Statement of
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Before the

Committee on Energy and Natural Resources
Subcommittee on Water and Power
United States Senate

Nexus of Energy and Water for Sustainability Act of 2014

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Chair Landrieu and Chairman Schatz, Ranking Members Murkowski and Lee, and members of the Subcommittee, thank you for the opportunity to testify on behalf of the U.S. Department of Energy (DOE) on S. 1971, Nexus of Energy and Water for Sustainability Act of 2014. The Administration has not completed its review of the bill.

Last week, the Administration released a report entitled *The Water-Energy Nexus: Challenges and Opportunities* (U.S. Department of Energy 2014). This report provides a comprehensive analysis of the water-energy nexus and its many dimensions. Energy and water systems interact physically in many settings, including electricity generation, oil and gas production, bioenergy production, water treatment, and commercial and industrial facilities. Energy and water systems collectively include private infrastructure and investment, as well as Federal, state and local interests. Continuing analysis will be necessary to prioritize the appropriate collective approach, including the agencies (private, state, local, or Federal) and shares of any costs and responsibilities.

The effort to date demonstrated by the extensive research and comprehensive nature of this report illustrates the Administration's attention to this issue. In my testimony, I will provide an update on the Department's activities in this area - one where I believe we share a mutual interest and concern. As we pursue our important mission areas of climate change, energy security and environmental responsibility, we must take into account dynamic interactions among our energy system, the population, the economy, other infrastructure systems and natural resources. One crucial interaction is that between our present-day energy and water systems.

The Energy-Water System

Action is required by private industry, as well as Federal, state, and local governments to ensure the development of the resilient, coupled energy-water systems of the future. We believe that the Energy Department, working in close cooperation with our interagency colleagues, is well positioned to help address the issues surrounding the energy-water nexus.

In particular, the Department can leverage its core competencies around four major strategic elements, including: user-driven, integrated data, modeling and analysis (DMA); strategic technology development; policy analysis; and stakeholder engagement.

Ultimately, we seek to:

- Advance next-generation, user-driven toolsets for deeper insights and planning, drawing on leading capabilities at our national laboratories while working in concert with the Nation's university community;
- Develop options for new solutions through strategic investments in technology research that target high priority opportunity areas;
- Analyze the policy space and ways to overcome institutional barriers that are preventing efficient and effective evolution of more resilient coupled energy-water systems; and
- Engage stakeholders in continuing discussions about alignment of these activities, pathways to implementation, and ways to create flexibility and institutional incentives in a rapidly changing decision landscape.

Our rationale for such action is clear: energy systems depend on water for nearly all phases of energy recovery, production, and electricity generation. Although some forms of renewable energy use very little water, overall, the dependency of the Nation's energy system on water is profound. Similarly, energy is essential to extract, convey, and deliver water of appropriate quality and quantity for diverse human uses, and then again to treat wastewaters prior to their return to the environment. Many operations in the energy sector rely on water, and many operations in the water sector rely on energy. They are inextricably linked. Developing ways to make our Nation's energy system less dependent on water will reduce stress on the available water supply and, as the Nation's energy system evolves, make sure that the needs of the newly configured system can be met.

Given this tight inter-linkage, it is noteworthy that historically, energy and water systems have for the most part, been developed, managed, and regulated independently. However, recent events have focused attention on emerging stresses and growing vulnerabilities at the energy-water nexus, raising concerns about how we think about and engineer this interconnection. To list only a few:

- When severe drought affected more than a third of the United States in 2012, limited water availability constrained the operation of power plants and other energy production activities. Under such conditions, thermal efficiency decreased (meaning less power from each affected facility), water discharge temperatures increased, and with the latter there is increasing probability for compounding the problem through de-rating (reducing operations from full capacity) to manage discharge within acceptable limits. It is significant that approximately 40 percent of all freshwater withdrawals (and 49 percent of all combined fresh and saline water withdrawals) in the U.S. are for thermo-electric cooling. Energy and agriculture often compete for scarce water resources, a dynamic only partially offset by the fact that energy demands are largely non-consumptive uses (meaning water is returned) whereas agriculture are largely consumptive.

- Hurricane Sandy demonstrated, in very real terms, the implications of another extreme weather event and the stresses encountered by the coupled system, such as power losses preventing the delivery of clean water as well as the treatment of wastewater and basic sanitation.
- The recent rapid expansion of unconventional oil and gas development facilitated by hydraulic fracturing and horizontal drilling has also highlighted issues and catalyzed national discussions about energy and water interdependencies. There are implications not only for water quantity, but water quality as well. It is noteworthy that many productive fields are in arid and semi-arid regions.
- Increasing water demands in arid areas can lead to increasing energy demands, with the trend toward increasing vulnerability. Figure 1 and Table 1 (included at the end of this text) reflect some of these growing demands for energy to manage water supplies in select western states.

