Energy-Water Nexus
($K)

FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request
15,575	15,085	34,250	96,100

Overview

The FY 2017 Budget Request for the Energy-Water Nexus (EWN) crosscut is an integrated set of cross-program collaborations that: 1) builds and deploys a DOE mission critical data, modeling, and analysis platform to improve understanding and inform decision-making for a broad range of users; 2) strategically targets crosscutting technology research, development, demonstration and deployment opportunities within the system of water and energy flows; and 3) is informed and supported by focused policy analysis and outreach and stakeholder engagement. Taken as an integrated whole, these investments position DOE to contribute strongly to the Nation's transition to more resilient coupled energy-water systems. The EWN Request outlined here draws on ideas presented in DOE's report, *The Water-Energy Nexus: Challenges and Opportunities* (June 2014). This publication represents the culmination of an intense two-year effort that engaged DOE's sister agencies, national laboratories, state and local governments, utilities, industry, the broader science community, and others. In FY 2015, Secretary of Energy Moniz launched a series of Energy-Water Nexus roundtables to gain insights and feedback on our current plans, to build collaborations and alliances, and to leverage DOE's capabilities and those of related regional entities. In addition to a capstone event touching on general aspects of the energy-water nexus and chaired by the Secretary, DOE conducted topic-specific roundtables on fuels, the electricity sector, water infrastructure, and systems integration. This extensive stakeholder outreach has helped to inform and fine-tune this FY 2017 crosscutting initiative. The 2015 DOE Quadrennial Technology Review (QTR), released on September 10, 2015, highlights several areas where technology advances could positively impact the challenges faced in the energy-water nexus, including desalination. Additionally, in FY 2015, DOE established a crosscutting, domestic energy and water research investment as part of a bilateral collaboration with China. In this latter initiative, U.S. scientists receive funding to conduct research on a set of coordinated topics and common Nexus challenges. Ultimately, activities in FY 2017 continue to build on the these foundational investments while introducing a number of strategically important new initiatives with the goal of accelerating the science, analytic capabilities, technology innovations, policy insight, and outreach for the most pressing challenges at the Nexus.

Present day water and energy systems are interdependent. From providing cooling to power plants to irrigating crops for biofuels, multiple phases of energy production and electricity generation use water. Conversely, extracting, conveying, and delivering water of appropriate quality for diverse human uses requires energy, and treating wastewaters prior to their return to the environment requires even more. Historically, interactions between energy and water have been considered on a regional or technology-by-technology basis. Despite their interdependency, energy and water systems have been developed, managed, and regulated independently.

Several current trends are increasing the urgency to address the energy-water nexus in an integrated way. First, precipitation and temperature patterns across the United States are undergoing rapid change with increasing frequency and intensity of extreme events. Already stressed by competing demands and interdependencies, record droughts (e.g., California), heat waves, floods, tropical storms, and winter storms have had significant effect on infrastructure, regional economies, and productivity in various parts of the U.S. Few communities have escaped these trends. Many of these challenges, either individually or oftentimes complicated by simultaneous occurrence, pose extreme challenges at the Nexus. Second, recent scientific evidence points to the accelerated drawdown of some critically important U.S. groundwater supplies, typically serving as the "backup plan" for insufficient or intermittent surface water supplies for energy and other uses. Third, U.S. population growth and regional migration trends indicate that the population in arid areas such as the Southwest is likely to continue to increase, further impacting the management of both energy and water systems. More generally throughout the country, migration patterns continue to feed the growth of densely populated settlements and the associated drivers for concentrated, connected infrastructure. These shifts bring their own set of unique challenges owing to the rapid growth in service demands, constraints posed by existing designs and land-use allocations, and the increased criticality of service reliability. Finally, introduction of new technologies in the energy and water domains could shift water and energy demands, potentially in disruptive ways if interdependencies are not explicitly addressed. Policy developments addressing water impacts of energy production are introducing an additional layer of complexity for decision making.

The overarching goal of this initiative is to assist the nation in moving towards resilient and sustainable coupled energy-water systems. Success will be measured through DOE's ability to:

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

While several federal agencies have missions that touch on the water side of the energy-water nexus, DOE's focus on the energy side is essential if the Nation is to realize meaningful solutions. The complexity at the energy-water nexus also demands a coordinated and integrated DOE approach, one that leverages the full range of Departmental assets, from basic science to applied research, policy, and, ultimately, outreach. This Crosscut, now in its first year (FY 2016) of funding as a coordinated set of investments, has been years in planning and preparation. At the most fundamental level, it intends to improve understanding of vulnerabilities and opportunities as they evolve over time, offer new solutions through knowledge and technology creation, and accelerate change through policy and stakeholder engagement.

