Preparing for Prime Time: What Small Wind Needs to Make Its Mark

by Paul Gipe
Small Wind--A Checkered Past

- Poor Performance
- Poor Reliability
- Costly
- Noisy
- Magnet for Hustlers & Charlatans
- Unsafe

Paul Gipe, wind-works.org
Better Performance

- 1/2 That of Large Turbines
  At Best
- Seldom Meet Projections
- Short Towers
  Big Problem
Typical Yields
Large & Small Turbines

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Higher Reliability

• Cheap = Short Life
• Seldom Last Long Enough
• Many Remain Derelict For Years
H40 4-Year Life

- Blade Failure
- Yaw Failure
- Insulation Failure
Less Costly

- SkyStream
- $18,000 Installed
- Yield: 375 kWh/m2/yr (6+ m/s)
- SPBT 12 years
- COE: $0.50/kWh

Paul Gipe, wind-works.org
Magnet for Hustlers & Charlatans

- Ease of Entry
- Preying on Ignorance
- Pyramid Schemes
- Drag Devices
- Ducted Devices
- Fantasy Wind
- Roof Top Wind

Magwind, Whitby Ontario

Paul Gipe, wind-works.org
Roof Top Mounting?

- Turbulence
- Poor Performance
  ~0 Net Energy!
  1.5 kW ~300-700 kWh/yr London
- Noise & Vibration
- Safety
- Simply a Bad Idea

Possibly Dublin, circa 1990s

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Roof Top Mounting?

- No, Don’t Do This!
Roof Top Mounting?

• Tied Off

Paul Gipe, wind-works.org
Roof Top Mounting

- Tied Off

Similar installation along main rail line near Bonn. AlGauier?
Roof Top Mounting?

• Tied Off

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Roof Top Mounting

- Never Operates
- Across from AGO
- Highly Visible
Roof Top Mounting?

• Well, OK Here
• Battery Charging
• Uninhabited

Newcastle, Indiana

Paul Gipe, wind-works.org

Jutland, Denmark
Safer

3 Deaths <30 kW
in 30 Years

12 Deaths <100 kW
in 30 Years

Pat Acker, 28, Bushland, TX, 1982
Small Wind Turbine Tower Safety

• Tilt-up Towers for Micros & Minis Always Preferable
Small Wind Turbine Tower Safety

- All Other Towers
  - Person Lifts
  - Fall Arrest Systems
  - Work Platforms
  - Anchors
  - Rotor Locking Pins
  - Tower Training

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Small Wind Turbine Tower Safety

- Minimal or No Work on Tower
- No Fall-Arrest System
- No Work Platform
- No Anchors
- No Training

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Canyon, Texas, 1979
Small Wind Turbine Fall Safety

- Work Platform
- Anchors
- Full Harness
- Lanyard

Paul Gipe, wind-works.org
Folkecenter, Denmark, 1997
Small Wind Turbine Tower Safety
1930s Had Work Platforms

Wincharger, Grand Teton NP, Wyoming

Paul Gipe, wind-works.org
Large Turbine Tower Safety

- Helmet
- Gloves
- Harness
- Radio
- Fall Arrest

© Rope Partner

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Small Wind--What’s Needed

- Standards
- Testing with Published Results!
- Informed Consumers
- Facing Reality Small Wind’s Limits

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Chateau Lastours, France
Small Turbine Testing Standards

- AWEA Proposed 1979
- Adopted 1988
  ... Sort of
- No Standard In Force
  ... After 30 Years!
- Standards Imminent?

