Economic Feasibility of Owning a Small Wind Generator

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Outline

- Research Goals
- Solution/Process
- System Studies
- Conclusions
Research Goals

- Develop a tool to estimate the amount of energy that will be produced by residential sized renewable energy systems

- Use this tool to analyze several systems in various locations to...
  ...determine expected energy production
  ...determine if system is economically viable
Process

1. Simulate load based on statistical data
2. Simulate renewable energy resource based on statistical data
3. Using a power curve, determine the amount energy produced by the renewable generator at each time interval
4. Determine the amount of saved energy and excess energy produced
5. Repeat for the number of days in the desired time period (while keeping track of total energy production)
6. Repeat all steps for the desired number of iterations to find an average
Simulate load

Simulate resources

Find energy production

Find total energy production of time period

Find Average

Simulate each hour using Gaussian distribution

Start with average hourly load

One simulated day of load

Repeat through all days of time period

Repeat through many iterations
Simulate load → Simulate resources
Simulate resources → Find energy production
Find energy production → Find total energy production of time period
Find total energy production of time period → Find Average

Average hourly wind speed

Weibull distribution to approximate wind speed

Average
Simulated

Single, simulated day of wind speed

Simulate load
Repeat through all days of time period
Repeat through many iterations

Find energy production

Find total energy production of time period

Find Average
For each hour of simulated wind speed, determine the energy output of the turbine and compare to the simulated load.
Repeat simulations until a trend is found

Histogram of saved energy (one month)

Mean: 209.71 kWh
Variance: 178.49

Histogram of excess energy (one month)

Mean: 25.95 kWh
Variance: 29.21
Southwest Windpower - Skystream 3.7

- **Rated Power Output**: 1.9 kW
- **Rated Wind Speed**: 9 m/s or 20 mph
- **Estimated Cost**: $6348
  - Equipment and labor not included
  - 70’ guyed tower

**Tower Options**: Various options from 30’ to 70’ including guyed and monopole towers
Bergey – Excel S

**Rated Power Output:** 10 kW  
**Rated Wind Speed:** 13.9 m/s or 31 mph  

**Estimated Cost:** $41300  
- Equipment and labor not included  
- 80’ lattice tower

**Tower Options:** Various options from 60’ to 140’ including guyed, monopole, and lattice towers
Entegrity – EW50

**Rated Power Output:** 50 kW

**Rated Wind Speed:** 11.3 m/s or 25.3 mph

**Estimated Cost:** $200000

- Estimate from Moscow High School installation
- 100’ monopole tower

**Tower Options:** Various options from 72’ to 120’ including lattice and monopole towers
**Assumptions**
- All Kansas Locations
- Based on expected energy production in November
- Residential Home with 2.69 kW average yearly load
- Cost of energy = 0.08 $/kWh
- No true net metering (0.02 $/kWh sellback)
- Cost of energy increases by 1% per year

**Simulations/Results**
(Kansas - Without Net Metering)

<table>
<thead>
<tr>
<th>Location</th>
<th>Avg. Wind Speed (60m)</th>
<th>Skystream ($6348)</th>
<th>Excel S ($41,300)</th>
<th>EW50 ($200,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manhattan, KS - Airport</td>
<td>3.32 (class 1)</td>
<td>$2,516.19</td>
<td>$4,949.51</td>
<td>$19,311.69</td>
</tr>
<tr>
<td>Manhattan, KS - Proper</td>
<td>6.16 (class 2)</td>
<td>$4,252.76</td>
<td>$8,753.35</td>
<td>$31,198.16</td>
</tr>
<tr>
<td>Moscow, KS</td>
<td>7.96 (class 5)</td>
<td>$6,300.45</td>
<td>$11,688.05</td>
<td>$47,516.05</td>
</tr>
</tbody>
</table>

The table provides the 20 Year Net Present Value (based on production mean) for different locations in Kansas, considering various wind speeds and associated costs.
## Assumptions

- All Kansas Locations
- Based on expected energy production in November
- Residential Home with 2.69 kW average yearly load
- Cost of energy = 0.08 $/kWh
- Net metering (0.08 $/kWh sellback)
- Cost of energy increases by 1% per year

### Simulations/Results (Kansas - With Net Metering)

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</tr>
</thead>
<tbody>
<tr>
<td>Manhattan, KS - Airport</td>
<td>3.32 (class 1)</td>
<td>$2,620.53</td>
<td>$6,503.81</td>
<td>$55,976.90</td>
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<tr>
<td>Manhattan, KS - Proper</td>
<td>6.16 (class 2)</td>
<td>$4,512.76</td>
<td>$13,695.64</td>
<td>$97,294.17</td>
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<tr>
<td>Moscow, KS</td>
<td>7.96 (class 5)</td>
<td>$6,876.33</td>
<td>$20,446.53</td>
<td>$155,415.69</td>
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</tbody>
</table>
Simulations/Results
(With Net Metering and High Cost of Energy)

<table>
<thead>
<tr>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Based on expected energy production in November</td>
</tr>
<tr>
<td>• Residential Home with 2.69 kW average yearly load</td>
</tr>
<tr>
<td>• Cost of energy increases by 1% per year</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>20 Year Net Present Value (based on production mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skystream ($6348)</td>
</tr>
<tr>
<td>0.24 $/kWh (national high)</td>
</tr>
<tr>
<td>Avg. Wind Speed (60m) 3.32 (class 1)</td>
</tr>
<tr>
<td>0.11 $/kWh (national avg.)</td>
</tr>
<tr>
<td>Avg. Wind Speed (60m) 6.16 (class 2)</td>
</tr>
<tr>
<td>0.14 $/kWh (11 states with higher)</td>
</tr>
<tr>
<td>Avg. Wind Speed (60m) 7.96 (class 5)</td>
</tr>
</tbody>
</table>
## Simulations/Results

### (Best Scenarios)

**Assumptions**
- Residential Home with 2.69 kW average yearly load
- Cost of energy increases by 1% per year

### 20 Year Net Present Value (based on production mean)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Skystream ($6348)</th>
<th>Excel S ($41,300)</th>
<th>EW50 ($200,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best wind in KS simulated with an average month</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.10 $/kWh</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg. Wind Speed (60m) 8.25 (class 6)</td>
<td>$9,015.44</td>
<td>$27,221.18</td>
<td>$205,392.81</td>
</tr>
<tr>
<td>Best wind in KS simulated with the best month (April)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.10 $/kWh</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg. Wind Speed (60m) 8.25 (class 6)</td>
<td>$12,148.56</td>
<td>$42,283.35</td>
<td>$291,022.88</td>
</tr>
<tr>
<td>Best wind in US simulated with the best month</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.24 $/kWh</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg. Wind Speed (60m) 10.8 (class 7)</td>
<td>$34,048.67</td>
<td>$132,823.78</td>
<td>$871,567.38</td>
</tr>
</tbody>
</table>
Conclusions

- A tool for predicting energy production by renewable energy sources has been developed. From this tool, payback estimates can be found.

- Through these simulations we have found
  - Net metering is not essential if systems are sized properly. However, large wind generators are economically infeasible without it.
  - Proper siting is essential for systems to succeed economically, due to both cost of energy and available wind resources.
One Thing to Note

- Most simulations were based on data from the month of November because it is a very average month for both wind resources and electrical load. More accurate analysis could be done by simulating each month of the year individually.
Thanks

Dr. Ruth Douglas Miller
Todd Halling
Questions?