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.

Paul Gipe, wind-works.org
Advanced Renewable Tariffs
For Small Wind Turbines

By Paul Gipe

Paul Gipe, wind-works.org
Small Wind Programs Overview

- The “Best” On-Grid Programs
- The Results
  Units, MW, Performance
- Time for Change
- Proposed Feed-in Tariffs

Paul Gipe, wind-works.org
Mick Sagrillo
Wisconsin’s Small Wind Guru

• Best Program?
  Wisconsin’s Focus on Energy

• Why?
  Subsidy Based on Performance
Wisconsin Focus on Energy

• Subsidies
  Based on Estimated Generation Since 2003

• Third Party Evaluation
  --for each project

• Mick on Other Programs
  “Throwing Money [at Equipment] Doesn’t Work”
  “You Give it Away That’s What It’s Worth”
  If You Do Dead Turbines Become “Monuments to Failed Policy”

Paul Gipe, wind-works.org
Wisconsin Focus on Energy

- Evaluates Each Product
- Evaluates Each Site
- Estimates Generation
- Algorithm to Calculate Subsidy Amount

  Power @11 m/s
  Full Subsidy @ 20% CF (Excellent WI Site)
  Installed Cost (Cap 25% <20 kW)

Paul Gipe, wind-works.org
Wisconsin Focus on Energy
Example: Skystream, 30 m Tower
Excellent Site = Most Subsidy

- 1.8 kW @ 11 m/s
- 20% CF = 3,150 kWh/yr
- Installed Cost: $17,000
- Subsidy = $4,250
- Net Cost = $12,700

Paul Gipe, wind-works.org
Wisconsin Focus on Energy
Example: Skystream, 30 m Tower
Average Site = Lower Subsidy

- 10% CF = 1,500 kWh/yr
- Subsidy 50% of Excellent Site
- Subsidy = $2,100
- Net Cost = $14,900

Paul Gipe, wind-works.org
Wisconsin Focus on Energy Results

• ~70 units, ~1.2 MW
• ~2/3 of Capacity:
  Used Danish Turbines
• No Performance Measurements
  All Systems Have Anemometers & kWh Meters
• That’s All--After 6 Years!
• Large Turbines ~500 MW

Paul Gipe, wind-works.org
Mike Bergey--Bergey Windpower

• Best Program?
  California or Oregon

• Why?
  Size of Program

Paul Gipe, wind-works.org
Tehachapi, California
CEC Emerging Renewables

• Traditional Stepped Subsidy

• Two Tranches
  $2,500/kW <7.5 kW
  $1,500/kW >7.5 kW <30 kW

• Product Must be Certified to Qualify

• No Measurements & No Monitoring

• Bureaucratic & Cumbersome

• Zoning Restrictions

Paul Gipe, wind-works.org
CEC Emerging Renewables Results

- 1% of $400 million in Subsidies in 10 years
- $4 million in Subsidies for Small Wind

Paul Gipe, wind-works.org
Tehachapi, California
California Small Wind Program Results

- Since 1998
- Total Installed: 426 units (CEC)
- Total Installed: 2.6 MW (CEC)
- Average: 40 units/yr; 250 kW/yr
- No Performance Data
- No Reports!

Paul Gipe, wind-works.org
California Small Wind Program

Results

Paul Gipe, wind-works.org
California Small Wind Program Results

Paul Gipe, wind-works.org
California Small Wind Program Results

$/kW (Thousands)

Year

0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0

99 00 01 02 03 04 05 06 07 08 09

6.2 4.4 4.6 5.5 5.1 5.0 4.4 4.2 5.7 5.3 4.7

Paul Gipe, wind-works.org
Oregon Small Wind: Results

- < 50 units, <100 kW in Entire State
- Downtown Portland Rooftop Wind
  
  4 Skysteams
  Estimated Yield: 2,250 kWh/yr/turbine
  $10,000/turbine
  Estimated Specific Yield: ~200 kWh/m²/yr
  Greenwashing--LEED Points

