Biofuels Beyond Ethanol

**Today**

**Ethanol** – as a blending agent from either grain or cellulosic material from Ag and/or Forestry industry

**Biodiesel** – Transesterified vegetable oils blended with diesel

**Green Diesel** – fats, algal oils, waste oils, or virgin oils converted to low-sulfur diesel in petroleum refinery

**Higher alcohols** – examples include: butanol, mixed alcohols, higher carbon alcohols (C5- and greater)

**Fischer-Tropsch Liquids** – and other products from syn gas including methanol, dimethyl ether, etc

**Pyrolysis Liquids** – alternative feedstock to petroleum refinery or gasification facility

**Methanol derived fuels** – Methanol to gasoline technology, dimethyl ether and other products

**Other fuels** – Liquid transportation fuels from sugars/oils refinery not discussed or yet envisioned

**Future**
Plug-in Hybrids are Emerging (require more robust batteries)

- **EV**
  - Charge Depleting (CD) only:
    - Sized for energy (300 mi. range),
    - ~1,000 deep discharge cycles
  - Battery Energy (kWh): > 40 kWh, P/E = 2

- **PHEV**
  - Charge Depleting and Sustaining:
    - Supplies energy (10-40 mi. range),
    - up to 5,000 deep cycles,
    - and power-assist (40 kW) for 10 sec @ 25% SOC,
    - up to 300,000 shallow cycles
    - Cost goal – $250/kWh (by 2015)
  - Battery Energy (kWh): ~5-15 kWh, P/E = 3-15

- **HEV**
  - Charge Sustaining (CS) only:
    - Sized for power-assist (40 kW)
    - 10 sec @ 55% SOC,
    - ~300,000 shallow cycles
    - Cost goal – $200/kWh (by 2015)
  - Battery Energy (kWh): ~1-2 kWh, P/E = 15-20+
Benefits of 20% Wind in US

- Over $1 trillion in economic investment and over $400 billion in total cumulative economic impacts
- Almost Half a million jobs for manufacturing, installation and operations
- New property tax revenues of over $1.88 billion & $783 million in annual payments, largely to rural landowners
- Natural gas demand reduced by approximately 7 billion cubic feet/day, nearly half current electric sector consumption, and prices reduced by ~11%, saving consumers approximately $128 B through 2030.
- 825 million tons of CO2 emissions avoided in 2030, equivalent to 25% of expected electric sector emissions
- Reduced water consumption in the electric sector by 8%, or 4 trillion gallons, enough to supply Denver for 100 years

Will require energy infrastructure improvements, stable state and federal policies & technology improvements
Smart metering has two distinct features:

- Capture and display of complex energy use data
- Communication with the utility and the end user

For end users, smart metering allows for:

- Net-metering
- Access to real-time pricing
- Real-time feedback for management
- Integration with dynamic building controls

For utilities, smart metering allows for:

- A better understanding of consumption patterns in order to secure better, less volatile pricing and to manage renewable resources
- Demand response programs that encourage customer to use energy smarter and cut their energy costs
- Interactive management of distributed resources and storage

---

Smart Grids and Networks Required for Next Generation Technologies

---

**Smart Meters**

---

**Residential**
- Residential Home
- Residential Home
- Storage

**Commercial**
- Commercial Load
- PV
- Storage
Renewable Energy Interconnections

Central Station

Large wind farms, CSP, PV, biopower, hydro, geothermal interconnect at transmission and sub-transmission levels

Distributed

PV, small wind, and fuel cells interconnect at the distribution level
Evolution of Nuclear Power

- **Improved Efficiency**
- **Process Heat**
- **Resource Conservation**

**Evolution of Nuclear Power**

- **Generation I**
  - Early Prototype Reactors
  - Shippingport
  - Dresden, Fermi I
  - Magnox

- **Generation II**
  - Commercial Power Reactors
  - LWR-PWR, BWR
  - CANDU
  - VVER/RBMK
  - AGR

- **Generation III**
  - Advanced LWRs
  - ABWR
  - EPR
  - AP600

- **Generation III+**
  - Generation III Evolutionary Designs Offering Passive Safety
  - AP1000
  - ACR 700
  - ESBWR

**Timeline**

- Gen I
  - 1950
- Gen II
  - 1960
  - 1970
  - 1980
  - 1990
- Gen III
  - 2000
  - 2010
  - 2020
- Gen III+
  - 2030
- Gen IV
Spent Nuclear Fuel Reprocessing Products

Uranium: 499 kg, 0.12 m³ as oxide

- Americium: 0.64 kg, 0.000048 m³ as oxide
- Curium: 0.027 kg, 0.0000022 m³ as oxide

- Cs/Sr Alumino-Silicate: 14.7 kg, 0.006 m³
- Gases on Molecular Sieve: 1.4 kg, 0.00026 m³
- Technetium/TRU Losses/Zr Hulls & Structure: 154 kg, 0.035 m³
- Fission Prod./U/TRU Losses in Borosilicate Glass: 50 kg, 0.018 m³

Recycle as Fuel

Storage / Permanent Disposal < 10% of the Repository Space
How to Make Things Happen!

