National Synopsis

The recently-completed Western, Central, and Eastern Regional Energy-Water Nexus workshops possessed a variety of similarities, yet each displayed unique attributes.

Looking at group dynamics, the energy level was highest in the Central and Western workshops, and lowest in the Eastern region. The workshops generated significant information regarding problems and needs; obtaining specificity and quantification of 'Needs' was problematic. Participants either did not know how much improved technologies/processes need to be in the future, or were unwilling to provide that information. Solutions to remedy this situation are being evaluated at present.

Eastern region participants generally had a more difficult time 'seeing' the interactions between energy and water than their Western and Central counterparts, and generally did not seem to view water vis a vis energy production as significant long-term problem—this may be a result of 'Eastern' water law and the relatively high precipitation rates in the region (and thus a perception that water is not now, nor will be in the future, a problem).

The Central Region provided an interesting comparative look at the issues and concerns that arise when 'Western' and 'Eastern' water law collide in a region characterized by increasing water demand and energy production. The region's states display radically different approaches and levels of intensity for measuring, monitoring, and managing their water resources; this is caused by legal structures, perceptions of scarcity, and budget limitations.

Participants at the Western Region meeting, not surprisingly, were heavily engaged. It is this region that faces the greatest water-energy challenges due to high population growth and scarce water resources.

Several common problem areas were identified in all three workshops, including:

- The **lack of long-term or integrated resource planning** that effectively addresses energy-water interactions at a state, watershed, or regional level.
- Participants in all regions **express concern over (and see opportunities in) the volumes of produced waters** discharged from oil, coal bed methane, and mining activities.
- The **lack of consistent and detailed data, and the lack of models** that can be used to address current and emerging problems at the energy-water nexus.
- Participants note that the **water intensity of conventional electricity generating technologies is a problem**, they cite the **lack of water-intensity considerations in current energy RD&D programs** as an indication of the division between energy and water communities, and **note the insufficient resources devoted to developing less-water**

intensive alternative electricity generation technologies (solar, wind, etc.)

- Participants note a **lack of fundamental understanding of the nation's surface and groundwater resources**, including location, quantity, quality, interactions between surface and groundwater, sustainable yield, and even the current volumes extracted or returned. They note that this **lack of understanding hampers the rational management of today's resources and makes long-range or integrated planning virtually impossible** (This is the 'If you don't know what you have, how can you manage it?' quandary.).
- The **cost and value of water was also a topic of significant interest and concern** in all regions—participants note that at present, end-users do not pay the true cost of the water they consume; that water has historically been (and continues to be) undervalued in the United States; and that the legal and regulatory frameworks that bound water make it highly problematic to address this problem.

Unique problem areas also appeared:

- Eastern region participants are **particularly concerned about the decay of water treatment and delivery infrastructures**, noting significant energy consumption and water loss from leakage.
- Central and Western region participants note **significant transmission and distribution problems and constraints**, with a lack of carrying capacity for electricity and natural gas noted. They also comment on the difficulties presented by large-scale integration of renewable energy technologies into the grid.
- Western region participants were more **interested in climate change and its impacts on water supplies and energy production** than other groups.
- **Conservation programs were significant foci at the Western region meeting**; they noted needs for both increased energy conservation programs and the development of national-scale water conservation efforts and programs.
- The **potentially massive water demand posed by ethanol production** is a significant concern for those in the Central region

Western Region Synopsis

Water Availability

- Need: Analysis of tradeoffs between water efficiency and thermal efficiency
- Need: Better assessment of resources
    - Comprehensive system including data and maps covering energy systems, water resources, ownership, controls or river habitats
- Need: Identify and map recharge areas
- Need: Identify potential water resources not in use
- Need: RD&D on recharge and recovery technologies
- Need: Identify/quantify potential conservation in various sectors
- Need: Assess and characterize bioenergy water demands
- Need: Development of remote sensing technologies for water resource assessments.

