Takeaways from the 2015 DOE Energy-Water Nexus Roundtable Series

DOE's 2015 Energy-Water Nexus Roundtable Series engaged stakeholders from industry, academia, utilities, state and local governments, National Laboratories, and other federal agencies in focused discussions about the energy-water nexus. These six roundtable discussions[1] brought up a number of challenges and opportunities in DOE's mission space in the areas of fuels, water infrastructure, electricity, and systems integration. This document includes (1) top-level takeaways from the entire roundtable series that cut across science, technology, and policy and (2) topical summaries of discussions from all six roundtables in the series.

TOP-LEVEL TAKEAWAYS

<u>Climate Change:</u> **Climate change is exacerbating collisions between energy and water. At a regional level, change in the timing, location, and intensity of precipitation is affecting the availability of fresh water for energy and other uses, potentially leading to vulnerability in the energy system. In addition, alternate sources of water often require additional energy for pumping and treatment to deliver the needed quantity to the point of use, thus impacting greenhouse gas (GHG) emissions. Effectively addressing climate change requires new approaches to technology, policies, and markets that take into account the interconnection among energy, water, and climate and avoid exacerbating one problem to solve another.**

- Current dry cooling technologies for thermoelectric generation introduce an energy penalty, thus potentially leading to more GHG emissions.
- Energy-related innovations in water treatment and water infrastructure, such as net-positive energy wastewater treatment, can reduce energy demand, produce electricity or fuels, and/or provide a flexible electricity load to balance intermittent renewable generation. Regulatory, finance, and other policies addressing the water sector should take into account these potential benefits.
- Guidance and implementation options for climate policies, such as the Clean Power Plan, should consider water implications of scenarios (e.g. changes in water use for cooling in the electricity sector) and the possible positive contributions of the water sector (e.g. net-positive energy waste water treatment).
- With the current drought, California and other southwestern states are more systematically approaching the connections among energy, water, and climate change with some urgency.
- Other nations are addressing similar questions; there are benefits to sharing knowledge and insight internationally.

<u>Energy Security:</u> **Water resources can significantly affect reliability and resilience of energy systems at local, regional, and national scales. A consideration of risk related to water should therefore be embedded into energy systems analysis, design, planning, business models, and technology deployment.**

- Long term planning in the electricity sector can benefit from insight into potential tradeoffs relating to availability of water resources. In particular, future scenarios for hydropower

[1] No consensus was reached in these discussions.

generation and thermoelectric cooling should incorporate climate change, competing water uses, population growth, and other factors.
- Because water is not consistently easily accessible where it is needed, the availability of water resources for fuels producers, and thus the reliability of operations, is affected by transportation and logistics.
- Other nations are addressing similar questions and there are benefits to sharing knowledge and insight internationally.

<u>Life Cycle Environmental Responsibility:</u> **In some instances, addressing local environmental issues in energy-water systems can indirectly lead to impacts at other locations or in other environmental domains. An understanding of lifecycle and systemic implications can inform technology and policy development, both domestically and internationally. Negative unintended consequences may be avoided if a broader systems approach is adopted.**

- Injection of produced waste water from oil and gas production into Underground Injection Control Wells for disposal is leading to induced seismicity in some regions.
- Existing regulations affecting wastewater treatment plants that target water treatment but not energy use can affect carbon emissions, sometimes increasing them.
- Over-application of fertilizer can lead to runoff of nitrogen and phosphorous. High nutrient loads in waterways are leading to tightening of requirements for nitrogen removal in wastewater treatment. Such treatment processes are currently energy-intensive.
- Responsible deployment of energy crops could aid in runoff management, with attendant reductions in treatment costs and negative environmental impacts.

<u>Systems Complexity and Systems Change:</u> **There are unsynchronized changes underway in the energy and water sectors that add complexity to both understanding the challenges and developing solutions in climate change, energy security, and lifecycle environmental responsibility. In addition, while many of the effects in the energy-water nexus are felt at a regional level, interaction between regions can lead to additional indirect effects. Data, models, and analysis are important to inform understanding of implications of change and interactions among regions.**

- The evolving geographic dispersion of oil and gas production, produced water treatment, biofeedstock cultivation, and fuel refining leads to interactions among regions in energy-water impacts.
- There is some diversification of players underway in some portions of the electricity sector, and a transition from centralized to distributed electricity generation in some areas. In some regions, the water sector is also decentralizing.
- In electricity, with the increased deployment of variable renewables, the market for demand management, storage, and related ancillary services is shifting.
- In California and the Southwest, water rights systems over a century old are evolving in response to drought and other factors, potentially affecting both thermoelectric generation and fuels production. Water trading markets, which lease or sell water rights, are gaining traction in some regions. This evolution, together with changes in electricity and carbon markets will, in some cases, increase the market value of intentional integration of water and energy systems.
- In certain key regions, such as California, the tight integration between energy and water infrastructures is starting to create opportunities for policy and incentive cross-fertilization.