• *It is not about technology!*
### Pathway to Zero Energy Homes

<table>
<thead>
<tr>
<th></th>
<th>Current Home (baseline)</th>
<th>ENERGY STAR Home</th>
<th>Today’s ZEH (niche)</th>
<th>2020 ZEH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size (sq ft)</strong></td>
<td>2200</td>
<td>2200</td>
<td>2200</td>
<td>2500</td>
</tr>
<tr>
<td><strong>Typical Cost/ Incremental Cost</strong></td>
<td>$235,000</td>
<td>No Incremental Cost</td>
<td>$75,000 over baseline</td>
<td>$20,000 over baseline</td>
</tr>
<tr>
<td><strong>Kwh/day Consumption</strong></td>
<td>58 kwh/day</td>
<td>49 kwh/day</td>
<td>25 kwh/day</td>
<td>15 kwh/day</td>
</tr>
<tr>
<td><strong>Renewables</strong></td>
<td>0</td>
<td>0</td>
<td>50% Solar Hot Water 6 KW of PV</td>
<td>100% Solar Hot Water 3-4 KW of PV (15 kwh/day, avg)</td>
</tr>
<tr>
<td><strong>Percentage from Grid</strong></td>
<td>100%</td>
<td>100%</td>
<td>30%</td>
<td>10-15% (seasonal)</td>
</tr>
</tbody>
</table>
**Solar Energy Technology**

### PV Cost & Market Penetration Targets

- **Historical vs. Targets**
- **Cumulative U.S. Installed Capacity (GW)**
- **Cost of Energy in Cents/kW (2009)**
- **Systems Price Range**

### CSP Cost & Market Penetration Targets

- **Pending Budget Increase**
- **CSP Deployment (GW)**
- **Cost Reductions**

### PV System Optimization Strategy

<table>
<thead>
<tr>
<th>TECHNICAL IMPROVEMENT OPPORTUNITIES</th>
<th>METRICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TER 1 Tiers</td>
<td>TER 2 Tiers</td>
</tr>
<tr>
<td>Modules</td>
<td>Inverter</td>
</tr>
<tr>
<td>Absorber</td>
<td></td>
</tr>
<tr>
<td>Cells and Contacts</td>
<td></td>
</tr>
<tr>
<td>Interconnects</td>
<td></td>
</tr>
<tr>
<td>Packaging</td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td></td>
</tr>
<tr>
<td>Inverters &amp; BOS</td>
<td></td>
</tr>
<tr>
<td>Inverter Components/Design</td>
<td></td>
</tr>
<tr>
<td>Inverter Packaging/Manufacturing</td>
<td></td>
</tr>
<tr>
<td>Other BOS</td>
<td></td>
</tr>
<tr>
<td>Storage</td>
<td>SEI &amp;</td>
</tr>
<tr>
<td></td>
<td>Integration</td>
</tr>
<tr>
<td></td>
<td>Manufacturing/Assembly</td>
</tr>
<tr>
<td></td>
<td>Installation/Maintenance</td>
</tr>
</tbody>
</table>

### CSP Plant Optimization Strategy

<table>
<thead>
<tr>
<th>TIER 1 TIOs</th>
<th>TIER 2 TIOs</th>
<th>Performance</th>
<th>Reliability</th>
<th>Cost</th>
<th>O&amp;M</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Field</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentrator</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance of Solar Field</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Energy Storage (TES) &amp; Heat Transfer Fluid (HTF)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TES &amp; HTF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat Exchanger</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atmospheric Energy Storage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Plant Balance of Systems (BOS)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Plant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O&amp;M Variances</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System Engineering &amp; Integration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systems Engineering &amp; Integration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Software &amp; Analytical Tools</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deployment Facilitation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market Analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support &amp; Outreach</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Impacts of 100 GW of Clean Energy

100 GW Scenario

- Clean technologies meet all new electricity consumption through 2017
- Capacity additions are a blend of clean technologies: wind, PV, CSP and geothermal
- Supported by current programs: 20% Wind Initiative, the Solar America Initiative, and Enhanced Geothermal Technology

Accelerates price parity with conventional sources

- The federal government purchases of clean electricity can stimulate the 100 GW Scenario
- Federal government demand exceeds 10% of 100 GW target
- By 2017, price parity will be achieved for the government’s purchase of clean electricity under this scenario
Success in Driving Down Cost of Wind

Program Supported Accomplishments

GE Wind 1.5 MW Series
- Over 10,000 units sold
- 47% of 2006 US market

Clipper 2.5 MW Liberty
- New advanced drive train
- >5,600 MW of firm and contingent orders for delivery through 2011

Southwest Windpower 1.8 kW

Since the 1970s, Federal government has spent just under $4 billion to support advanced wind technology and project development. The current existing U.S. wind capacity is worth $13 billion and will produce ~31 billion kWh of electricity in 2007.