The water-energy infrastructure is long-planned and long-lived. Many factors influence our decisions on the coupled energy-water system, including changing weather patterns, population growth and migration, shifting patterns in economic development, changes in land use and land cover, technology development and deployment, and policy and institutional changes. This complex planning environment presents both challenges and opportunities. At the Department, and throughout the government, we need to better understand the system to ensure it is robust and resilient in the long term.

With that goal of better understanding the system, I would now like to turn to current efforts of the Department on two fronts. The first is the creation within the Department of a cross-cutting organization, the Water Energy Technology Team (WETT) and its accomplishments to date.

The second is last week's release of the major report entitled *The Water-Energy Nexus: Challenges and Opportunities* that I touched on at the beginning of my testimony.

Water-Energy Technology Team

While DOE has been conducting research and development (R&D) related to the energy-water nexus for more than a decade, the formation of the WETT was prompted primarily by the Fall 2012 release of the fifth in a series of related reports from the Government Accountability Office (GAO) (GAO 2012). Following the GAO's recommendations, the DOE conducted a series of internal workshops in the fall of 2012 focused on power plant cooling, water in energy production, and DMA.

This effort also leveraged two significant and related activities undertaken by DOE's basic research program, the Office of Science. The first was a research community workshop involving representatives from many "water-interested" agencies. The resulting report, *Community Modeling and Long-Term Predictions of the Integrated Water Cycle* (DOE Office of Science 2012), has had impact on the conceptual framing of this topic.

The second was a study on *Climate and Energy-Water-Land System Interactions* (PNNL 2012), summarizing results of a second workshop and follow-up analyses that similarly involved other agencies and agency-designated scientists. This activity was coordinated through two working groups of the U.S. Global Change Research Program. These two workshops and corresponding reports helped inform the scope of the problem, the research needs, and the range of tools and capabilities that would be required to address the integrated DMA challenges. They helped to broaden our vision of important, complex dynamics. For example, and particularly for the second report, they informed our understanding of the increasing energy demands in arid areas, issues associated with thermal discharge restrictions, and, more generally, variation and characteristic differences spanning regions. Additionally, the latter report made a strong case for the need to consider land-use and land-cover change as a key element when exploring the energy-water nexus.

As a result of the findings from these workshops and analyses, DOE formed the Water-Energy Technology Team that now includes well over 100 participants from more than 20 offices within the Department. It also includes representation from the national laboratories. It is currently organized into four working groups: (1) *Data, Modeling, and Analysis, (2) Policy Frameworks and Analysis, (3) Stakeholder Coordination and Outreach, and (4) Technology Research, Development, Demonstration, and Deployment.* These working groups, and the topics they address, are seen as part of an integrated systems approach.

A sampling of current cross-cutting activities includes, but is not limited to:

- The Data, Modeling, and Analysis team, which has:
    - Gathered more than 30 representatives from 11 national laboratories in early May of 2014 to begin considering options for future energy-water analysis strategies;
    - Instituted mechanisms to improve connections and synergies between offices;
    - Engaged other agencies for DMA, including the formation of a new *ad hoc* interagency working group for climate model downscaling to gain deeper, more consistent, and scientifically rigorous insights into U.S. regional climate outlooks for parameters of particular interest at the energy-water nexus;
    - Developed an extensive inventory of DOE and national laboratory core capabilities; and
    - Engaged the research community in various workshops and related venues.
- The Office of Fossil Energy recently released a Funding Opportunity Announcement that includes requests for innovative uses of waste heat from power plants, low-cost water treatment options, and novel concepts for high-temperature heat exchange, all of which have water-energy implications.
- ARPA-E recently held a workshop on breakthrough possibilities for air cooling of power plants (and other applications).
- Through their most recent open solicitation, ARPA-E has invested in a project that takes a novel approach to the recovery of energy from waste heat via a closed-loop salt water/electricity generation cycle.
- The Bioenergy Technology Office within the Office of Energy Efficiency and Renewable Energy (EERE) put out a Request for Information on the general topic of bio-waste-to-energy in FY 2014, and is planning a workshop on the topic in preparation for possible

solicitations in FY 2015. Plans are to include both the EPA and external stakeholders in this effort.