While pilot efforts are underway, additional possibilities remain. Other areas of the country where water stress is likely to increase might benefit from parallel approaches.

Summary of Energy-Water Roundtable #1: Roundtable Series Kickoff

Washington, DC
May 7, 2015

Chair: Secretary of Energy Ernest Moniz
Co-Chair: Christy Goldfuss, White House Council on Environmental Quality

Key Insights:

- Climate change is "exacerbating collisions" between energy and water.
- Many domestic and international stakeholders across industry, government, academia, and nonprofits are enthusiastic to work with DOE on the energy-water nexus.
- In addition to technology solutions, policy and implementation are also critical.
- States are key partners in implementing regional solutions.

Physical/Technical Challenges and Opportunities:

- The price tag for updating water infrastructure is estimated at $600B to $1T.
- One person stated that we lose 1 out of 4 gallons because of aging water infrastructure.
- An important technology goal is a more efficient pump; one organization calculates significant nationwide energy savings if pumps can be improved from 55% to 80% efficient.
- Both energy and water systems can benefit from "smart" (i.e., information technology) infrastructure.
- At least one person believes that the wastewater industry will transition entirely to net-zero and net-positive energy. One organization estimates that spending $4.8B could retrofit the 100 largest wastewater utilities to net-zero energy use.
- Flexible scheduling of electricity for wastewater treatment plant operation is a form of demand response, and could help to balance intermittent renewables.
- Waste energy (including both chemical energy and waste heat) stored in wastewater and sewage could be used to create "urban batteries."
- The wastewater industry states that the greatest threat to their reliability is electric power loss.
- There is interest in a National Research Center for technology and innovation on water and wastewater.
- The oil and gas sector is using nontraditional water and finding beneficial uses for produced water. For example, some companies can frack wells with seawater or 100% untreated produced water that is not desalted.
- There is often overlap between areas of unconventional oil and gas resources and areas of water risk. E&P companies are partly water management companies, managing higher volumes of water than of oil and gas. There is interest in productive re-use of produced waters, rather than simply disposing of them as "deleterious" waters by pumping them back underground.
- Roundtable participants generally did not address the question of robustness under the uncertainty of climate change, potentially indicating that the chosen participants were not able to address the question, or that a gap may exist in planning or analysis.

Economic/Finance Challenges and Opportunities:

- Water pricing and quality varies from state to state, and few are sending the right price signals in terms of the value of water.
- Water supply risk can be a make-or-break decision for financing of electricity generation and infrastructure.

Policy/Regulatory Challenges and Opportunities:

- There may be opportunities to co-optimize water and carbon, both at the site-specific level and the national policy level (e.g., the Clean Power Plan).
- An "implementation network" could help smaller operators and installations to embrace advanced technology solutions. One existing analog, for agriculture, is the USDA's Cooperative Research and Extension Services.
- We can think differently about water infrastructure; it can become an energy resource in some cases, particularly with the right policy framework. For example, we could treat net-positive wastewater plants on equal footing with solar or wind in state Renewable Portfolio Standards.
- A Low-Income Home Energy Assistance Program (LIHEAP)-like program for water could provide low-income rate relief.
- For review of grant proposals for federal funding, for example, we need a new holistic approach to evaluate engineering proposals related to complex systems, rather than a process-based approach. Similarly, for workforce training, we need "nexus engineers" who are comfortable working at interfaces.
- We could think about writing regulations that are "smart enough to grow" based on adaptive management for compliance.
- One person stated that policies are needed to encourage productive reuse of water in the fossil industry.
- International stakeholders stressed the connection of "land" and "food" to the energy-water nexus.

