Renewables Comparison
Wind vs. Solar Energy

Erwin Lavric, Sara Pattison, Haven Richardson, Carter Wood
Goal of the project

To determine whether wind energy or solar energy is a more efficient and sustainable alternative to coal energy for commercial use.
Wind Energy and Solar Energy, but what are they?

Wind energy is generated by: Wind turbines - which are turbines with a large vaned wheel that is rotated by wind to generate electricity.

Solar energy is generated by: Solar panels - which are panels that absorb the sun’s rays to be converted to generate electricity or heat.
Solar Technology

Photovoltaic (PV) captures sunlight and converts it directly to electricity with panels made with semiconductor materials.

Concentrating Solar Power (CSP) systems use mirrors and lenses to focus the sun’s light energy and convert it to heat. The heat creates steam which will turn a turbine creating energy.
Wind Technology

Horizontal Axis design are windmills with a long thin base and have 2-3 propeller-like blades extending outwards from the top of the windmill which rotate as the wind blows. The blades spin a shaft inside of the turbine and the moving shaft spins a generator to create electricity.

Vertical Axis design include windmills that have their blades more parallel to the base so that they when they spin, it is about the base rather than perpendicular to it. Internally, vertical axis windmills generate electricity the same way the horizontal axis designs do.
Why Wind vs. Solar?

Fastest growing renewable options

Nuclear/Hydroelectric only ~1% growth

Almost unlimited space

Ocean tethered turbines

Scale flexibility
Why Renewables?

Coal production down

Energy demand increase

CO₂ emissions rising

Energy-related carbon dioxide (CO₂) emissions by country or region (2012-40)
billion metric tons

Total energy consumption by end-use sector, 1960-2040
quadrillion Btu
Scope

Through the analysis of Cost-Benefit Analyses, Life Cycle Analyses and other important impacts, we will be able to conclude whether solar power or wind power is commercially better suited to be a main source of energy in the U.S.
Aspects to Consider

- Cost-Benefit Analysis
- Life-Cycle Assessment
- Durability
- Noise
- Location
- Innovations
Functional Units

CBA

Cost per energy output (dollar/ kilowatt hours)

LCA

CO2 per energy output (gram CO2 e/ kilowatt hours)
Cost Benefit Analysis
Boundaries

New Plant Construction
Operation of Plant
Maintenance of Plant
Assumptions

CO2 abatement = $50 per metric ton

Same cost of land

Based on avoided emissions and avoided costs

Same new plant used to process energy received

Transmission lines same for both wind and solar

Construction takes 1.5 years
CO2/MWH: Fossil Fuel Plants

Baseline reduction

Used coal for comparison

Different fossil fuels have different carbon emissions

<table>
<thead>
<tr>
<th>Heat Rate (Btu/KWH)</th>
<th>Gas CC</th>
<th>Coal</th>
<th>Gas SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Plant (1)</td>
<td>6,430</td>
<td>8,800</td>
<td>9,750</td>
</tr>
<tr>
<td>Old Plant (2)</td>
<td>7,050</td>
<td>10,498</td>
<td>10,850</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Efficiency</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>New Plant</td>
<td>53.1%</td>
<td>38.6%</td>
<td>35.0%</td>
</tr>
<tr>
<td>Old Plant</td>
<td>48.4%</td>
<td>32.5%</td>
<td>31.5%</td>
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</table>

<table>
<thead>
<tr>
<th>CO₂ Emissions: Pounds per MWH (3)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>New Plant</td>
<td>752.3</td>
<td>1,812.8</td>
<td>1,140.8</td>
</tr>
<tr>
<td>Old Plant</td>
<td>624.9</td>
<td>2,162.6</td>
<td>1,269.5</td>
</tr>
</tbody>
</table>

Footnotes:
CBA

Avoided Emissions Capacity
% of time online (nationwide)