Paul Gipe, wind-works.org
Washington State Small Wind Tariff

- Performance-Based Incentive
  Form of Net Metering
- But Payment/kWh on All Generation
- Out of State Product: $0.12/kWh
- Retail Rate Offset: $0.08/kWh
- Total: ~$0.18/kWh
- Results: ~30 units, 30 kW

Paul Gipe, wind-works.org
## Small Wind On-Grid
Installed in USA in 2008

<table>
<thead>
<tr>
<th>kW Size</th>
<th>Units</th>
<th>~MW</th>
<th>~$ million*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10</td>
<td>2,825</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td>10-20</td>
<td>72</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>20-100</td>
<td>87</td>
<td>6</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>2,984</td>
<td>14</td>
<td>54</td>
</tr>
</tbody>
</table>

*At $4,000/kW
Paul Gipe, wind-works.org
Small Wind On-Grid USA 2008

- Small Wind: 100% Net Metering
- AWEA: Small Wind Subsidy Needed
  
  $2,000/kW on Top of Federal Subsidy
  
  ~50% of Installed Cost
  
  ~Equivalent to Installed Cost of Large Turbines

Paul Gipe, wind-works.org
Small Wind On-Grid USA 2008

- **US 2008 Commercial Investment**
  ~$20 Billion

- **Small Wind On-Grid**
  ~0.3% of Total US Wind Investment in 2008

Paul Gipe, wind-works.org
BWEA Small Wind Market Report

On-Grid

- <2,000 units/yr
- ~4,500 Units Total
- ~6 MW Total Capacity
- ~7 million kWh/yr Total
- **Specific Capacity:**
  
  1200 kWh/kWyr; Very Optimistic

Paul Gipe, wind-works.org
Britain’s Energy Savings Trust Field Trials

• Monitored 57 Turbines
• 38 Rooftop Units, 19 Ground-Mounted
• Wind Speed Most Sites <5 m/s
• Rooftop
  No Rooftop Turbine >200 kWh/yr
  Some Rooftop Turbines Net Consumers
  Best Rooftop Performer <300 kWh/m²/yr
  Ground-Mounted Turbines ~20 CF; ~450 kW/m²/yr

Paul Gipe, wind-works.org
Massachusetts Cadmus Report

- Monitored 21 Units
  Generation ~1/3 of Projected
- Capacity Factor
  Best: 10-11%; Poorest: 1-4%
- Bergey Excel
  Low: 1,300 kWh/yr; <50 kWh/m²/yr
  High: 7,600 kWh/yr; ~250 kWh/m²/yr
- ARE 442:
  9,400 kWh/yr; ~250 kWh/m²/yr
- Ouch!

Paul Gipe, wind-works.org
Small Wind Programs Worldwide Summary

• All Have Failed To Date
  In Volume
  In Capacity
  In Generation
  In Reliability

Paul Gipe, wind-works.org
H40 Wulf Test Field
Paying Only for Performance Leads to Maturity

• Estimates of Generation Better than Nothing
• Metered kWh Best
• After 30 Years Time for Small Turbine Industry to Grow Up

Paul Gipe, wind-works.org
Small Wind: Time for Change

• Wean the Industry From Subsidies
  Capital Grants & Rebates Have Failed

• Move to Payment for Generation
  Production-Based Incentives?
  Feed-in Tariffs?

• Maturity: Facing Reality
  Acknowledging What Small Wind Costs
  Higher than Large Wind--Lower than Solar PV
  Standards to Protect Consumers

