetration is not going to happen under business as usual scenario
• Policy choices will have a large impact on achieving a 20% goal
• 20% Vision action plan: Fall 2007
Renewable Portfolio Standard

- 27 states & D.C.
- Mandate on electric suppliers
- % electricity from renewables by ?
- Michigan 10% by 2015 & 20% goal by 2025
- Would count existing 3% renewables toward goal
MI 10 percent RPS by 2015

- ~1,250 wind turbines
  - 313 acres of wind tower land footprints
- 50,279 acres of wind farm area
- 49,966 acres would continue to be usable
- With a total of 37,361,780 acres of land area in Michigan, the 2015 RPS goal would require use of 0.14 percent of it.
Available Today
Small, Medium & Large
St. Elizabeth’s – 400 watt
1.8 kW Skystream

L. Mawby Vineyards

Suttons Bay, Michigan
Detroit EITC – 6 kW
Zeeland West High School

10-kW Bergey XL-10 on an 85-foot tower

Financed primarily through donations, including a local contractor

School uses all of the electricity generated

Annual savings = $1200.
Northwestern Michigan College
10 kW
Laker Public Schools
Three 65 kW
Ishpeming Housing Commission
200 kW
Mackinaw City – Two 900 kW
Harvest Wind Farm

- John Deere Wind Energy Project
- Huron County
- 32 Wind Turbines, 1.65 MW each
- 52.8 MW / Enough to Power 15,000 homes
- Commercial Operation: Wolverine Power
Future?
WMU Information and Resources

• Alternative and Renewable Energy
  – [http://wmich.edu/mfe/energy](http://wmich.edu/mfe/energy)

• WMU Wind Energy Lab and Research

• WMU Sustainability Efforts and Programs
Installation Costs

- Estimate $2-5/installed watt for typical system
- Smaller systems require smaller initial outlay, but cost more per watt
- Taller towers cost more, but usually reduce the payback period

A 4-10 kW system can meet the needs of a typical home
Net Metering

- Customers provide excess electricity to utilities
- Bill credit, no payment
- Renewables up to 30 kW
- Alternative to batteries
- MPSC and utilities working on improvements

www.michigan.gov/netmetering
Community Energy Project Grants

- Federal funds thru Michigan Energy Office
- Non-profit & public orgs eligible
- Wind Energy Education is 1 category of 5
- Up to $6,000, 20 projects in all categories
- Deadline – Sept 2009 for 2010 grants
Local Ownership Models

- Minnesota farmer cooperative (Minwind)
- FLIP structure
- Farmer-owned small wind
- Farmer-owned commercial-scale
Siting Guidelines

• Siting & zoning are primarily township or county responsibility
• There are state and federal requirements, e.g. Federal Aviation Administration
• Energy Office has voluntary guidelines
• Different requirements for “On-Site Use” & “Utility Grid”
• [www.michigan.gov/eorenew](http://www.michigan.gov/eorenew)
Siting Topics

- Set-Backs
- Sound Levels
- Construction Codes & Utility Interconnection
- Safety
- Visual Impact
- Environmental Impact
- Avian & Wildlife Impact
- Electromagnetic Interference
- Shadow Flicker
- Decommissioning
- Complaint Resolution
Avian Impact

- Siting guidelines require third party analysis
- Look at endangered species, wildlife refuges, bat hibernacula, wooded ridge tops, migration pathways
- 4 Midwest studies have shown minimal impact – ave 2.7 birds/turbine/year

<table>
<thead>
<tr>
<th>Causes of Bird Fatalities</th>
<th>Number per 10,000 fatalities</th>
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<tbody>
<tr>
<td>5,500 – buildings/windows</td>
<td></td>
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<tr>
<td>1,000 – domestic cats</td>
<td></td>
</tr>
<tr>
<td>1,000 – other</td>
<td></td>
</tr>
<tr>
<td>800 – high tension lines</td>
<td></td>
</tr>
<tr>
<td>700 – vehicles</td>
<td></td>
</tr>
<tr>
<td>700 – pesticides</td>
<td></td>
</tr>
<tr>
<td>250 – communication towers</td>
<td></td>
</tr>
<tr>
<td>Less than 1 – wind turbines</td>
<td></td>
</tr>
</tbody>
</table>

Source: Erickson, et al. 2000, Summary of Anthropogenic Causes of Bird Mortality
For every 10,000 birds killed by human activities, less than one death is caused by a wind turbine.

Sound Levels

- Siting guidelines:
  - 55 dB(A) at property line
- Normal conversation:
  - 50-65 dB(A)
- Refrigerator:
  - 70 dB(A)
- Today’s turbines are much quieter than older turbines
Visual Impact

- Siting guidelines require
- Tubular towers
- Single, non-reflective matte color
- Similar design, size, & appearance
- No advertising, nacelles may have lettering
- Avoid scenic areas
Kinetic Art?
Carpe Ventem
USDA 9006 Grants

- Biomass, Solar, & Wind
- Up to 25% of project costs
- Minimum - $2,500
- Maximum - $500,000
- Agricultural producer or rural small business