On/off peak times

Demand high during day

Storage needed for off-peak

92% for gas turbine
CBA

Energy Cost per MWH
No cost for sun and wind
O&M minimal
Based on capacity

Energy Information Association
## Overall Net Benefits

<table>
<thead>
<tr>
<th></th>
<th>Wind</th>
<th>Solar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoided Emissions</td>
<td>$284,526</td>
<td>$185,338</td>
</tr>
<tr>
<td>Avoided Energy Cost</td>
<td>$98,925</td>
<td>$67,732</td>
</tr>
<tr>
<td>Avoided Capacity Cost</td>
<td>$70,482</td>
<td>$46,425</td>
</tr>
<tr>
<td>Fixed Cost Incurred</td>
<td>-$162,687</td>
<td>-$181,434</td>
</tr>
<tr>
<td>Other Costs(Periodic O&amp;M)</td>
<td>-$7,755</td>
<td>-$4,713</td>
</tr>
<tr>
<td>Total Net Benefits/MW/Year</td>
<td>$283,311</td>
<td>$113,349</td>
</tr>
</tbody>
</table>
Wind Power 2013 Studies

Electric Markets and Policy Group (Berkeley)
U.S. Energy Information Association
American Tradition Institute
Data Sources

Electric Markets and Policy Group (Berkeley)
- Market report
- Wind power funding/subsidies

U.S. Energy Information Association
- Independent source/ 3rd party

American Tradition Institute
- Right wing nonprofit
- Fought against global warming “fear mongering”

Brookings Institution (Princeton)
- Focuses on Global Economy and Development
Life Cycle Assessment

Boundaries

- End of Life
- Raw Material
- Product Use
- Material Processing
- Assembly
- Part Manufacturing
Life Cycle Assessment

Life Cycle Assessment Harmonization Project
Life Cycle Assessment
New Solar Innovations

Sistine Solar

Solar skin

Elon Musk

Roof panels

Use of Boron instead of Aluminum
New Wind Innovations

Offshore wind technologies

According to National Renewable Energy Laboratory, there is a gross wind power resource of 4,223 GW/year off the coast of the United States.

Bladeless Wind Turbine

- Takes advantage of vortex of wind created when air moves around an object
- Made of carbon fiber and fiberglass
- Motor at the base to improve stability
- Completely silent and birds are free to fly around them
Generation and carbon footprint reduction about 40%

53% off in manufacturing costs.
51% off in operating costs.
80% off in maintenance costs.

40% global power generation costs reduction.
40% carbon footprint reduction.
**Durability/ Maintenance**

**Solar**

- Minimal maintenance
- Predicted 30 year life span
- 80% power after 20 years

**Wind**

- Varies greatly
- Gearbox type requires annual maintenance
- Direct drive needs very little maintenance
- Predicted 20-25 year life span
Location/Integration Options

Solar
- Few limitations to location
- Can be mounted nearly anywhere
- Must be facing the Sun

Wind
- Must be 30 feet above anything within 500 feet
- Very unfavorable in urban areas
Location/Integration Options

Average Daily Solar Radiation Per Month

DECEMBER

Average Daily Solar Radiation Per Month

JUNE

kWh/m²/day

- 10 to 14
- 8 to 10
- 7 to 8
- 6 to 7
- 5 to 6
- 4 to 5
- 3 to 4
- 2 to 3
- 0 to 2

Flat Plate Tilted South at Latitude
Location/Integration Options

*Department of Energy, 2014
Solar Cost/kwh by Location

*DOE 2016 report
Noise

Solar
● Completely silent during operation

Wind
● At high wind speeds, small turbines operate around 100 dB
● Can potentially be bothersome if near houses
Conclusions

Wind more carbon efficient

Wind more cost effective

Location very impactful on implementation

Solar growing at a faster rate

<table>
<thead>
<tr>
<th>Source</th>
<th>Production Growth 2014-2015</th>
<th>Generation (GWH/Year)</th>
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</thead>
<tbody>
<tr>
<td>Wind</td>
<td>5.0%</td>
<td>295.2</td>
</tr>
<tr>
<td>Solar</td>
<td>35.2%</td>
<td>35.8</td>
</tr>
</tbody>
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