Paul Gipe, wind-works.org
Small Wind Feed-in Tariffs

• No Proof Yet
  Feed-in Tariffs Will Make Small Wind a Success

• Worked for Large Turbines
  Feed-in Tariffs Led Way to Maturity

Paul Gipe, wind-works.org
## Existing World Small Wind Tariffs

<table>
<thead>
<tr>
<th>Location</th>
<th>Years</th>
<th>€/kWh</th>
<th>CAD/kWh</th>
<th>USD/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portugal</td>
<td>15</td>
<td>0.432</td>
<td>0.680</td>
<td>0.620</td>
</tr>
<tr>
<td>Italy &lt;200 kW</td>
<td>15</td>
<td>0.300</td>
<td>0.472</td>
<td>0.431</td>
</tr>
<tr>
<td>Israel &lt;15 kW</td>
<td>20</td>
<td>0.294</td>
<td>0.462</td>
<td>0.422</td>
</tr>
<tr>
<td>Israel &lt;50 kW</td>
<td>20</td>
<td>0.230</td>
<td>0.361</td>
<td>0.329</td>
</tr>
</tbody>
</table>

Paul Gipe, wind-works.org
## Existing North American Small Wind Tariffs

<table>
<thead>
<tr>
<th>State/Region</th>
<th>Years</th>
<th>€/kWh</th>
<th>CAD/kWh</th>
<th>USD/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermont &lt;15 kW</td>
<td>20</td>
<td>0.139</td>
<td>0.219</td>
<td>0.200</td>
</tr>
<tr>
<td>Washington Out State</td>
<td>6</td>
<td>0.090</td>
<td>0.147</td>
<td>0.120</td>
</tr>
<tr>
<td>Washington in State</td>
<td>6</td>
<td>0.309</td>
<td>0.503</td>
<td>0.410</td>
</tr>
<tr>
<td>Wisconsin, Xcel</td>
<td>10</td>
<td>0.050</td>
<td>0.081</td>
<td>0.066</td>
</tr>
<tr>
<td>Wisconsin, MG&amp;E</td>
<td>10</td>
<td>0.046</td>
<td>0.075</td>
<td>0.061</td>
</tr>
</tbody>
</table>

Paul Gipe, wind-works.org
### Proposed British Small Wind Tariffs

<table>
<thead>
<tr>
<th>Years</th>
<th>€/kWh</th>
<th>CAD/kWh</th>
<th>USD/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5 kW-15 kW</td>
<td>20</td>
<td>0.261</td>
<td>0.411</td>
</tr>
<tr>
<td>15 kW-50 kW</td>
<td>20</td>
<td>0.205</td>
<td>0.322</td>
</tr>
<tr>
<td>50 kW-250 kW</td>
<td>20</td>
<td>0.205</td>
<td>0.322</td>
</tr>
</tbody>
</table>

Paul Gipe, wind-works.org
## Proposed US Small Wind Tariffs

<table>
<thead>
<tr>
<th></th>
<th>Years</th>
<th>€/kWh</th>
<th>CAD/kWh</th>
<th>USD/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>MI &lt;2,000 ft²</td>
<td>20</td>
<td>0.188</td>
<td>0.307</td>
<td>0.250</td>
</tr>
<tr>
<td>MN &lt;1,000 ft²</td>
<td>20</td>
<td>0.188</td>
<td>0.307</td>
<td>0.250</td>
</tr>
<tr>
<td>IP&amp;L&gt;50 &lt;100 kW</td>
<td>10</td>
<td>0.105</td>
<td>0.172</td>
<td>0.140</td>
</tr>
</tbody>
</table>

Paul Gipe, wind-works.org
Skystream Tariff Needed

Assumptions

- $13,500 Installed
- Yield from SWP Estimates*
- Annual Reoccurring Expenses: 4%
- 6 m/s

* Not Independently Verified.

