Disclaimer: The views expressed are those of Paul Gipe and are not necessarily those of the sponsor.

Disclosure: Paul Gipe has worked with Aerovironment, ANZSES, APROMA, ASES, AusWEA, AWEA, BWEA, BWE, CanWEA, CAW, CEERT, DGW, DSF, EECA, ES&T, GEO, GPI Atlantic, IREQ, KWEA, MADE, Microsoft, ManSEA, MSU, NRCan, NRG Systems, NASA, NREL, NZWEA, ORWWG, OSEA, PG&E, SeaWest, SEI, TREC, USDOE, WAWWG, WE Energies, the Folkecenter, the Izaak Walton League, the Minnesota Project, the Sierra Club, and Zond Systems, and written for magazines in the USA, Canada, France, Denmark, and Germany.
Lessons
From 30+ Years of Experience

• No Panaceas
• No Cheap Solutions
• No Breakthroughs--No Miracles
• Numbers Matter
• Experience Matters
• Size Matters

Paul Gipe, wind-works.org
Lessons

• Always Check the Numbers
  Vortec: The Numbers Didn’t Add Up

• Always Check the References
  Vortec: References Discredited in the USA

• Always Google
  Vortec: Ducted Turbine Critics on the Web

• Always Go to the Library
  . . . Or to Your Neighborhood Bookstore!
  Lots of Wind Books Now Available

Paul Gipe, wind-works.org
Lessons

• Always Be Wary of “New” Designs
Scams, Frauds, & Flakes
Tell-Tale Signs

• Hype High--Experience Low
• New Design-- “Not Like Those Others”
• “New” Patents
• “Works @ 2 m/s!
• Drag Devices (Squirrels in a Cage)
• Ducted Turbines!
• Pyramid Schemes
  “Get in on the Ground Floor Now”
• Fancy Web Sites
  Cheaper than Hardware
Nomenclature

- Mid-80s HAWT
- Internal Ladder
- w/ Fall Restraint
- Work Platform
- Tip Brakes
- “Rocket” Tower

Paul Gipe, wind-works.org
Applications--Off-the-Grid

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Applications--Homes

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Applications--Farms

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Applications--Wind Power Plants

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Small Groups or Clusters

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Era of Distributed Generation

- Here Now
- Resilient, Not Brittle
- Short Lead Times
- Near Load, Less Losses
- Opportunity for Many
- Fosters Energy Awareness
Distributed Wind Energy

Hohe Westerwald, Germany

Paul Gipe, wind-works.org

Hohe Westerwald, Germany
Distributed Wind Energy

Wisconsin, USA

Michigan, USA

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Distributed Wind Energy

Thy, Denmark
Wind Plant Arrays--Rectilinear

160-250 kW: Mojave, California

Paul Gipe, wind-works.org
Typical California Spacing

3 RD

6 RD

Paul Gipe & Assoc.
Wind Plant Arrays
Linear

Paul Gipe & Assoc.
Single Turbine Interconnection

Paul Gipe, wind-works.org
Cluster

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Measures of Productivity

• **Capacity (Plant) Factor**
  Misleading Indicator
  Used for Fossil-Fired Plants
  Not Suited for Wind Energy Use

• **kWh/kW/yr (for Planning Purposes)**
  When Sufficient Data is Unavailable

• **Annual Specific Yield (kWh/m²/yr)**
  The Only Measure Specific to Wind Energy

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Measures of Cost

- $/kW of Installed Capacity
  Often a Misleading Indicator

- $/m^2 of Installed Swept Area
  Most Useful When Resource is Unknown

- $/kWh/yr of Annual Generation
  Most Important Criteria in the End

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Interconnected Wind Turbines

- 90,000 units worldwide--115 TWh/yr
- 600 TWh cumulative generation
- 7,400 million operating hours
- 75% induction (asynchronous) generators
- 25% AC-DC-AC with inverters

Paul Gipe & Assoc.
Large Turbine Manufacturers

- Vestas (DK)
- Bonus-Siemans
- NEG-Micon (DK)
- Enercon (D)
- GE Wind (D-US)
- Gamesa (ES)
- Mitsubishi (JP)