Summary of Energy-Water Roundtable #2: Fuels

Denver, CO
July 1, 2015

Chair: Under Secretary for Science and Energy Lynn Orr
Co-Chair: Dan Arvizu, Laboratory Director, NREL

The Fuels Roundtable included approximately 45 leaders in the water and energy sectors from government, industry, non-profits, academia, and the National Laboratories. It explored energy-water challenges, strategies and visions related to fuels production. Participants covered a diverse array of topics, including water quality, efficiency, treatment, management, disposal, and recycling during oil and gas production, biofeedstock processing and upgrading, and fuel refining. The discussion brought up a number of important issues that suggest challenges and opportunities relevant to DOE's mission. The roundtable was divided into two discussion groups:

- Oil and gas
- Bioenergy

Summary of the Discussion

Water Demand, Availability, and Treatment in the Oil and Gas Sector: There is a need to appropriately value and utilize produced water streams, and to keep water at the surface, however, opportunities for productive reuse of produced water vary greatly by location. The cost of transportation and the logistics of handling produced water are major factors in determining water treatment opportunities. East of the 98^{th} meridian (due to more average rainfall), water discharge and disposal regulations require the discharged water to contain no pollutants. That can create a barrier to the discharging of water at the surface, therefore oil and gas operators will utilize underground disposal. West of the 98^{th} meridian, however, wastewater can be productively discharged at the surface if the waste water meets Clean Water Act standards for agricultural use.[2] Unconventional oil and gas operators are not allowed to transport produced waste water off leased land for reuse at other lease sites.

Companies could create a consortium to share water treatment facilities to take advantage of economies of scale in the 17 Western States and Hawaii. Because they are competitors, they may not want to send each other their wastewater, but government could play a role (see Bureau of Reclamation Title 16).[3]

While research is being conducted on waterless and water-alternative fracturing, those alternatives are not being recognized as an alternative to hydraulic fracturing by many companies, primarily due to perceived safety issues.

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[2] The Clean Water Act requires permits for onshore oil and gas facilities (40 CFR Part 435), including a ban on the discharge of pollutants. However, west of the 98^{th} meridian in the continental U.S., there is an exception for wastewater that is of good enough quality for use in agricultural and wildlife propagation, such as watering cattle.
[3] According to the Bureau of Reclamation, Title XVI of P.L. 102-575, as amended, provides authority for Reclamation's water recycling and reuse program, titled "Title XVI." Through the Title XVI program, Reclamation identifies and investigates opportunities to reclaim and reuse wastewaters and naturally impaired ground and surface water in the 17 Western States and Hawaii. Title XVI includes funding for the planning, design, and construction of water recycling and reuse projects in partnership with local government entities.

Water Demand, Availability, and Treatment in the Bioenergy Sector: There is a need for new systems-holistic approaches to water and water management that consider water demand from bioenergy as well as other sources, and that also include social/political dimensions, societal benefits, and other factors that drive decisionmaking. To this end, there may be a federal role in "putting the pieces together" by integrating efforts to define landscapes in terms of experimental units (soil type, water quality, etc.) with efforts to define landscapes in a way that allows making decisions and evaluating alternatives. This effort would require integrating plant-level, field-level, and watershed models at multiple scales.

Needs for bioenergy production and conversion are local, and not amenable to one-size-fits-all solutions. Costs associated with transporting biomass to biorefineries are a major economic consideration for new biorefinery projects.

There are potential opportunities for biorefineries to utilize new waste streams, including wet waste streams, mixed wastes, organic landfill waste, biosolids for fuels, and contaminated water at superfund sites. There is a corresponding need for research and development into conversion processes associated with these waste streams, including biological treatment rather than chemical treatment. Some biorefineries are repositioning themselves as producers of products, such as industrial chemicals and biosolids, in addition to fuels.

Opportunities may exist to valorize environmental benefits and incorporate them into financial instruments, such as credits for water and water quality.

Themes Common to Both Oil and Gas, and Bioenergy Discussions: Properly valuing byproduct water as a resource, rather than as a waste, is important for produced water as well as biorefinery water. Additionally, treatment and reuse of water is location-specific and subject to land owner restrictions in both sectors, and may not be amenable to a one-size-fits-all approach. Transportation and logistics concerns also exist and are critical to the economics of siting projects in both sectors.