Wind power sales price (bus bar) based on 58% of wind plants installed since 1999.

<table>
<thead>
<tr>
<th>Year</th>
<th>Projects</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>7</td>
<td>450</td>
</tr>
<tr>
<td>2000</td>
<td>10</td>
<td>562</td>
</tr>
<tr>
<td>2001</td>
<td>14</td>
<td>660</td>
</tr>
<tr>
<td>2002</td>
<td>30</td>
<td>1,541</td>
</tr>
<tr>
<td>2003</td>
<td>42</td>
<td>2,416</td>
</tr>
<tr>
<td>2004</td>
<td>54</td>
<td>3,216</td>
</tr>
<tr>
<td>2005</td>
<td>70</td>
<td>4,309</td>
</tr>
<tr>
<td>2006</td>
<td>85</td>
<td>5,678</td>
</tr>
</tbody>
</table>

Primary Supplies of Wind Turbines in 2006

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>% of total worldwide market of 15,016 GW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vestas (DK)</td>
<td>28.2%</td>
</tr>
<tr>
<td>Gamesa (ES)</td>
<td>15.6%</td>
</tr>
<tr>
<td>GE Wind (US)</td>
<td>15.5%</td>
</tr>
<tr>
<td>Enercon (GE)</td>
<td>15.4%</td>
</tr>
<tr>
<td>Suzlon (Ind)</td>
<td>7.7%</td>
</tr>
<tr>
<td>Siemens (DK)</td>
<td>7.3%</td>
</tr>
<tr>
<td>Other</td>
<td>10.3%</td>
</tr>
</tbody>
</table>

Sample includes projects built from 1998-2006

Source: Berkeley Lab database.

Geothermal is a Mature Technology

Technology Status

- Geothermal power is baseload generation
- Costs range 5 cents/kWh (flash) to 8 cents/kWh (binary)
- Essentially no carbon or other gaseous emissions. Binary cycle is emissions free

U.S. Market

- Installed capacity of 2,900 MWe in six states: CA, NV, UT, HI, ID, AK
- Hydrothermal potential for additional 5,600 MWe in 11 western states by 2015; total potential up to 23,000 MWe
- Oil and gas associated wastewater potential from 900 MWe to 5,000 MWe

Technology Has Reduced Costs for Hydrothermal Resources

Future market penetration estimates are derived from 2007 Geothermal Energy Association data on projects under various stages of development.
Fuel Cell Vehicles & Hydrogen Infrastructure:

DOE Vehicle/Infrastructure Demonstration
Four teams, in 50/50 cost-shared projects, operating 77 fuel cell vehicles and 14 hydrogen stations

Verified fuel cell vehicle performance:

- **EFFICIENCY:** 53 – 58% (>2x higher than internal combustion gasoline engines)
- **RANGE:** 103 – 190 miles
- **FUEL CELL SYSTEM DURABILITY:** 1600 hours (~48,000 miles)

Demonstrated Fuel Cost: $3/gge, from natural gas

DOT is demonstrating fuel cell buses and providing data to DOE for analysis

Eight buses in California, Massachusetts, New York, South Carolina, and Washington, DC

Detailed data feeds back to inform R&D efforts
How to Make Things Happen!

- It is not about technology!

- *It is not about money!*
It’s Not About the Money!

- Venture capitalists invested almost $3 billion in clean energy in US 2007
- Global investments have expanded 60% from $93b to $148 billion from 2006 to 2007
- Solar, biofuels, wind and fuel cells generated more than $50 billion in revenue
- 2008 reports indicate more than 60% increases in investments
It IS about leadership, political will, and public policy!

- Public behavioral change regarding energy
- Electricity business model must change
- Must stimulate investment in biofuels
- More stringent building codes
- Congestion transportation pricing
- Feed In tariffs or other electricity policy options
- Carbon Tax or Cap and Trade
- Etc., etc.
Market Access Policies are Critical

Exhibit 1: Lifting CA net metering caps could double installations thru 2015.

Exhibit 2: Improved interconnection in CT, FL, MA, ME, TN, WA could increase installations by >50% through 2015.

Source: DOE/Navigant High-Fidelity U.S. Market Penetration Scenario Model

Nationwide availability of interconnection & net-metering will be required for PV market penetration.
Why Should Kauai Lead the Way in Renewable Energy?

- Reliance on oil leaves the status quo option tenuous at best
- Clean energy can lead to economic diversity and development
  - View shed issues are a “red herring”
- Federal and International partners will provide resources if you move quickly
- Because you possess the leadership to make it happen??
One Key Ingredient

What Is the One Key to Making a Clean Energy Future Happen for the United States, Hawaii and Kauai?