Recent Trends in Sustainable Energy Development in the United States

Marilyn A. Brown
School of Public Policy
Georgia Institute of Technology

National Research Council's Japan-U.S. Workshop on Sustainable Energy Futures

Washington, DC
June 26, 2012
Global Trends: Where the Action Is

- U.S. energy demand is growing much more slowly than the rest of the world
- Today we consume almost 25% of the world’s energy production; in 2100 the U.S. will consume less than 10%

Per Capita Energy Use and GDP (1980-2010)

Source: Energy Information Administration (EIA)
The U.S.: Green Tech – Clean Tech Economy is Progressing, But Slowly

Primary Energy Consumption by Fuel:
1980-2035 (quadrillion Btu per year)

Projected Fuel Mix for Electricity Generation (Trillion kWh per year)
U.S. Energy & Climate Goals

• By 2020, reduce energy-related GHG emissions by 17% (83% by 2050)
• By 2035, 80% of America’s electricity will come from clean energy sources
• By 2020, 20% improvement in the energy efficiency of commercial buildings relative to 2010
• By 2030, reduce home energy use by 30-50% (compared to 2009 energy codes for new homes & pre-retrofit for existing homes)
• By 2022, improve the energy intensity of U.S. manufacturers by 25%
• By 2015, put 1 million electric vehicles on the road
• By 2025, require passenger cars and light-duty trucks to average 54.5 miles-per-gallon
• Decrease the price of electricity from solar power 75% by 2020, making it cost competitive with coal

• How Can these Goals be Achieved?
18 Technology Assessments mapped to Six Strategies

- Stationary and transport power are increasingly linked by energy, climate, health, and air quality issues and goals

Source: U.S. Department of Energy Quadrennial Technology Review
Stationary Power: Technology Headroom

Building and Industrial Efficiency:
- Data Collection and usage
- Integrated systems analyses
- Next-gen processes and products

Grid Modernization:
- Communication and data
- Management and control
- Energy storage

Clean Electricity:
- Drive down costs
- Coupling between energy and water use
- Increase modularity and scalability
- Infrastructure compatibility

Source: U.S. Department of Energy Quadrennial Technology Review
Energy Efficiency: The Largest Energy Resource, But More is Needed

Energy use per capita and per dollar of gross domestic product and emissions per dollar of gross domestic product, 1980-2035 (index, 2005=1)

Source: Steven Nadel, ACEEE, 2011.

Source: AEO2012 Early Release Overview, EIA.
• Cost of Conserved Energy = the additional cost that must be invested in order to implement a long-term energy-saving strategy or feature.
Light Source Efficiency Trends

- Better LED performance increases energy savings and reduces cost

Source: Cree. December 1, 2009. “LED Lighting Overview”
Systems Integration Offers Future Savings (e.g., Climate Master Launches Trilogy™)

- ~65% energy savings vs. minimum efficiency (SEER 13) equipment
- ~33% savings vs. state-of-the-art two-stage GHP with the super heater
Changes in Energy Intensity in Six Key US Industries

Combined Heat and Power can improve System Efficiencies by 30%

Lots of Opportunities for CHP in Industry: Proposed CHP Plant in Alloy, WV

- Waste heat from silicon manufacturing could generate 60 MW of electricity
Social Benefit-Cost Ratios of Two CHP Policy Options

Nano-info-bio Technologies could Make Industry much Leaner

Significant improvements are anticipated in:

- Energy-efficient distillation through supercomputing
- Novel energy-efficient separations
- Super-durable materials for aggressive environments
- Molecular-level control of catalytic materials
- Self-optimizing sensor systems
- Recovery and use of waste heat

Additions to U.S. Electricity Generation Capacity, 1985-2035

The U.S. is predicted to add less than 10 GW of generating capacity (~1% of total) per year over the next 25 years, most of which will be natural gas.

Source: Annual Energy Outlook, EIA.
Location of Projected New Nuclear Power Reactors

Nuclear Power Reactors Under Construction:

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
<th>Reactor Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern Company</td>
<td>Burke County, GA (Vogtle 3, 4)</td>
<td>AP1000</td>
</tr>
<tr>
<td>South Carolina Electric &amp; Gas</td>
<td>Jenkinsville, SC (Summer 2, 3)</td>
<td>AP1000</td>
</tr>
<tr>
<td>Tennessee Valley Authority</td>
<td>Rhea County, TN (Watts Bar 2)*</td>
<td>Gen II PWR</td>
</tr>
</tbody>
</table>

U.S. Electricity Production Costs
1995-2011, In 2011 cents per kilowatt-hour

Production Costs = Operations and Maintenance Costs + Fuel Costs

Source: Ventyx Velocity Suite, Updated: 5/12
Water Consumption for Various Power Generation Technologies

CSP = Concentrating Solar Power, CCS = Carbon Capture and Storage, PV = Solar Photovoltaic

“Why should I worry when the grid is better than 99% reliable?”