Critical needs include sophisticated systems research and decision-making tools. Alignment of federal agency goals, particularly with respect to regulatory approaches, should also be analyzed, as regulations related to oil and gas as well as bioenergy can occasionally give rise to unintended economic and environmental consequences. Finally, participants suggested that smaller players in oil and gas production, wastewater treatment, and biorefining industries would benefit from additional federal support.

Participants

Stakeholder Participation	
1	Agriculture
3	Consultant
17	Federal Government
19	Industry
5	Research – Academic
11	Research – National Laboratory
1	Research – Non-profit
2	State Government

DOE offices and National Laboratories:

- Office of the Undersecretary for Science and Energy
- EPSA, Office of Energy Systems Analysis and Integration
- CI, Director for Public Engagement, Congressional Intergovernmental
- FE, Office of Oil and Natural Gas
- EERE, Office of Renewable Power, Bioenergy Technologies Office
- EERE, Deputy Assistant Secretary for Transportation
- National Energy Technology Laboratory
- National Renewable Energy Laboratory

Summary of Energy-Water Roundtable #3: Water Infrastructure

New York City
July 29, 2015

Chair: Kevin Knobloch, Chief of Staff of the Secretary of Energy
Host: Anthony Fiore, NYC Department of Environmental Protection

The Water Infrastructure Roundtable included 23 leaders in the water and energy sectors from government, industry, non-profits, academia, and the national laboratories. The focus was on water infrastructure processes, technologies, and systems that increase energy efficiency and energy recovery for water and wastewater treatment and conveyance. Note that participants expressed a wide range of opinions, and this memo will simply summarize the discussion. Participants were asked to respond to the following discussion points:

- Challenges and opportunities for wastewater treatment plants
- Visualizing the "utility of the future"
- Policy and regulatory dynamics

Summary of the Discussion

Challenges and opportunities for wastewater treatment facilities. Today's wastewater treatment facilities must consider physical/technical, economic, regulatory, and societal factors when considering the need for water intensity reductions, conservation practices and technology, and enhancing opportunities for energy and resource recovery. Key points from the discussion:

- There is a need to address the energy-water nexus related to wastewater treatment plants (WWTPs) as a system-wide "ecosystem" problem requiring collaboration of all sectors involved, rather than treating it as a problem only for utilities.
- Utility partnerships are underway to provide real-time grid balance by flexibly scheduling wastewater treatment operations.
- Resilience of energy-water systems during natural disasters is an important goal; for example, wastewater treatment plants can be powered by distributed generation.
- Some participants think that benchmarking energy and water use of WWTPs would be beneficial; others think that benchmarking is only useful internal to each plant because of the great variety of locations and types of plants.
- While larger WWTPs consume the bulk of energy for the sector, smaller WWTPs (down to ~1 million gallons/day) can also benefit from innovative energy technologies such as combined heat and power. In addition, opportunities for energy savings or energy extraction exist for smaller WWTPs that depend on wastewater conveyance costs, novel waste stream availability, and other local and regional factors.
- Smaller WWTPs may not have the manpower to apply for federal loans and grants.

Visualizing the "utility of the future." Defining optimal characteristics of a sustainable water-energy utility will help identify the steps to realize such utilities in the future. Key points from the discussion:

- The traditional, linear model of wastewater treatment as a service is evolving to a more circular (but still complex) model of productive reuse.
- WWTPs are not competitors, and could therefore collaborate on data, technology deployment, and best practices.

- One participant described a potential “co-innovation” strategy that could occur at multiple scales. Regulators would be involved in new projects from the beginning, rather than only serving as gatekeepers at the permitting stage. At a larger scale, technology innovators and project developers could be more involved in the development of regulations, in order to inform more adaptive and systems-holistic regulatory approaches.
- WWTPs should be standardized, so that they can be easily built and optimized.
- The wastewater treatment industry cannot easily build new plants from the ground up due to high capital costs, availability of land, need to maintain service, desire to avoid stranded assets, and other factors. Therefore, the industry must plan to transition to new technologies while effectively utilizing existing infrastructure.
- The wastewater treatment industry needs support in training operators and attracting new talent for the “utility of the future.”

