Sustainability Technologies for the 21st Century

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“[Our challenge is to] make the world work for 100% of humanity in the shortest time possible through spontaneous cooperation without ecological offence or the disadvantage of anyone.” (www.bfi.org).
Topics of Presentation

• Overview
• Sustainability Technologies
• Barriers to Adoption
• Global Competition for Subsidies
• Summary
American Capital Energy

• Started in 2006 to design, develop and install commercial PV power plants
• Cumulative installations of over 50 MW in >45 projects; over 70 MW currently under contract
• EPC specialists for commercial roof tops, landfill, and brownfield utility-scale PV power plants
A Plus for the Environment:
1, 850 kW PV Array on Landfill in western MA at WMECo
## Status of Wind and Solar Photovoltaic Power Production

<table>
<thead>
<tr>
<th>Generator</th>
<th>2012 Installed</th>
<th>Cumulative US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>13 GW</td>
<td>&gt;60 GW (3%)</td>
</tr>
<tr>
<td></td>
<td>42% of new incremental capacity</td>
<td>(20% of world’s wind capacity)</td>
</tr>
<tr>
<td></td>
<td>&gt; capacity of gas installed in 2012</td>
<td></td>
</tr>
<tr>
<td>Solar</td>
<td>3.3 GW ($11 Billion)</td>
<td>&gt;8 GW (&lt;1%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(less than 10% of world’s PV capacity)</td>
</tr>
</tbody>
</table>

**Historic footnotes:** May 25, 26, 2012, solar PV in Germany operated near its ~25 GW installed capacity of solar PV electricity and produced close to 22 GW peak for several hours (~40% of demand)

Installed PV capacity (32.5 GW) in Germany now greater than wind (30.3 GW), but wind energy is x2-4 greater because of higher capacity factor
Global PV Markets
(Source: Paula Mints, SPV Market Research)

PV Shipments
10 Year CAGR 48%

PV Shipments/Low 2013 Estimate
Conservative Estimate
Accelerated Estimate
Global PV Markets
(Source: Paula Mints, SPV Market Research)

2013 Regional Demand Est ~35.6-GWp/Installations ~40-GWp (inventory)

- Europe: 44%
- US: 10%
- Japan: 9%
- Latin America: 2%
- India: 3%
- China: 28%
- ROW: 4%
- US: 10%
- Latin America: 9%
- India: 3%
What is Driving/Hindering Renewable Energy Technology Adoption?

Pluses:
• Availability of clean technologies
• Costs are declining
• Clean environment emphasis
• Rise of subsidies for renewables in global markets

Minuses:
• Lack of infrastructure
• Lack of political support/will
• Embedded subsidies for fossil fuels in global economy
Carbon and Emission Free Technologies for Sustainability

• Electricity:
  – Wind and Photovoltaics

• Fuel:
  – Steam Reforming of Organic Waste Products for Fuel and Byproducts
  – Potable water
  – Commercial syngases: (H2, CH4, CO2)
  – Fertilizer
Sustainability with PV

- Available at all levels:
  - Large PV power plants
  - Distributed PV on rooftops, large and small
  - Landfills
Sustainability with Biomass Steam Reformer Technology

Patented U.S. Nos. (T. R. Galloway)
7,132,183, 7,220,502, 7,753,973, 7,998,226

Diagram:
- **Biomass or Waste** flows through a **Rotary Kiln** and reacts with steam.
- **CH₄, H₂O, CO₂ & light gases** are produced.
- Steam flows through a **Steam Reformer**.
- **Hydrogen Product** is generated.
- **Electricity Generation** occurs.
- **Kiln Vent** and **Syngas** are outputs.
- **15% of feed-sterilized granular carbon-sequestering residue sold as fertilizer**.

- **Brayton** and **Solar PV & thermal** are energy sources.
STEAM/CO$_2$ GAS TEST RESULTS
Average of all feedstocks

<table>
<thead>
<tr>
<th>Compound</th>
<th>Description</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>H$_2$</td>
<td>Hydrogen</td>
<td>59 - 63 vol%</td>
</tr>
<tr>
<td>CO</td>
<td>Carbon Monoxide</td>
<td>19 - 30</td>
</tr>
<tr>
<td>CO$_2$</td>
<td>Carbon Dioxide</td>
<td>3 - 10</td>
</tr>
<tr>
<td>CH$_4$</td>
<td>Methane</td>
<td>5 - 8</td>
</tr>
<tr>
<td>C$_2$H$_6$</td>
<td>Ethane</td>
<td>0.5</td>
</tr>
<tr>
<td>Higher HCs</td>
<td>Propane thru hexane</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Sulfur Cmps</td>
<td>All compounds</td>
<td>&lt;4 ppm</td>
</tr>
<tr>
<td>Polychlorinated dibenzofurans + dioxins</td>
<td></td>
<td>0.0041 ppt TEQ</td>
</tr>
</tbody>
</table>

ng/m$^3$
Sustainability with Steam Reformer Technology

• Feedstock can be mixture of municipal/commercial solid waste and agricultural biomass
  – sewage sludge, toxic waste, chemical waste
  – pharmaceuticals, hospital waste, medical waste,
  – agricultural waste, biomass, coal, etc.