This FY 2017 crosscut is responsive to a variety of Congressional and stakeholder directives and requests. Section 979 of the Energy Policy Act of 2005 directed the DOE to carry out a program addressing energy-related issues associated with the provision of water and water-related issues associated with the provision of energy. Since that time, the Government Accountability Office (GAO) has issued a series of reports calling for improved DOE information and coordination at the energy-water nexus, including improving federal data for power plant water use (2009), improving information on water produced during oil and gas production (2012), and increasing federal coordination to better manage energy and water tradeoffs (2012).

Highlights and Major Changes in the FY 2017 Budget Request

In FY 2016, DOE manages its EWN activities as a coordinated set of programmatic efforts included within the enacted budgets for six major programs: the offices of Energy Efficiency and Renewable Energy (EERE), Energy Policy and Systems Analysis (EPSA), Fossil Energy (FE), International Affairs (IA), Indian Energy (IE), and Science (SC). FY 2017 activities are organized around the four major pillars, noted below, and continue and expand, strategically, into areas as noted.

1. ***Data, Modeling, and Analysis (DMA)*** helps to understand current energy system vulnerabilities while exploring complex systems dynamics for subsequent applications in planning the resilient, efficient, and competitive energy-water systems of the future. DOE's efforts will advance foundational models, produce and analyze modeled output, and integrate data sets at spatial and temporal scales that matter to decision-makers at Federal, regional, state, and municipal levels. Improving capabilities will provide insights into technology RDD&D opportunities. The work outlined here builds on a DOE Office of Science workshop addressing modeling and long term predictions of the integrated water cycle. DMA work focuses on the following four sub-pillars:
    a. *Layered Energy Resilience Data-Knowledge System* will fill key data gaps, identify scope, prepare a preliminary design, and begin development of an integrated data analytic system at the energy-water nexus. Efforts will initially emphasize work around the vast data inventories and capabilities distributed throughout DOE. FY 2016 funds are predominantly for scoping, planning, conceptual design, and expanding interagency engagement. FY 2017 supports the first phase of system build-out.
    b. *Integrated Multi-System, Multi-Scale Modeling Framework and Impact, Adaptation, and Vulnerability Model Development* will improve interoperability and process representations across a range of major modeling platforms that require integration to enable coupled simulations at the energy-water nexus. FY 2017 continues support for this foundational modeling capability with the goal of advancing both an advanced multi-model predictive system and an innovative suite of use-inspired multi-model tools.
    c. *Impacts, Adaptation, and Vulnerability Strategic Research and Analysis* will deliver a broad range of energy-water analyses, tools, and research insights to address priority needs of decision-makers and the research community.

d. *Regional-Scale Data, Modeling, and Analysis Test Beds*, new in FY 2017, will design and begin deployment of three regional-scale data, modeling, and analysis test beds. Major objectives of the test beds are to accelerate development and synthesis of integrated toolsets in diverse, contextualized environments; test the predictive limits and identify gaps of current and evolving capabilities on priority topics at the Nexus; identify and capitalize on unique topical and place-based DMA resources; and, ultimately, explore complex systems dynamics and the interaction of stressors at sub-regional and trans-regional scales.

2. ***Technology Research Development, Demonstration, and Deployment (RDD&D)*** produces technology solutions and infrastructure options to address vulnerabilities and increase resilience, and it offers the possibility of efficiency improvements and cost reductions to facilitate accelerated technology deployment. Technology RDD&D priorities are those opportunities with potential for highest impact as identified in energy-water flow analyses presented in the June 2014 report. The FY 2017 Request features a low-carbon, low-energy, low-cost desalination innovation hub as well as complementary investments in other technology areas.
   a. *A low-carbon, low-energy, low-cost desalination energy innovation hub* will serve as a center of research focused on developing integrated technological system solutions and enabling technologies for de-energizing, de-carbonizing, and reducing the cost of desalination. While preliminary research is currently underway on these topics, the proposed effort will serve as a significant and necessary first-of-a-kind focused critical mass R&D effort on new technologies for cost-effective desalination. It will establish a central pillar in DOE and the nation's RD&D efforts in this critically important and highly multi-disciplinary field. This Hub will examine low-carbon, low-energy, low-cost desalination approaches that will support production of municipal drinking water, production of agricultural water supplies and treatment of nontraditional water sources, such as produced water from oil and gas extraction.
   b. *Energy-Optimized Treatment, Management, and Beneficial Use of Non-Traditional Water* will complement the hub, advancing targeted treatment technologies and low carbon energy sources to address treatment of non-traditional waters for projected beneficial uses.
   c. *Sustainable Low Energy Water Utilities* will pursue processes, technologies, and systems that increase energy efficiency and energy recovery in water and wastewater treatment and conveyance.
   d. *Water-Efficient Cooling for Electricity Generation* will pursue increased efficiency in heat exchangers and cooling systems to reduce the need for water for cooling in thermoelectric power plants. In addition, reduction of water use in thermoelectric generation connects to the Supercritical CO_2 budget crosscut: the investments in the highly efficient supercritical CO_2 Brayton cycle presented in the Supercritical CO_2 budget crosscut have the potential to reduce the water requirements for thermoelectric cooling.