Policy and regulatory dynamics. For current and future wastewater treatment plants, public policy and regulatory dynamics play a critical role in decisionmaking. Participants were asked to describe the policy and regulatory landscape from their perspective, as well as to identify possible roles for DOE and other government agencies. Key points:

- Pricing carbon would solve many of the wastewater treatment industry’s problems by incentivizing appropriate pricing of electricity, embedded energy, and biosolids disposal.
- Federal policy subsidizes nitrogen (fertilizer) use by farmers, while also requiring costly and energy-intensive nitrogen destruction by WWTPs. These conflicting policies create systems-level inefficiencies in terms of energy use and environmental goals.
- Smarter regulations should allow WWTPs to co-optimize for energy efficiency and water and wastewater treatment, rather than one or the other.
- The wastewater treatment industry is generally reluctant to deploy innovative technologies due to regulatory demands and high capital costs. They would therefore benefit from test beds for scaling up innovative technologies.

Participants

Stakeholder Participation	
6	Utilities
1	Regulators
5	Industry
1	Industry Associations
2	State and Local Government
2	EPA
1	Academia
2	Consulting
3	Nonprofit

DOE offices and National Laboratories:

- EERE, Advanced Manufacturing Office
- EPSA, Office of Energy Systems Analysis and Integration
- CI, Director for Public Engagement, Congressional Intergovernmental
- National Energy Technology Laboratory
- Brookhaven National Laboratory

Summary of Energy-Water Roundtable #4: Electricity

Washington, DC
August 13, 2015

Chair: Under Secretary for Science and Energy Lynn Orr
Co-Chair: Assistant Secretary Pat Hoffman, Office of Electricity

The Electricity Roundtable focused on technology innovation, planning, and regulatory strategies that can contribute to resilience of the electricity system under changing water availability. Leaders in the water and energy sectors from government, industry, non-profits, and academia explored energy-water technology challenges, planning strategies and regulatory approaches that can contribute to resilience of the electricity system under changing water availability. The three major focus areas for the roundtable were:

- Water Demand and Technology Innovation for Electricity Generation
- Strategic Planning for Electricity and Water Systems
- Institutional Challenges to Integrating Electricity and Water Planning

Summary of the Discussion

Water Demand and Technology Innovation for Electricity Generation: Different generation technologies require different levels and qualities of water supply to produce electricity; access to these water supplies is becoming both more challenging and more opportunistic as generators/water consumers look for new ways to utilize available water supplies, especially in areas where water supplies may be limited due to climate (e.g., drought) or competing demands. Further, cooling takes up a large physical footprint, which is problematic in small and urban facilities. A number of technologies and other sources of water were discussed:

- The best way to reduce water use water use in thermoelectric cooling is to increase generation efficiency. There are currently trade-offs among cost, size, and energy requirements for air (or dry) cooling systems.
- Desalination may play a role with diminishing water supplies, but it is energy intensive and expensive. In California, seawater is being considered as a potential source of drinking water, so alternative uses are discouraged.
- Graywater is loved by the public, but is problematic in practice due to a lack of supply and low quality of water. At times power companies are held captive due to limited graywater supplies, and quality is not guaranteed, adding to costs.
- Many more plants are using non-freshwater, but as consumption drops there are opportunities for unused water that must be moved to the utilities. There may be a market for that water.

Strategic Planning for Electricity and Water Systems: Integrated planning of energy and water is necessary at the local and regional level. Such planning should not only consider the availability of the needed resources (e.g., water), but also existing transmission and distribution infrastructure. Planning is occurring at many different scales (city, county, state, environmental plans [e.g., federal river plans], and a whole separate effort for water quality) for water and energy issues. These planners interface with varying degrees of intimacy and caution should be exercised when increasing complexity of the systems. Opportunities for engagement (e.g., local, state, federal levels) and opportunities for improved strategic planning were discussed:

- Valuation of attributes that are beneficial to the electricity system is becoming more important as new technologies emerge (such as storage, solar, etc.) and water use should be a part of this discussion. For example, participants discussed the need for incremental fees for reliability, long-distance transmission, and low water use.
- State-level policy makers and regulators can play an important role in improving coordinated system planning, leveraging existing interconnection-level electricity system planning.