Water Cost/Value

- Need: Research on common metrics to value externalities (cultural/environmental)
- Need: Research on uses of water versus value of water
- Need: Analysis of pricing policies and impacts on energy/water conservation
- Need: Research on metrics to help establish true value of clean water
- Need: Better standards and methodologies for decision support system to capture full value of water.
- Need: Research to develop predictive model for long-term value of water
- Need: Real-time monitoring data

Produced water

- Need: Reduce treatment costs for produced water
    - R/O filtration cost reduction
    - Improve membrane efficiencies
- Need: Quantify CBM produced water volumes
- Need: RD&D on technology solution to disposal/use of produced water
- Need: Develop materials and equipment that allow use of produced/low quality water in industrial processes

Water intensity of thermoelectric cooling

- Need: Develop technologies for more efficient water use in energy producing industries
- Need: DOE provides rate relief/preapproval/federal incentives for implementation of more water efficient technologies
- Need: Demonstrations and first-commercialization of more water efficient technologies

Integrated Resource Planning

- Need: Research on hydropower impacts on water systems and ecosystems
- Need: Understand the impact of water cost on energy price
- Need: Integrated assessment of interaction between water and energy
- Need: Better RD&D coordination among major players in water and energy research (AWWA, EPRI, etc.)

- Need: Information and analysis of complexity of overlaying authorities, regulations and policies
- Need: Develop models/decision support tools for truly integrated systems (air, water, energy)
    - Need: Consistent, uniform datasets to feed models
- Need: DOE supports translational (interdisciplinary) science programs that integrate water/energy science with decision makers
- Need: Define scale of 'hydrographic neighborhoods'
- Need: Analytical tools that incorporate water/land
- Need: Integrated measurement and monitoring system
- Need: Demand forecasting tools
- Need: Consistent data standards

Conservation programs

- Need: Compile case studies of successful conservation programs (e.g. evapotranspiration monitors for irrigation)
- Need: Federal requirements/regulations for standardized energy-efficient systems/technologies to be used by commercial and residential customers
- Need: Scientific/technical bases for development of Federal water efficiency standards
- Need: "WaterStar"
- Need: Federally-supported innovation contests/programs for appliances
- Need: RD&D on crops that consume less water/low quality water
- Need: Develop water efficiency metrics

Infrastructure

- Need: Prioritize opportunities to increase water efficiencies throughout the system
- Need: Prioritize infrastructure needs based on areas specific to national interest
- Need: Identify water infrastructure needed under climate change scenarios
- Need: R&D on integrating non-dispatchable resources into the grid
    - Control systems, storage technologies, superconductors, DG integration models
- Need: Neutral evaluation/certification of new technology performance
- Need: Install turbines at existing reservoirs that do not have power generation
- Need: RD&D on advanced storage technologies
    - Flywheels, advanced superconducting batteries, compressed air, ice)

Climate change

- Need: Analysis of impacts of climate change and climate variability on hydropower resources
- Need: Understand and project potential impacts on water supplies
- Need: Develop and implement adaptive management, planning and mitigation approaches
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Central Region Synopsis

Siting

- Need: An integrated model of electricity-water interactions.
- Need: Improve intake structures and improved regulatory flexibility to adapt intake structures to address drought-induced low flows, impacts from upstream users, etc.

Transmission and Distribution

- Need: Tools that can illustrate the overlay of where demand is and where generation occurs, and where demand will be growing.
- Need: Understand the impacts on and interactions between hydropower operations and transmission operations.

Water Availability Impacts on Electricity/Energy Production

- Need: Research and development on advanced cooling technologies, on methods to improve thermal conversion efficiencies (including materials development and advanced fluid dynamics), and the practicality of using degraded water for plant cooling.
- Need: Further investigate removing water from flue gases, and to quantify the amount of water such processes may produce.
- Need: Collect and quantify data on the locations and available volumes/sustainability of produced waters and coal bed methane outfall waters.
- Need: Understand the potential energy and water demands of oil shale production in the Central region and to include these in long-range planning activities.

