Energy-Water Science & Technology Research Roadmap

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US Energy Sustainability

A critical piece is missing

Renewable & Alternative Sources

Infrastructure Upgrades

Increased Fuel Supply

Energy Efficiency

Environmental Impact
Overview

• Energy-Water Nexus Issues Summary

• Energy-Water Science and Technology Roadmap
  – Process, schedule, goals, participants

• Technical Workshops Summary
  – Regional and national issues and challenges identified
  – Some suggested science and technology research and development directions
Energy and Water are 
... Inextricably linked

**Water for Energy**

- Thermoelectric cooling
- Hydropower
- Energy minerals extraction / mining
- Fuel Production (fossil fuels, H\textsubscript{2}, biofuels/ethanol)
- Emission controls

**Energy for Water**

- Water production, processing, distribution, and end-use
- Energy minerals extraction / mining
- Fuel Production (fossil fuels, H\textsubscript{2}, biofuels/ethanol)
- Emission controls
Energy and agriculture withdraw the most water in the U.S.

Estimated Freshwater Withdrawals by Sector, 2000

- Primarily Nonconsumptive
- Primarily Consumptive
- Thermostelectric 39%
- Public Supply 14%
- Industrial 6%
- Irrigation 39%
- Livestock 2%

Note: Hydropower uses are not included here!

Source: USGS Circular 1268, March, 2004
Energy accounts for a growing portion of water consumption

U.S. Freshwater Consumption, 100 Bgal/day

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation</td>
<td>80.6%</td>
</tr>
<tr>
<td>Livestock</td>
<td>3.3%</td>
</tr>
<tr>
<td>Domestic</td>
<td>7.1%</td>
</tr>
<tr>
<td>Thermoelectric</td>
<td>3.3%</td>
</tr>
<tr>
<td>Commercial</td>
<td>1.2%</td>
</tr>
<tr>
<td>Industrial</td>
<td>3.3%</td>
</tr>
<tr>
<td>Mining</td>
<td>1.2%</td>
</tr>
</tbody>
</table>

Constraint: Absolute Water Consumption

Constraint: Thermal Discharge Limits
Water challenges are nationwide

Projected Population Growth (2000-2020)
Source: NETL (2002)

Total Freshwater Withdrawal, 1995/Available Precip
percent, number of counties in parentheses

Source: USGS Circular 1200 (Year 1995), EPRI 2003
Energy and Water Conflicts Are Appearing Now
The U.S. will need 30% more electricity by 2025

Projection:
y = 67.05(x) - 130,700

Future energy development will put new demands on water

- Many newer technologies will be more water intensive
- Biofuels and hydrogen economy would require significantly more water than fossil transportation fuels
- Constraints will grow for power plant siting because of water for cooling needs, advanced scrubbing, and CO₂ removal
Energy-Water Roadmap

• Energy-Water Roadmap for DOE
  – Assess emerging energy and water resource issues based on user and stakeholder needs
  – Develop energy and water science and technology priorities
  – Due to DOE by September 2006

• Executive Committee
  – Representatives from - energy utilities, water management groups, environmental groups, energy and water regulators, utility associations, oil and gas, natural resource experts

• Energy and Water Stakeholders
  – Industry, government, academia, NGO’s,
  – Participants in technical workshops

• National Lab Team
  – 11 Department of Energy multi-purpose laboratories
  – Sandia National Laboratories: coordinate roadmap efforts – workshops and reports
  – Entire team: support science and technology issues analysis
Energy-Water Roadmap Process

National Energy-Water Roadmap Process

Energy-Water Categories

Energy-Water Pathway

Approximate Time Line

Executive Committee
Process Guidance & Oversight
Content Review & Approval

Energy-Water Nexus Advisory Group
National Laboratory Group

Needs Assessment Workshops
User / Customer Driven

West Region
Central Region
East Region

Gap Analysis and Evaluations

Cross-Cutting Policy & Economic Issues

National Energy-Water Roadmap Report

Peer Review
DOE Review

Future Program Planning and Research and Investment Guidance

Publication Sept 2006

Energy-Water Nexus Advisory Group

July-Sept 2005

Oct 2005 - Jan 2006

Feb 2006

Tech Innovation Workshop
Technology Provider Driven

Tech Approaches & Innovation

R&D Priorities and Strategies

May 2006

May - Jun 2006

Regional and National Research Perspectives and Directions
Roadmapping was nationwide

- Three regional workshops: Nov 2005 through mid-January 2006
  - Kansas City, Baltimore, Salt Lake City
  - Almost 350 participants from 45 states involved overall

- Focus on emerging user and stakeholder problems, issues, and needs and science and technology role in developing effective solutions

- Broad spectrum of regional, state, and local participation and input
  - Representatives from energy companies, electric utilities, water utilities, water managers, economic development groups, energy regulators, environmental groups, tribal nations, other water-use sectors

- Captured high-level issues, needs, and recommendations identified in each workshop
Examples of Major National Needs and Issues Identified the Regional Workshops

1. Integrated regional energy and water resource planning and decision support
2. Improved water supply and demand characterization/monitoring
3. Improved water efficiency in thermoelectric power generation
4. Oil and gas produced water treatment to enable use rather than disposal
5. Energy efficiency for impaired water treatment and use
6. Water requirements for emerging/renewable energy resources
7. Improved biofuels/biomass water use efficiency studies
8. Infrastructure changes for improved energy/water efficiency
Examples of science-technology responses match needs

Improved data on regional water availability and sustainability
- Statistical determination of monitoring needed, improved water data collection and frequency
- Improved sensors and data management systems

Coordinated regional natural resources planning
- Modeling and decision support tools for improved resource management and utilization
- Climate, hydrology, meteorology variability and uncertainty modeling
- Assessment of ecological water needs and demands

Improved materials, processes, and technologies to enhance water use efficiency and energy use efficiency
- Basic research in chemical and biological processes to improve energy and water use efficiency
- Applied research and more joint industry-government field demonstrations of emerging technologies
- Implementation of energy technologies with high water use efficiency

System-level consideration of energy-water solutions
- Energy and water transmission infrastructure improvements to enhance efficiency
- Co-location of energy and water production facilities to improve overall resource efficiency
Energy-Water Science and Technology Roadmap Summary

• Results from all Workshops are presented at www.sandia.gov/energy-water

• Final report available September 2006

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Backup slides
Water and Energy are related commodities in our economy.
Example 3: Oil Shale development could impact water availability and quality

- Reserves are in areas of limited water resources
- In situ retort the emerging technology
- Water needed for retorting, steam flushing, and cooling
- Concerns over in situ migration of retort by-products and impact on ground water quality
Future energy development will put new demands on water

- Many new technologies will be more water intensive
- Hydrogen economy would require even more water:

- Constraints will grow for energy development and power plant siting

Gallons/MMBTU

Equivalent to 1,000,000 Gallons/MWh at 34.1% thermal to electric conversion efficiency
Example 2: Saline water may be a required water resource in the near future.

Saline aquifers in the continental U.S. The brown shading refers to the depth of the aquifer. With appropriate treatment, inland brackish water resources could be an important source of water for thermoelectric power plant cooling. (Data from Feth, 1965)
Example: Bioenergy Production May Increase Water Demand

- Total U.S. gasoline market ~140 billion gallons/yr
- 2-10 gallons of water used per gallon of ethanol refined
- Irrigated and non-irrigated ethanol have potential water concerns