Institutional Challenges to Integrating Electricity and Water Planning: The current status of planning various in different parts of the country for both electricity and water, based on the underlying policies, regulations, laws. Bridging these sectors and how they are managed from an institutional perspective requires an understanding of their current constraints (e.g., water rights, state laws, policies) as well as any competing uses to engage appropriate decision-makers from both sectors in dialogues. Further, at the state level, convening empowered energy and water planners from the cabinet-level can empower discussions. Further, it was noted that while date collection to inform future policies and regulations that may bridge the energy and water sectors is important, being able to manage and utilize the data can be a challenge. Examples of current state challenges/opportunities to engage from an institutional perspective were noted:

- Some restructured states (i.e., Maryland) do not have generation planning; energy planning processes could be used to talk about water.
- End-use for water is important and being considered in some states (i.e., California) climate plans.
- In some states (i.e., Arizona), electricity generation uses less than 3% of the state's water. While people and companies are willing to participate in these conversations, they recognize that they can't make a big overall impact.

Participants

Stakeholder Participation	
5	Utility – Electric
1	Utility – Water
5	Industry Association
2	State Regulator
4	State Association
2	Federal Agency
1	Business/Vendor
1	Research – Academic
2	Research – National Lab

DOE offices and National Laboratories:

- Office of the Undersecretary for Energy and Science
- EPSA, Office of Energy Systems Analysis and Integration
- CI, Public Engagement
- OE, National Electricity Delivery Division
- FE, Division of Advanced Energy Systems
- FE, Office of Advanced Fossil Technology
- EERE, Office of Renewable Power, Wind and Water Technologies Office
- EERE, Office of Energy Efficiency, Advanced Manufacturing Office

Summary of Energy-Water Roundtable #5: Systems Integration

Austin, TX
August 20, 2015

Chair: Melanie Kenderdine, Counselor to the Secretary and Director, Energy Policy and Systems Analysis
Co-Chair: Michael Webber, UT-Austin

The Systems Integration Roundtable brought together leaders from industry, utilities, academia, nonprofits, and national labs to discuss systems integration in the energy-water nexus. The "energy" focus for this roundtable was primarily specific to electricity. The discussion focused on:

- Modeling to inform planning for resilience of future energy-water systems
- Adapting energy-water systems to changing electricity markets
- Integrated, adaptive policy for future energy-water systems

Summary of the Discussion

Modeling to Inform Planning for Resilience of Future Energy-Water Systems. The prospect of sustained drought, extreme weather, and changes in water and energy infrastructure poses a challenge for planning, design and operations of energy and water systems. Modeling and related analysis can inform understanding of productive synergies, untapped resources, tradeoffs, and mutually beneficial collaborations. Key points from the discussion:

- There is a need for greater resolution, fidelity, and interoperability among energy, water, and climate models, as well as for improved stakeholder involvement and more rigorous characterization of uncertainties.
- While management and planning in the water-energy-carbon nexus will include tradeoffs, there is a need to avoid exacerbating one problem to solve another. For example, dry cooling for thermoelectric generation consumes less water, but current technologies are less energy-efficient, potentially leading to increased carbon emissions.
- Energy and water systems that are designed to operate separately can become subject to joint vulnerability when they are accidently connected by circumstances such as drought. Integrated design should connect energy and water systems where such connection will lead to increased efficiency, lower cost, and/or increased system resilience.
- Treatment for public water supply, wastewater treatment, pumping for water conveyance, and desalination and can be ramped up and down to provide grid balancing; this is an example of energy and water providing solutions for each other.

Adapting Energy-Water Systems to Changing Electricity Markets. Changing electricity markets have the potential to affect future energy-water infrastructure, such as through an increasing share of renewables affecting dispatch curves, the need for load balancing and the market for ancillary services. Key points from the discussion:

- Optimizing electricity markets, electricity technology (including generation and smart metering), and energy-water interactions simultaneously is a significant challenge, as these three elements of energy-water systems often evolve separately and follow very different trajectories.
- Low prices for both electricity and water, particularly in ERCOT, disincentivize innovation as well as energy and water efficiency.

Integrated, Adaptive Policy for Future Energy-Water Systems. Policy and regulation affecting energy-water systems often focuses on energy or water systems, but not both. New challenges, such as widespread drought, combined with new opportunities, such as advanced sensors and metering, may lead toward more integrated and adaptive policies and regulations. Key points from the discussion:

- Integrated and adaptive policies should (1) consider connections in a broad systems-holistic context, (2) create a shared understanding of the couplings between energy and water, and (3) increase resilience of energy and water sectors to meet foreseen and unforeseen challenges.
- There is no single organizational home for water at DOE or anywhere else in federal, state, and local government.
- Energy-water data is a critical need for energy-water systems modeling, and this data is not widely accessible.
- There may be opportunities to integrate water into the Clean Power Plan implementation.
- Integrated energy-water policies deployed at the state level, for example in California, will provide "test beds" for other state and federal policy development.
- A central, public inventory of water policies affecting energy could benefit policymakers.