Cost/Value of Water

Participants note that this is largely an economics and social research question, with no science or technology angle.

Water-friendly Energy Technologies

Conventional Hydropower

- Need: Investigate in the near-term the potential for adding new hydropower generation on existing dams.
- Need: Reinstitute in the near-term RD&D programs to improve turbine technology and variable speed machinery.

Nuclear power

- Need: Close the fuel cycle by examining the feasibility of fuel reprocessing.
- Need: Examine in the near-term improved reactor core types (i.e., cooling/moderating strategies) with higher thermal efficiencies.

Coal-fired/fueled processes

- Need: Better cost and performance data and incentives to entice utilities to participate in IGCC RD&D activities, and thus to move the technology toward market maturity.
- Need: Coal-to-liquid fuel and coal-to-gas processes need significant development and demonstration work before they can be considered market-ready.

Ethanol production

- Need: Calculate and analyze the water demand of future projected corn-based ethanol production in regards to incremental consumption and demand.

- Need: Improve ethanol processing science to reduce in-plant water demand.
- Need: Shift to cellulose feedstocks.

Distributed Generation (Wind/Solar/Low-head hydro)

- Need research on better wind forecasting methods to ease wind technologies' integration into the grid and improve its effectiveness.
- Need to develop a model case of distributed generation to examine its viability at a local/community level.
- Need to investigate the integration of wind energy into hydrogen production.

Long-Range Planning

- Need: Develop consistent demand forecasting methodologies and uniform standards for the development of groundwater and surface water models.

Need: A regional GIS-based system to be created that details current energy infrastructure.

- Need: Identify major water users (including power plants), their draws/consumption and their locations, the uses of the water drawn, and the sources of the drawn water.
- Need: Understand the water draw/consumption rates of differing energy production technologies in order to undertake rational long-term planning.
- Need: A national-scale gap analysis to determine where data is lacking.
- Need: Technical studies of aquifer storage and recovery.
- Need: Research to determine the hydrological groundwater—surface water interactions and relationships.
- Need: Collect data including in-stream/aquifer quantity; quality; location; ownership; consumptive/non-consumptive use; temperature;

Competing Demands

- Need: With a relatively fixed (in the near-term) supply, and increasing demand, participants note that each end-use sector needs to investigate ways of reducing water consumption in order for all demands to be met. Participants also note an overarching need for the development of water use indices.

Urban Use

- Need: Expand the use of brackish or reclaimed waters for watering grassy areas (golf courses, parks, landscaping, etc.); this will offset fresh water use.

Agriculture Use

- Need: R&D efforts to develop crops that use less water/are more drought tolerant.
- Need: RD&D on water management/conservation technologies.
- Need: Improve weather forecasting and to increase the number of local weather stations.

Recreational/Environmental

- Need: Conduct research to better define minimum flow needs, in terms of quality, quantity, and in time. Such a research program should include a broad, representative group of stakeholders.

Eastern Region Synopsis

Source Quality and Quantity

Participants in the Eastern Region note a range of current and emerging water quality and quantity problems including urbanization/sprawl impacts on hydrology; saltwater intrusion; interregional pollution; fossil fuel extraction-related impacts; and non-point pollution. To effectively address these problems, participants identified a host of needs, including

- Need: Develop improved scrubber technology to reduce mercury emissions at the source. Participants note a need for such technologies to be tested at the 50 megawatt or better scale to obtain real-world data.
- Need: Examine productive/beneficial use of waters that may otherwise present a pollution concern (coal bed methane waters, mine waters, etc.). Participants see this as a near-term problem that presents a long-term opportunity.
- Need: Research hydrologic cycles to understand why wells in the Eastern Region are not recharging the way that they should.
- Need: Research the near- and long-term impacts of water-borne contaminants, including pharmaceuticals and livestock feed additives.