- The Advanced Manufacturing Office within EERE is supporting a project that was competitively awarded under the Innovative Manufacturing Initiative FOA and that proposes a unique combination of forward osmosis, membrane distillation, and anaerobic membrane bioreactors in order to achieve dramatic reductions in the energy requirements of industrial and municipal wastewater treatment.
- The EPA and DOE are working closely together to identify potential areas for collaboration in improving the energy efficiency of water treatment, including the possibility of distributed generation of electricity from wastewater treatment plants.
- The Energy Policy and Systems Analysis office has planned to target strategic areas of policy analysis interest, including issues related to the energy-water nexus in the Quadrennial Energy Review (QER). Just last week, at one of our scheduled public listening sessions on the QER, we focused specifically on energy and water. The two panels, with experts from state and local government, academia, the private sector and civil society, underscored the nature of this nexus – not least given the extreme drought facing the West, and their collective expectations that such extreme events would become more frequent as the climate changes. Both a background paper prepared for that meeting, as well as the full transcript of the session itself are available on the DOE website at: http://www.energy.gov/epsa/events/qer-public-meeting-san-francisco-water-energy-nexus.
- DOE has participated in various national and international dialogs on this topic as part of focused and broader engagement efforts.

Water-Energy Report

One of the major WETT accomplishments has been the preparation and June 18, 2014 release of the report entitled *The Water-Energy Nexus: Challenges and Opportunities.*

Overarching conclusions of the report include:

- Energy and water systems are highly interdependent;
- We cannot assume the future is like the past in terms of climate, technology, and the evolving decision landscape;
- Water scarcity, variability, and uncertainty are becoming more prominent, potentially leading to vulnerabilities of the U.S. energy system;
- We need a more integrated approach to address the challenges and opportunities of the water-energy nexus;
- DOE has strong expertise in technology, modeling, analysis, and data that can contribute to understanding the issues and solutions across the entire nexus; and
- Collaboration with DOE's many current and potential partners is crucial.

The report itself identifies six strategic pillars that inform approaches for addressing challenges across the water-energy nexus:

1. Optimize the freshwater efficiency of energy production, electricity generation, and end use systems.
2. Optimize the energy efficiency of water management, treatment, distribution, and end use systems.
3. Enhance the reliability and resilience of energy and water systems.
4. Increase safe and productive use of nontraditional water sources.
5. Promote responsible energy operations with respect to water quality, ecosystem, and seismic impacts.
6. Exploit productive synergies among water and energy systems.

In context of these pillars, and in the area of DMA, DOE seeks to pursue advances for robust projections, scenarios, analyses at decision-relevant scales; characterization of uncertainty and risks; modeling and analysis of extreme events with insights into potential system shocks; interoperable DMA platforms, including a layered, integrated data system; and improvements in evaluation of models with observations, as well as more effective and direct use of observations to improve projections. Data and information needs span a wide range of spatial and temporal scales, requiring improved capacity for "telescopic resolution."

Technology R&D in areas such as the recovery of dissipated energy, advances in cooling systems, alternatives to freshwater in unconventional oil and gas, desalination, net-zero wastewater treatment, and efficient equipment and appliances can increase the options available to meet challenges. More generally, improvements in sensors, data collection, analysis, and reporting could yield benefits to multiple decision-makers. Addressing energy and water systems as an integrated whole can stimulate additional innovations.

While the report seeks to outline some of the opportunities and risks in the energy-water system, it is clearly only a first step in a process that will need to engage many others outside the Department. It is thus intended as an opening to a much larger collaboration that will bring together many partners in the energy-water arena. Federal agencies have a role in the energy-water nexus, as do regional, state, tribal, and local authorities. Importantly, a diverse array of non-governmental organizations, including private companies, national non-governmental organizations (NGOs), foreign governments, universities, and municipal facilities must all be involved if we are to make adequate progress on these issues. It is in the interest of private firms to improve efficiency and continue to deliver their energy products reliably. Local and State governments that have primary regulatory jurisdiction in many of these areas will need and want to participate in prioritization of issues and seeking flexible solutions. If activities related to the energy-water nexus receive appropriations in future budgets, these activities could reside at multiple federal agencies that have authorities to undertake such activities, including DOE. We look forward to your reactions to this work.