Contrasts between Electricity and Water

	Electricity	**Water**
Physical Characteristics	Availability has primarily continental/global scope	Availability has local scope
	Cannot generally be stored	Can be stored; can be used as proxy or hedge for electricity
	Can be generated on demand	Cannot be generated on demand
	Attributes include voltage, frequency (ancillary services)	Attributes include temperature, contaminant concentrations
Economics and Markets	Industry is rapidly evolving and diversifying	Industry is evolving and modernizing more slowly in some regions
	Industry moving from centralized to distributed	Industry not yet moving toward distributed in most regions
	Widespread electricity markets	Water trading markets (leasing and selling water rights) are slowly gaining traction
	Active spot market	No spot market
	Priced according to supply and demand	Not generally priced according to supply and demand
Data	EIA centrally collects data	Data collection distributed across states and several federal agencies
Policy	Organizational home at DOE	No organizational home in federal government
	Federal reliability requirement	No federal reliability requirement

Participants

Stakeholder Participation	
3	Electric Utilities
1	Water Utilities
1	ISO/RTO

2	Industry
5	Academia
2	Nonprofits

DOE offices and National Laboratories:

- EPSA, Office of Energy Systems Analysis and Integration
- CI, Director for Public Engagement, Congressional Intergovernmental
- Sandia National Laboratories
- Pacific Northwest National Laboratory
- National Renewable Energy Laboratory

Summary of Energy-Water Roundtable #6: Roundtable Series Capstone

Washington, DC
October 16, 2015

Chair: Secretary of Energy Ernest Moniz
Co-Chair: Robert Simon, White House Office of Science and Technology Policy

The October 16th roundtable was the capstone for an energy-water roundtable series that began with a kickoff roundtable in May, followed by four subject-specific regional roundtables in fuels, water infrastructure, electricity, and systems integration. No consensus was reached in these discussions. DOE staff prepared a series synthesis document from the first five roundtables prior to the capstone roundtable. This document included key takeaways from the series and potential next steps for DOE. Participants at the capstone roundtable were asked to give their reactions to the synthesis document, any evident gaps, and how their organizations could work with DOE on next steps. This summary includes (1) specific reactions to the synthesis document, and (2) a summary of the capstone discussion. The revised synthesis (including participant feedback) is being finalized in a separate document.

1. Specific Reactions to the Synthesis Document

- The four key takeaways in the synthesis document (related to climate change, energy security, lifecycle environmental responsibility, and systems complexity/systems change) are accurate.
- The telecommunications sector, in particular, is very interested in data, modeling, and analysis testbeds.
- Prices of energy and water are too low in some regions, creating little incentive to invest in innovative technologies.
- A clear technology RDD&D direction in the energy-water space is needed, but this is challenging because the energy sector in many cases evolves more rapidly than the water sector.
- The DOE appliance standards program could play a role in further emissions and water savings.
- Wastewater treatment technology solutions depend on local constraints and require site-specific implementation.
- The oil and gas sector is interested in working with DOE through the industry-based Energy Water Initiative (EWI)[4] on beneficial reuse of produced water.

2. Summary of the Discussion

Physical Challenges and Opportunities:

- Electric utilities are seeing clear, rapid change driven by water stress in many regions. In the Southeast, for example, floods and droughts must both be addressed, as must changes in regional population and technology.
- Climate change impacts such as sea level rise and saltwater intrusion are already being observed, and can create vulnerability in the energy-water-food nexus.

[4] The Energy Water Initiative (EWI) is a collaborative effort among participating members of the U.S. oil and natural gas industry to study, describe, and improve lifecycle water use and management in upstream unconventional oil and natural gas exploration and production.