- Nordex (DK)
- Ecotecnia (ES)
- DeWind (D)
- Suzlon (India)
- Lagerwey (NL)
- RePower (D)
- Fuhrlander (D)

Paul Gipe & Assoc.
Drive Trains
Traditional Danish
Bonus 63 m, 1.3 MW

© Bonus

Paul Gipe & Assoc.
Direct-Drive Wind Turbines

- Enercon (D)
- Lagerwey (NL?)
- Jeumont-Industrie (F)
Drive Trains
Direct-Drive (Large)

Paul Gipe & Assoc.
© Lagerwey
AEO Estimating Methods

- **Back-of-the-Envelope (Swept Area)**
  Simple Approximation

- **Power Curve & Speed Distribution**
  Method Used by the Pros
  Accuracy Dependent Upon Data

- **Manufacturers’ Tables**
  Dependent Upon Honesty of Manufacturer

- **Software**
  Must Know Assumptions Used (RETScreen)
Medium-Size & Large Wind Turbines

Rotor Diameter (m)

- 50
- 250
- 500
- 1000
- 1500
- 2000

Swept Area (m²)

- 0
- 1000
- 2000
- 3000
- 4000
- 5000

Diameter (meters)

- 15
- 25
- 40
- 60
- 70
- 80
AEO Medium & Large Turbines

AEO for Medium-Size Wind Turbines
Per Square Meter of Swept Area

Average Annual Wind Speed (m/s) vs Thousand kWh/year/m²

Average Annual Wind Speed (mph)

4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8

AEO Medium & Large Turbines
### Estimating AEO

**Swept Area Method for 7 m/s**

<table>
<thead>
<tr>
<th>Turbine</th>
<th>Swept Area (m²)</th>
<th>Yield (kWh/m²/yr)</th>
<th>AEO (kWh/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>36 m; .5 MW</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000,000</td>
</tr>
<tr>
<td>50 m; .75 MW</td>
<td>2,000</td>
<td>1,000</td>
<td>2,000,000</td>
</tr>
<tr>
<td>62 m; 1 MW</td>
<td>3,000</td>
<td>1,000</td>
<td>3,000,000</td>
</tr>
<tr>
<td>80 m; 2 MW</td>
<td>5,000</td>
<td>1,000</td>
<td>5,000,000</td>
</tr>
</tbody>
</table>

*Paul Gipe & Assoc.*

*At Hub Height*
Potential per Farm

• Turbines Use Only ~5-10% Land Area!
• Potential to Significantly Boost Farm Income

Buffalo Ridge, Minnesota
Paul Gipe, wind-works.org
How Renewable Energy Can Benefit Farmers

- **#1 Royalties**
  Lowest Risk -- Lowest Reward
  % of Gross Revenue (2-4%)

- **#2 Ownership**
  Highest Risk -- Highest Reward
  Farmer Retains Profit

Cros de Georand, France

Paul Gipe, wind-works.org
Potential per Windy Ontario Farm

- 2MW Turbine, 80 m Ø, 80 m Tower
- ~$4 million CAD Installed
- ~3.5 million kWh/Year (~6 m/s)
- ~$450,000 CAD/yr @ $0.13/kWh
- Simple Payback: ~10 Years
- After Payback: ~$300,000 CAD/yr