S.1971

Before I conclude, let me comment briefly on S.1971, the Nexus of Energy and Water for Sustainability Act of 2014. While the Administration is still reviewing this bill and does not have a formal position at this time, we appreciate the Committee's efforts to address this issue. I can say that broadly we are in agreement that a close level of communication and coordination

among federal agencies is important to advancing our work on this increasingly vulnerable intersection of our energy and water systems. Moving forward, we would like to continue working with the Committee on preliminary concerns regarding the details of the collaborative structure and reporting provisions on issues related to the nexus of energy and water.

Conclusion

DOE has undertaken an ambitious effort to respond to the challenge of the energy-water nexus. Strategic partnerships to advance and accelerate progress toward a robust and resilient energy and water system at the nexus of energy and water are important.

Ultimately, the Energy Department's longstanding leadership in modeling and technology research and development makes it well suited to contribute to the need for data-driven and empirical solutions to address energy system vulnerabilities arising from the coupled energy-water system. Forming the WETT, and the various accomplishments of our work to date, including our newly released report, are important.

Thank you and I look forward to any questions you may have.

References

DOE Office of Science. “Community Modeling and Long-Term Predictions of the Integrated Water Cycle: Report from the September 2012 Workshop”. September 2012. http://climatemodeling.science.energy.gov/f/2013/Water_Cycle_Report_High_Res.pdf

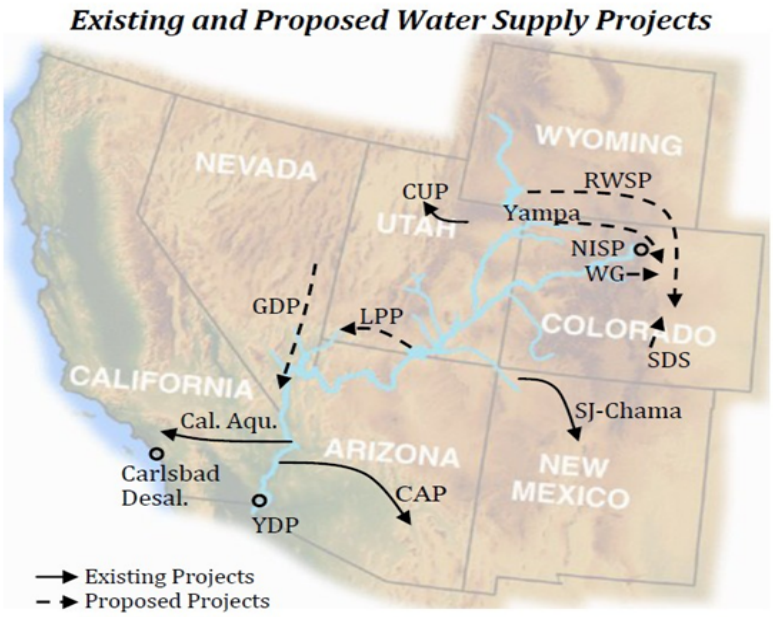
Government Accountability Office (GAO). “Energy-Water Nexus: Information on the Quantity, Quality, and Management of Water Produced During Oil and Gas Production”. January 2012. http://www.gao.gov/assets/590/587522.pdf

Skaggs, Hibbard, Janetos, Rice. “Climate and Energy-Water-Land System Interactions” PNNL-21185. March 2012. http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-21185.pdf

U.S. Department of Energy. “The Water-Energy Nexus: Challenges and Opportunities”. June 2014. http://www.energy.gov/sites/prod/files/2014/06/f16/Water%20Energy%20Nexus%20Report%20June%202014.pdf

Attachments

Figure 1. This figure illustrates the increasing energy requirements for new water projects in select western states in relationship to the current baselines. Specific details and sources of data for each individual project are contained in Table 1, below. (Source: PNNL 2012)



Abbreviation	Project Name
Cal. Aqu.	California Aqueduct
CAP	Central Arizona Project
Carlsbad Desal.	Carlsbad Desalination Plant
CUP	Central Utah Project
GDP	Groundwater Development Project
LPP	Lake Powell Pipeline
NISP	Northern Integrated Supply Project
RWSP	Regional Watershed Supply Project
SDS	Southern Delivery System
SJ-Chama	San Juan-Chama Project
WG	Windy Gap Firming Project
Yampa	Yampa Pumpback Project
YDP	Yuma Desalting Project

