Introduction

The amount of solar energy falling to the Earth far exceeds current human consumption. Assuming 300 W/m\(^2\) irradiation for 12 hours a day, which is average for the Southwest United States, about 100 quadrillions BTU (~10\(^{20}\) J) – the amount of energy consumed annually in the U.S. - can be collected from an approximately 100 x 100 mile square. The problem with utilizing renewable energy, however, is its highly dispersed nature. Solar and wind energy is distributed over large areas at a relatively low density. With the above irradiation assumptions, collecting 30 kW power to move a small car would require an area of 10x10 meters. Unlike oil and gas where only a small wellhead installation on the surface enables extraction of large amounts of energy, wind and solar necessarily have to be collected over large swaths of land. To be economically viable this should be low utilization land such as deserts or mountains, generally far removed from populated areas where the energy is ultimately consumed. The clean energy challenge, therefore, is not in finding energy - wind and solar alone far exceed human needs - the challenge is in converting the energy into a form suitable for consumption, accumulating it and delivering it to the consumer on demand and at competitive cost.

Present day energy carriers

Figure 1 shows the energy flow diagram for the United States. Currently, solar and wind energy are utilized almost exclusively as electricity, and other than via electrified transportation do not make inroads into the transportation fuel market. Yet electricity accounts for only about 18% of energy delivered to consumers (12.71 out of total of 72.86 quads consumed by all sectors combined). While large investments directed in increasing the use of electricity in the industrial and transportation sectors have been made, complete replacement of natural gas and petroleum carriers by electricity (even if technologically feasible) would require nearly 5-fold increase in the electrical grid capacity, an extremely large and costly undertaking.
Shifting the paradigm: Synthetic liquid fuels offer vehicle for monetizing wind and solar energy

Written by Maxim Lyubovsky
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Estimated U.S. Energy Consumption in 2015: 97.5 Quads

Figure 1. 2015 U.S. energy flowchart. Figures 2 and 3 show distribution of solar and wind resources in the United States. Renewable resources are concentrated in the Southwest and Great Planes regions, but population is highest on the coasts and energy is ultimately consumed. Figure 4 maps locations of electric generating facilities throughout the U.S. It shows that today electricity is generated in close proximity to consumers to avoid long distance transmission of electricity on a large scale. Coal and natural gas, for the most part, are used to bring energy to the population centers where it is converted to electricity.
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Figure 2. U.S. Potovoltaic Solar Resource Map.
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The average wind speeds indicated on the map are model-derived estimates that may not represent the true wind resource at any given location. Terrain features, vegetation, buildings, and atmospheric effects may cause the wind speed to depart from the map estimates. Expert advice should be sought in placing wind turbines and estimating their energy production.


Table 2. Cost estimates for methanol production from H2 and CO2.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Component</th>
<th>Cost (2017 $/MMBtu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H2</td>
<td>Electricity component in electrolysis</td>
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<tr>
<td>H2</td>
<td>Natural gas</td>
<td>$0.50</td>
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<td>H2</td>
<td>CO2 capture</td>
<td>$0.14</td>
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<tr>
<td>MeOH</td>
<td>Levelized PPA for onshore wind power</td>
<td>$0.0235</td>
</tr>
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<td>MeOH</td>
<td>Levelized PPA for onshore wind power</td>
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</tr>
<tr>
<td>MeOH</td>
<td>Transportation component in electrolysis</td>
<td>$0.60</td>
</tr>
</tbody>
</table>

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Figure 5. Historic wholesale market price for methanol, $/gal. Source: Methanex.