• Process operates via chemical reduction to generate a clean H₂-rich syngas, CO, CO₂, H₂O steam, and other commodities:
  – nitrogen-free fertilizer, irrigation water, mixed alcohols

• Syngases can be operated in closed loop with fuel cell (hydrogen or SOFC), storage options for night-time use

• No toxic emissions ( which are characteristic of incinerators )
Barriers to Sustainable Development of Renewables (PV, Wind)

- Capacity factor
  - 10-15% for PV, >20% for wind
- Lack of convenient, low cost storage
  - storage doubles cost of electricity
- Standards
  - written for base load power plants
- Capital costs
  - ITC for solar PV, PTC for wind temporary
- Regulation and Interconnect - Smart Grid and Plant Control
  - Regulations block IPP operations in many states
  - lengthens and complicates interconnect studies (adds to increase “soft” costs)
Interconnect Issues Contributing to “Soft” Costs in PV Plant Deployment

- PV and wind intermittency is basic issue
- Current SCADA-based PV power plant supervision and control is system of choice for utilities
- SCADA is not suited for real time PV plant control that will best deal with intermittency
- Combination of Smart Grid for demand-side and enhanced real time PV plant generation-side monitoring and control may be solution

PV Plant Performance Analysis and Control Strategy

One Physical Model for Three Types of Analysis: (a) Steady State, (b) Quasi-Dynamic, and (c) Time Domain
Seamless Applications: (a) Fault Studies, (b) Adequacy Studies, etc. (see graph below)
Barriers to Sustainable Development of Renewables – (cont’d)
What Do We Hope to Learn From PMU-Base Analysis

- Can PMU technology contribute to improved PV plant monitoring and control
- Will PMU monitoring add value to PV energy from the utility perspective
- Are monitoring and Control technologies robust enough to be deployed remotely

This discussion will continue in panel tomorrow Friday 10:15 am, “Utility-Scale PV: Next Generation Technology”
Barriers to Sustainable Development of Renewables – (cont’d)

• Lack of clean non-polluted air valuation
  – public policy and incentives ignore environmental and health costs of fossil fuels

• Global subsidy infrastructure for fossil fuels
  – embedded in 1st world countries as a pillar guaranteeing a high standard of living
Clean Air Valuation....
More Publicity Needed

“Pollution kills... One study by Cornell University concluded that a staggering 40 percent of deaths worldwide are caused by water, air and soil pollution Think about that. In the United States alone, 100,000 people die a year because of pollution. That’s more than the combined deaths from car accidents, drunk drivers, gang wars, suicides or Iraq and Afghanistan” *. 


CA still leader in adopting and implementing direct measures to reduce emissions and protect public health, including CA’s clean car standards (www.calcleancars.org ), goods movement measures and the Low carbon Fuel Standard (www.energy.ca.gov)
Global Subsidies and “Grid Parity”
Unstable Incentives in USA for PV and Wind at Best

<table>
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<th>Generator</th>
<th>Conventional U.S. subsidies and renewable energy  PTC/ITC</th>
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<tbody>
<tr>
<td>Oil</td>
<td>-$ 4 Billion annually; -100% depreciation allowance</td>
</tr>
<tr>
<td>Wind</td>
<td>-2.2 c/kWh PTC, yearly renewal -$1.3 Billion annually</td>
</tr>
<tr>
<td>Solar</td>
<td>-30% ITC will be terminated in 2016 -accelerated plant depreciation being phased out at the end of 2013 -State Solar Renewable Energy Credit (SREC) programs poorly designed for sustainable PV businesses (gold rush, crash and burn cycles)</td>
</tr>
</tbody>
</table>
World fossil fuel consumption subsidies by net oil and gas exporter/importer

Rich get richer: only 8% of $409 Billion of global subsidies went to poorest 20% of population *

World subsidies to fossil-fuel consumption

Why is there National/Global Competition for Subsidies (www.iea.org)?

- Subsidies lower energy costs, increase standard of living (if someone else pays for them)
- Disproportionally benefit middle class and rich
- Exacerbate global wealth disparities - make rich richer, poor poorer
- Encourage use of energy so as to enhance CO2 emission and particulate pollution

Conventional fuel subsidies relegate renewables to be the “poor man” of the energy world!
“Grid Parity” for PV Prices and Conventional (Fossil Fuel) Retail Prices is Here (www.pvparity.eu)

Annual Sun hours in:

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<tr>
<th>Europe</th>
<th>USA</th>
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<tbody>
<tr>
<td>900 h/a*: €0.32 kWh</td>
<td>North of Canadian border</td>
</tr>
<tr>
<td>1,800 h/a*: €0.16 kWh</td>
<td>SW USA $0.23-0.28 /kWh</td>
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* h/a: Hours of sun per annum. 900 h/a corresponds to northern countries of Europe. 1,800 h/a corresponds to southern countries of Europe.

Source: EPJIA.
Summary

- Technologies for sustainable living are available NOW to fulfill the Buckminster Fuller vision
- Multiple non-technological barriers slow US. adoption
- Monetization of pollution cost on human health are lacking
- Global fossil fuel subsidies distort the playing field and discussions of “grid parity”
- Struggle to recognize multiple values of renewable energies and incentivize them adequately is global
- Lack of value recognition not confined to any one political system or philosophy