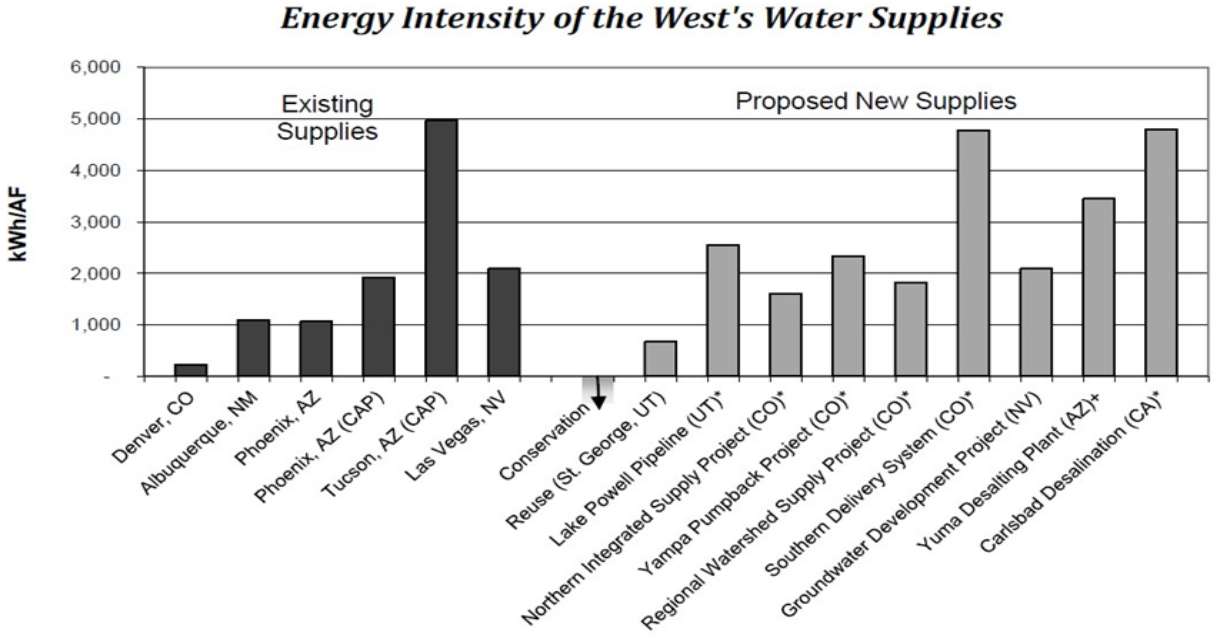


Table 1. Energy Use for Water Delivery at Selected Project Sites in the Southwest. (Source: PNNL 2012).

Project (State)	Water Delivery (AF/yr)	Net Energy Use (MWh/yr)	Sources
Lake Powell Pipeline (UT)	86,000	307,020	Volume data: Utah Department of Water Resources. 2011. Draft Lake Powell Pipeline Study Water Needs Assessment, prepared by MWH. March 2011. Energy Intensity data: Utah Board of Water Resources. 2008. Lake Powell Hydroelectric System Notice of Intent to File an Application for Original License (Volume 1).
Northern Integrated Supply Project (CO)	40,000	33,980 - 57,980	U.S. Army Corps of Engineers. 2008. Northern Integrated Supply Project Draft Environmental Impact Statement, table 4-15. April 2008.
Yampa Pumpback Project (CO)	300,000	595,680	Northern Water Conservancy District. 2006. Multi-basin Water Supply Investigation.
Regional Watershed Supply Project (CO)	250,000	199,000 - 496,000	Volume data: Wyco Power and Water, Inc. 2011. Application for Preliminary Permit, Regional Watershed Supply Project. Filed with the Federal Energy Regulatory Commission August 31, 2011. Energy Intensity data: Derived from Preliminary Permit Application; analysis summarized in Western Resource Advocates. 2011. Motion to Intervene in Opposition and Comments on the Preliminary Permit Application for the Regional Watershed Supply Project, Project No. P-14263-000. Filed with FERC on December 15, 2011.
Southern Delivery System (CO)	52,900	246,038	U.S. Bureau of Reclamation. 2008. Southern Delivery System Final Environmental Impact Statement. December 2008.
Groundwater Development Project (NV)	217,655	383,073	Volume data: Southern Nevada Water Authority. 2011. Southern Nevada Water Authority Clark, Lincoln, and White Pine Counties Groundwater Development Project. Conceptual Plan of Development. Prepared for the U.S. BLM, March 2011. Energy data: Derived from power capacity needs and an assumed operating rate of 85% (data provided in SNWA, 2011).
Carlsbad Desalination Plant	56,000	260,680	City of Carlsbad, CA. 2005. Precise Development Plan and Desalination Plant Project Environmental Impact Report, p. 4.2-19.