- Information and communication technology systems can allow systems to self-monitor and control themselves autonomously; deploying these technologies for energy and water systems will be important in developing smart cities.
- The areas most underserved by broadband are rural and tribal areas; this lack of broadband access greatly limits capabilities for advanced water management in these regions.
- Energy-efficient water treatment and increased use of nontraditional water sources are important needs for addressing challenges in the food-energy-water nexus.
- In wastewater treatment technologies, a focus on implementation at the plant-level (which depends on local constraints) is a greater need than additional research and analysis.
- The significant amounts of land required for water and wastewater treatment facilities could be further utilized to deploy renewables.
- Oklahoma produces 1.5 billion barrels of produced water per year, which could be a substantial opportunity for productive reuse.
- The oil and gas sector has published case studies on water management practices in order to foster opportunities for better water management.
- Leading biofuels producers consume 2.45 gallons of water per gallon of ethanol produced, and they expect to become more water-efficient in the future.

Data, Modeling, and Analysis Opportunities**:**

- Interdisciplinary systems analysis of big, complex problems such as the energy-water nexus is fraught with uncertainty and must address the potential for catastrophic failures. There is a need to take into account differential rates of change in system components as well as the temporal dimensions of various policy solutions.
- It may be beneficial to do a formal threat assessment for the energy-water nexus, in order to identify the most critical challenges. This assessment could then inform more expansive data collection and modeling efforts.
- California recently adopted a cost calculator that can be used to evaluate the effectiveness of water use. This effort uses hydrologic basin-level analysis, and also requires IOUs to input data, with the intent being to create a “data garage.”
- More widespread analysis of water use down to the municipal utility level could be beneficial to identify how much is being wasted and where opportunities lie.

Economic and Organizational Challenges and Opportunities:

- Water pricing is one way to allocate water to the most economically valuable uses. Formal water markets and water banks are other options. This is in contrast to public allocation schemes (such as water rights based on first use) that do not necessarily allocate water to the most economically valuable uses.
- Integrating silos within private sector companies is challenging but necessary to address the energy-water nexus.
- The need for lifecycle environmental responsibility in the energy-water nexus must be paired with infrastructure investment.
- One private sector participant felt that more and better data are not a top priority, as the issues that need investment, for that company, are already known.

Policy/Government Challenges and Opportunities:

Federal Organization and Integrated Regulatory Policy:

- Improved integration of energy and water at the Cabinet level may be needed.

- Integration of DOE work with states and with FERC on the smart grid into work on the energy-water nexus is a critical need. Harnessing investments in electric infrastructure can aid in managing water and energy together.
- States control water through water rights, but the U.S. Army Corps of Engineers (USACE) owns water permitting (river operation). Collaboration between these entities to treat water rights and permits in an integrated fashion will be required in order to optimize water use.
- There may be opportunities to revise PMA operating arrangements, and/or to improve nonfederal hydropower generation, in order to address climate change and maintain energy security.
- Water impacts of the Clean Power Plan are uncertain; a changing generation mix will affect water use in some regions.
- New regulations on electricity generation will significantly affect water use, likely reducing water use by electricity generation across the country. While most electricity regulation occurs at the state level, understanding the interplay between federal and state regulations is important.
- Regarding wastewater treatment regulations, federal agencies should ensure that they are properly aligned to achieve resilience in the energy-water space, as well as consider how to properly engage states and local governments. Many solutions in wastewater treatment are at the local level.

State, Local, and Tribal Policy:

- There are policy opportunities at the water-energy-communications nexus. California has ordered electric utilities to conduct pilot programs with water utilities for enhanced integration utilizing the smart meter backbone network. In addition, planned and ongoing deployments of high-speed communications networks should be leveraged to better manage water and energy.
- Tribal interests in the energy-water nexus focus on how to protect resources and maintain sustainability for the tribe, for example, by reducing water use and recharging aquifers.
- In the TVA region, TVA's integrated resource plan (IRP) was expected to be a 10-year plan, but due to changing conditions, it was redone after 7 years. There may continue to be a need for more frequent updates.
- Several states have passed legislation to prohibit disposing of fats, oils, and grease in landfills. This creates a new waste stream that can be utilized by energy-positive wastewater treatment plants.

<u>Outreach and Engagement Challenges and Opportunities:</u>

- Public outreach and communication related to the energy-water nexus is needed, as the general public often does not understand their relationship. Receiving public buy-in is necessary for changes in policy.
- Reframing the oil and gas discussion of produced water to be about not only productive reuse per se, but about drought resilience, could open up a broader conversation among stakeholders and create stronger buy-in.
- Some states would benefit from increased engagement and technical assistance from DOE on produced water issues.
- The creation of a technical assistance advisory board for DOE's work in data, modeling, and analysis could be beneficial.