Pinson Cycloturbine, 1979

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Small Wind Test Fields

- Commercial
  - NREL, CO
  - WindTest, Germany
  - AEI, TX
  - Windward, UT
  - PEI, Canada

- Private Unfunded
  - Mike Klemen, ND
  - Wulf Test Field, CA
  - Folkecenter, DK

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Wulf Field Tehachapi, California
Turbines Tested

Air 303/403/X.1/X.2/X.3
Marlec 910F
BWC 850
Whisper H40
LVM 6F

Paul Gipe, wind-works.org
Wulf Field Tehachapi, California
Turbines Tested

Paul Gipe, wind-works.org
Wulf Field Tehachapi, California
Tests Performed

Power Curves

Power Loss

Noise Emissions

Paul Gipe, wind-works.org
Wulf Field Tehachapi, California
Test Results Published

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Air X Power Curve Measurements

400 W = 175 W (40%)
Air Breeze Power Curve
200 W = 160 W (75%)
Small Turbine Noise Measurements

- Meters Costly
- Somewhat Complex
- Difficult for Amateurs
Air 403 Noise Measurements

Air 403 Noise at Wulf Test Field

dB(A) (Leq) vs Wind Speed (mph)
Calculated Emission Source Strength
Selected Small Wind Turbines

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NREL Noise Measurements
Excel S (7 m)

![Graph showing sound pressure level vs. standardized wind speed for different conditions: Turbine operating - inverter on line (diamonds), Turbine operating - inverter off line (triangles), Background noise (squares).]
Proposed Small Wind Tariffs

- MI, RI, IL: $0.25/kWh
  <15 m diameter (2,000 ft²)
- MN: $0.25/kWh
  <10 m diameter (1,000 ft²)
- Payments Go to Consumer
  Payment Only for Performance
  Necessary Step for Small Wind

Paul Gipe, wind-works.org
Skystream
Cost of Energy Estimates

Skystream, Alexandria, Indiana

Paul Gipe, wind-works.org
Skystream Cost of Energy Assumptions

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

* Not Independently Verified.

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### Skystream Cost of Energy Chabot Profitability Index Method

<table>
<thead>
<tr>
<th>Average Weighted Cost of Capital Before Tax</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Equity</td>
<td>20%</td>
</tr>
<tr>
<td>Return on Equity</td>
<td>13.0%</td>
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<tr>
<td>ROE</td>
<td>80%</td>
</tr>
<tr>
<td>Debt</td>
<td>6.94%</td>
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<tr>
<td>Interest on Debt</td>
<td>0.0815</td>
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<tr>
<td>Nominal AWCC</td>
<td>3.0%</td>
</tr>
<tr>
<td>Inflation</td>
<td>5.0%</td>
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<tr>
<td>AWCC real</td>
<td>t</td>
</tr>
</tbody>
</table>

Paul Gipe, wind-works.org
### Skystream Cost of Energy

#### 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 /m²</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>
Skystream Cost of Energy

Average Wind Speed (m/s)

Profitability Index
0 0.1 0.2 0.3

$/kWh

Paul Gipe, wind-works.org
Skystream Cost of Energy
$0.30-$0.38/kWh

Average Wind Speed (m/s)

Profitability Index
- 0
- 0.1
- 0.2
- 0.3

$/kWh

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Entegrity Cost of Energy Assumptions

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

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Entegrity Cost of Energy
$1,150/m²

Profitability Index
0 0.1 0.2 0.3

Average Wind Speed (m/s)

$/kWh

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Entegrity Cost of Energy

$0.25/kWh

Average Wind Speed (m/s)

$/kWh

Profitability Index

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Used 17 m Cost of Energy
$750/m², $0.16/kWh

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Small Wind Tariff

• Cost of Generation Plus Profit
  $0.25/kWh Reasonable Compromise

• Limitation on “Excessive” Profit
  Size Cap: <10 m (1,000 ft²)
  Availability of 15 Used Turbines
  Entegrity Only New 15 m Product

Paul Gipe, wind-works.org

Tehachapi, California
Informed Consumers

• Demand Better Products
  Less Susceptible to Hustlers & Charlatans
  Less Susceptible to Aggressive Marketing

• Know What They’re Buying

• Know What to Expect
  Published Test Results

• Know What is Being Delivered
  Metering a Must

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Facing Reality

- Many SWTs Not Ready for Prime Time
- Much Work Must be Done
- Performance Will Lag Large Turbines
- Micros & Minis Only for Battery Charging

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Small Turbines Must Become as Reliable and as Productive as Today’s Big Turbines

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