Water Treatment/Delivery Infrastructure

- Need: Quantify leakage from old water pipes. This effort should quantify the volume of water lost, the volume of water that could reasonably be captured by reducing leakage, and the energy consumed (and lost) due to distribution losses.
- Need: Improved tools to detect and define leaks, including geophysical methods for locating and inspecting pipe leaks and automatic meter reading and improved meters to define and quantify leakage.
- Need: Improved water monitoring technologies. Specifically, participants cite the need for online, real-time sensors for contaminants (including current and emerging contaminants and radioactive substances) and analytical tools and methodologies with detection limits at parts per billion.
- Need: Improved reverse osmosis water treatment technologies.
- Need: Improved, lower-energy-use disinfection technologies.
- Need: Investigate cost-effective avoidance/efficiency approaches to reduce the strain on the current infrastructure and perhaps avoid the need for infrastructure upgrades or additions.
- Need: Develop funding mechanisms for infrastructure upgrades. Participants note that many utilities have done a poor job with preventive maintenance, and as a result face steep (and often insurmountable) financial hurdles to improving their infrastructure.

Lack of Data/Models/Tools

- Need: Forecast long-term water quality/characteristics changes and implications on water supply for energy
- Need: Predictive and optimization modeling capability for water supply (quality, quantity, timing, horizon) and water/energy demand.
- Need: Data base of water usage, quality, and trends on a national, state, local level.
- Need: Data on location and characteristics of impaired water sources
- Need: Understand sustainability of groundwater use
- Need: Cost-benefit analysis methodology of increased water quality
- Need: Standardization of reporting

Competing and Increasing Demands

- Need: GIS-based regional analysis of uses and interactions of water-energy
    - Energy flows to ag; water flows to ag/energy
    - Water supply
- Need: Substate level population growth projections that can be related to water, energy
- Need: Improve water use efficiency of crops (ex. Biomass)
- Need: Reduce energy/water intensity on the farm
- Need: Understanding/study of cost of diversions/lockage/river transportation on power production
    - Need localized studies of how/when downstream generation is impacted by upstream uses
- Need: New technology for post-use water treatment
- Need: Other energy sources that would be considered off-grid (cost competitive)
- Need: Research on innovative ways to increase supplies and to manage demand

Integrated Resource Planning/Competing Authorities

- Need: Develop long-term strategies for drought/flooding preparedness for energy sector
- Need: Develop social/mgmt science process and tools to understand/support water allocation decisions.
- Need: Adaptive management tools
- Need: Identify gaps in integrated energy/water planning tools and develop appropriate models to integrate energy/water
- Need: Long-term predictions of options for energy and water production

Cooling Technologies/Approaches

- Need: New/retrofit cooling technologies that use less water and maximize energy output
- Need: Characterize potential of cooling technologies in buildings and industry to cut demand side
- Need: Address use of lower quality water (characterization, disposal)
- Need: Investigate avoiding/reducing by going to dispersed generation
    - Sizing of plants to grey water supplies
    - Characteristics of plant to location
    - Ground cooling/uses/use of waste heat
- Need: Include water conservation in “future-gen” project
- Need: Technologies that can use impaired water for power production, or new materials that can facilitate the use of saline water
- Need: Look at using mine water for cooling

New/Renewable Technology Investments

- Need: Assess water requirements of hydrogen, bioethanol, bioelectricity
- Need: Grid integration/transmission studies/grid and dg management/control systems
- Need: Localized baseline EQ/ecological system/impact information to ease siting
- Need: Assess energy demands and water needs of carbon sequestration technologies
- Need: Improve efficiency of cold water desal technologies.
- Need: Improve conductivity/materials R&D to reduce transmission losses
- Need: Biomass gasification pilot plants of 5kW – 50MW
    - Need better controls (fuel differences make operations unstable)
    - Need to develop better processes
- Need: Biomass liquids pyrolysis R&D pathway
- Need: Water treatment
    - Need R&D on membranes to lower energy use, fouling, conc disposal
    - UV/ozone disinfection—lower energy use