Skibsted Fjord, Denmark
### RegioWind Germany

<table>
<thead>
<tr>
<th>Betriebskosten über gesamte Laufzeit</th>
<th>Umsatz in Mio. Euro</th>
<th>22,12</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1. Kaufmännische Betriebsführung in Mio Euro</td>
<td>0,33</td>
<td></td>
</tr>
<tr>
<td>- Kaufmännische Betriebsführung in % des Umsatzes</td>
<td>&lt;2% 2-3% &gt;3%</td>
<td>1,50 ***</td>
</tr>
<tr>
<td>3.2. Technische Betriebsführung in Mio Euro</td>
<td>0,55</td>
<td></td>
</tr>
<tr>
<td>- Technische Betriebsführung in % des Umsatzes</td>
<td>&lt;2% 2-3% &gt;3%</td>
<td>2,50 **</td>
</tr>
<tr>
<td>3.3. Betriebsführung in % des Umsatzes (kaufmännisch und technisch)</td>
<td>&lt;4% 4-6% &gt;6%</td>
<td>entfällt entfällt</td>
</tr>
<tr>
<td>3.4. Pacht Binnenland in Mio. Euro</td>
<td>1,44</td>
<td></td>
</tr>
<tr>
<td>- Pacht Binnenlandstandort in%</td>
<td>&lt;3% 3-5% &gt;5%</td>
<td>6,50% *</td>
</tr>
<tr>
<td>3.5. Pacht Küste in Mio. Euro</td>
<td>entfällt</td>
<td></td>
</tr>
<tr>
<td>- Pacht Küste%</td>
<td>&lt;5% 5-8% &gt;8%</td>
<td>entfällt</td>
</tr>
</tbody>
</table>

Paul Gipe & Assoc.
<table>
<thead>
<tr>
<th>Location</th>
<th>1-10</th>
<th>10-20</th>
<th>20-30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Germany</td>
<td>5-8%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interior Germany</td>
<td>3-5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cielo Wind Power, NM</td>
<td>6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cappeln Germany</td>
<td>4%</td>
<td>5.9%</td>
<td>5.7%</td>
</tr>
<tr>
<td>Indian Mesa, TX</td>
<td>4%</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>Woodward Mesa, TX</td>
<td>4%</td>
<td>6%</td>
<td></td>
</tr>
<tr>
<td>US BLM, CA</td>
<td>4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freiburg, Germany</td>
<td>3.8%</td>
<td>5.4%</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>2.5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ontario</td>
<td>1.5-2.5%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Paul Gipe, wind-works.org
Planning Agreement
Landowners

Land & Lease Agreement
Land. Assoc.

Planning Agreement
Ltd. Co.

Lease Agreement on Wind Plant Location

Wind Plants
WP 1
WP 2
WP 3
WP 4

Paderborn Co-op
Royalty Sharing Among Farmers
PEI Royalty Revenue Sharing

10% of Royalties

20% of Royalties

70% of Royalties
640 kW: Woodstock, Minnesota

Paul Gipe, wind-works.org
750 kW: Lake Benton, Minnesota

Paul Gipe, wind-works.org
For Best Royalties

- Contact OFA, NFU, CF
- Do Your Homework--First
- OSEA’s Landowner’s Guide

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Montfort, Wisconsin
For Best Royalties

- % of Revenue Stream
- with Minimum Payment/yr
- Don’t Be Misled by MW Size
  It’s the Revenue That Counts
- Form Land Association
  Val-Éo (Quebec) Model

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Montfort, Wisconsin
The Val-Éo (Quebec) Model

- Form Land Association (Co-op)
- Measure the Wind
- Negotiate from Position of Strength
- All Professional Services for Hire
- Only Works with ARTs/SOCs
Rural Ontario Economic Benefit

- 55,000 Farmers
- 1/2 MW per Farm = 27,000 MW
- 1/3 of All Ontario Electricity
- $4 billion CAD/Year Total Turnover

Money Stays Within Province
Money Circulates Through Rural Economy

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Husum, Germany
Wind Turbines

Sell Beer, Bier, Biere, Birra, Cerveza

Wie das Land, so das Jever.

Jever, D

Thyholmer, DK

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Sell Wine

Paul Gipe, wind-works.org
Sell Clothes

Paul Gipe, wind-works.org

Cathy Sims, Palmerston North, New Zealand
... sell Texas Towns--Yee Ha!
Promote Community

Paul Gipe & Assoc.

Wellington, NZ
Pave the Sidewalk
And the Way to the Future

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Wellington (Brooklyn), NZ
Renewables:
When You Look Closely . . .
. . . Worth Every Cent

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