Paul Gipe, wind-works.org
### Average Weighted Cost of Capital Before Tax

<table>
<thead>
<tr>
<th>Component</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity Return on Equity (ROE)</td>
<td>13.0%</td>
</tr>
<tr>
<td>Debt</td>
<td>80%</td>
</tr>
<tr>
<td>Interest on Debt</td>
<td>6.94%</td>
</tr>
<tr>
<td>Nominal AWCC</td>
<td>0.0815</td>
</tr>
<tr>
<td>Inflation</td>
<td>3.0%</td>
</tr>
<tr>
<td>AWCC real</td>
<td>5.0%</td>
</tr>
</tbody>
</table>

Paul Gipe, wind-works.org
# Skystream Tariff Needed

## Chabot Profitability Index Method

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotor Diameter</td>
<td>3.7 m</td>
</tr>
<tr>
<td>Installed Cost</td>
<td>$13,500</td>
</tr>
<tr>
<td>Specific Installed Cost</td>
<td>$1,256</td>
</tr>
<tr>
<td>Annual Expenses</td>
<td>4.0%</td>
</tr>
<tr>
<td>Term</td>
<td>20 years</td>
</tr>
<tr>
<td>Discount Rate (AWCC)</td>
<td>5.0%</td>
</tr>
<tr>
<td>Specific Yield</td>
<td>446 kWh/m²/y</td>
</tr>
<tr>
<td>Capital Recovery Factor (n,t)</td>
<td>0.0802</td>
</tr>
<tr>
<td>Profitability Index Target</td>
<td>0.3 NPV/I</td>
</tr>
<tr>
<td>Cost of Energy</td>
<td>$0.406/kWh</td>
</tr>
<tr>
<td>Simple Payback</td>
<td>9.6 years</td>
</tr>
</tbody>
</table>

Paul Gipe, wind-works.org
Skystream Tariff Needed

$0.30-$0.38/kWh

Average Wind Speed (m/s)

Profitability Index
- 0
- 0.1
- 0.2
- 0.3

Sweet Spot

Paul Gipe, wind-works.org
Entegrity Tariff Needed
Assumptions

• $205,000 Installed
• Yield from Entegrity Estimates
• Annual Reoccurring Expenses: 4%

Paul Gipe, wind-works.org
Entegrity Tariff Needed
$0.20-$0.25/kWh at 6 m/s

Paul Gipe, wind-works.org
## Small Wind Tariff Summary

<table>
<thead>
<tr>
<th>Location</th>
<th>CAD/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>0.50</td>
</tr>
<tr>
<td>Israel</td>
<td>0.40-0.50</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.21</td>
</tr>
<tr>
<td>Vermont</td>
<td>0.22</td>
</tr>
<tr>
<td>Britain</td>
<td>0.30-0.40</td>
</tr>
</tbody>
</table>

Paul Gipe, wind-works.org
# Canadian Small Wind Tariff

<table>
<thead>
<tr>
<th>Tier 1: &lt;50 m²</th>
<th>CAD/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 2: &gt;50 m² &lt;500 m²</td>
<td>0.20-0.25</td>
</tr>
</tbody>
</table>

Paul Gipe, wind-works.org

Iles de la Madeleine
Olivier Krug--Krug Wind
France’s Largest Small Wind Installer
What’s Needed

- Compulsory Standards
  For Products & For Installers
- Inform Public
  About What Small Wind Can & Cannot Do
- Adapt Zoning to Tall Towers
- Right to Connect
- Move to Feed-in Tariffs
  No More Subsidies, Grants, Tax Credits

Paul Gipe, wind-works.org
Small Wind--What’s Needed
Informed Consumers

• Demand Better Products
  Less Susceptible to Hustlers & Charlatans
• Know What They’re Buying
• Know What to Expect
  Published Performance Tests
• Know What is Being Delivered
  Metering a Must

Paul Gipe, wind-works.org
Small Wind--What’s Needed

• Standards & Certification
  For Products & Installers

• Testing
  with Published Results!

• Facing Reality
  Small Wind’s Limits

Paul Gipe, wind-works.org

Chateau Lastours, France
Small Turbines Must Become as Productive as Large Turbines to Fulfill Their Promise

Paul Gipe, wind-works.org
The Small Wind Industry Needs Advanced Renewable Tariffs or it Will Remain Insignificant

Paul Gipe, wind-works.org
Now Available from Chelsea Green

WIND ENERGY BASICS
A Guide to Home- and Community-Scale Wind Energy Systems

SECOND EDITION
Paul Gipe