2009 U.S. electricity consumption: 3,741 Billion kW-h (EIA)

Estimated annual outage costs: $30 Billion - $130 Billion (LBNL report to OE, 2004)

2003 Northeast Blackout

- 508 generators tripped
- Cleveland → Toronto → NYC
- 7 minutes

Smart Grid: A Vision for the Future

Converter stations are the most expensive part of HVDC and limits the cost-effectiveness of systems to > 300-500 miles.

2000 MW ± 500 kV HVDC Converter Station $280 M

Power Electronics
Controls; Thermal Management
Power Converter
DC Breakers
Cable Analysis (insulators; dielectrics)
System / Applications
Advanced HVDC Converter Station $100 M

Source: Cross Sound Cable
Building (330 MW)
90m x 18 m x 11 m (l x w x h)
Technologies:
Smart Meters & Displays

- Meter that allows frequent data collection
- Enables alternative pricing
- Can interface with in-home or in-office displays of online consumption information
- NOT just an automatic meter reader

Energy Orbs that signal expensive & inexpensive times to use energy
Transport Power: Technology Headroom

Vehicle Efficiency:
- Increase internal combustion engine efficiency
- Light weighting and aerodynamics

Electrification:
- Batteries
- Electric motors and power electronics

Alternative hydrocarbon Fuels (for HDVs):
- Biofuels
- Alternative fossil fuels (only if less carbon than gasoline/diesel)

Source: U.S. Department of Energy Quadrennial Technology Review
Impact of plug-in electric range and charging infrastructure

- The benefit of ubiquitous charging becomes smaller as the all-electric range increases; for most applications, home charging is sufficient. Source: forthcoming EPRI report, “Understanding the Effects and Infrastructure Needs of Plug-In Electric Vehicle (PEV) Charging”

- Utility factor is the fraction of vehicle miles that could be driven on electric power without recharging

Source: U.S. Department of Energy Quadrennial Technology Review
U.S. Natural Gas Supply, 1990-2035

- Shale gas is expected to grow in the next several decades, reducing net imports and challenging the development of renewables and energy efficiency

Source: Annual Energy Outlook 2011, EIA.
Manufacturing the Next Generation of Lean and Green Technologies

• Product line choices are important
  – A new generation of fuel cells and batteries for motor vehicles
  – Biorefinery innovations for a next generation of biofuels
  – New plastics that double as integrated photovoltaic systems

• Corporate sustainability
  – Industry is adopting a much broader view of its energy and environmental responsibilities

Input/Output Coefficients Confirm the Labor Intensity of Energy Efficiency Investments

<table>
<thead>
<tr>
<th>Description</th>
<th>GRP Coefficients</th>
<th>Jobs Coefficients</th>
<th>Regional Purchase Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction and EE Equipment</td>
<td>$1.09</td>
<td>16.45</td>
<td>86%</td>
</tr>
<tr>
<td>Electricity</td>
<td>$1.08</td>
<td>5.63</td>
<td>94%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>$0.98</td>
<td>8.43</td>
<td>72%</td>
</tr>
<tr>
<td>All Others</td>
<td>$1.10</td>
<td>13.86</td>
<td>75%</td>
</tr>
</tbody>
</table>

Over 400 U.S. Manufacturing Plants Serve the Wind Industry Today

Manufacturing data updated through November 2010, includes wind-related facilities
Recommended Policy Directions to Promote U.S. Energy Sustainability

- A policy framework is needed that attracts diverse funding sources.
- Policies could help motivate businesses to focus more of their resources on green and lean energy systems – preserving jobs in existing industries.
- Advancing product innovation can enable next-generation green and clean technologies – creating new jobs in new industries.
- Policy making needs to take into account societal costs & benefits and consumer behavior.
FOR MORE INFORMATION

Dr. Marilyn A. Brown, Professor
Georgia Institute of Technology
School of Public Policy
DM Smith Building
685 Cherry Street, Room 312
Atlanta, GA 30332-0345

Email: Marilyn.Brown@pubpolicy.gatech.edu
Phone: 404-385-0303
Fax: 404-385-0504