3. ***Policy analysis*** informs understanding of the motivation and barriers to addressing vulnerability and resilience that can impact diverse regional, national, and global stakeholders. Work in FY 2017 will continue to characterize federal and state policies, economics, and other factors that impact the use of water in energy systems and the use of energy in water systems. This analysis will also help identify prioritization questions to be examined through DMA and identify technology deployment barriers and opportunities. By identifying policy factors influencing the deployment of key cooling, water treatment, and other technologies, the analysis will help to catalyze the timely and efficient transformation of the national energy-water systems to ensure that the U.S. industry remains at the forefront of clean and sustainable energy production and use.

4. ***Outreach and stakeholder engagement*** strengthens this overall collection of proposed activities by sharpening understanding of end-user needs, regional considerations, and other data sets, while helping to identify pathways and potential partners for deployment and implementation.

Overall, the FY 2017 Request features an investment portfolio that is balanced, integrated, and strategically aligned, while simultaneously preserving the unique mission imperatives of the individual programs. The integration occurs across the four pillars outlined above. For example, performance and cost specifications from technology RDD&D can feed both DMA and policy analysis. Policy analysis informs understanding of technology deployment barriers and opportunities. In addition to being broadly useful to the R&D community, DMA produces analytical tools, forecasts, and datasets and can help to identify technology opportunity.

Energy-Water Nexus
Funding by Appropriation and Program ($K)

	FY 2015 Enacted	FY 2015 Current	FY 2016 Enacted	FY 2017 Request	FY 2017 vs FY 2016
Departmental Administration					
Energy Policy and Systems Analysis: Program Direction	2,550	2,550	2,550	2,600	+50
International Affairs: Program Direction	---	---	300	400	+100
Total, Departmental Administration	**2,550**	**2,550**	**2,850**	**3,000**	**+150**
Energy Efficiency & Renewable Energy					
Advanced Manufacturing: Advanced Manufacturing R&D Facilities	---	---	---	25,000	+25,000
Advanced Manufacturing: Advanced Manufacturing R&D Projects	---	---	2,300	---	-2,300
Advanced Manufacturing: Industrial Technical Assistance	---	---	2,000	---	-2,000
Bioenergy Technologies: Conversion Technologies	---	---	---	4,000	+4,000
Geothermal Technologies: Low Temperature and Coproduced Resources	1,045	1,045	2,000	2,000	---
Geothermal Technologies: Systems Analyses	180	---	---	---	---
Solar Energy: Concentrating Solar Power	---	---	---	15,000	+15,000
Water Power: Hydropower Technologies	---	---	600	6,000	+5,400
Total, Energy Efficiency & Renewable Energy	**1,225**	**1,045**	**6,900**	**52,000**	**+45,100**
Fossil Energy Research & Development					
Crosscutting Research and Analysis: Water Management R&D	7,000	6,783	6,000	15,800	+9,800
Fuel Supply Impact Mitigation: Environmentally Prudent Development	3,000	0	0	---	---
Total, Fossil Energy Research & Development	**10,000**	**6,783**	**6,000**	**15,800**	**+3,800**
Office of Indian Energy Policy and Programs					
Tribal Energy Program: Tribal Energy Grant Program	---	---	500	1,000	+500
Tribal Energy Program: Technical Assistance	---	---	200	---	-200
Total, Office of Indian Energy Policy and Programs	**---**	**---**	**700**	**1,000**	**+300**
Science					
Biological and Environmental Research: Climate and Environmental Sciences	**1,800**	**1,800**	**11,800**	**24,300**	**+12,500**
Total, Energy-Water Nexus	**15,575**	**12,178**	**28,250**	**96,100**	**+67,850**

Energy-Water Nexus
FY 2017 Funding by Pillar ($K)

	Data, Modeling, and Analysis	Technology Research Development, Demonstration, and Deployment	Policy Analysis	Outreach and Stakeholder Engagement	Total
Departmental Administration					
Energy Policy and Systems Analysis: Program Direction	1,500	---	1,000	100	**2,600**
International Affairs: Program Direction	300	---	---	100	**400**
Departmental Administration Total	**1,800**	**---**	**1,000**	**200**	**3,000**
Energy Efficiency & Renewable Energy					
Advanced Manufacturing: Advanced Manufacturing R&D Facilities	---	25,000	---	---	**25,000**
Bioenergy Technologies: Conversion Technologies	---	4,000	---	---	**4,000**
Geothermal Technologies: Low Temperature and Coproduced Resources	---	2,000	---	---	**2.000**
Solar Energy: Concentrating Solar Power	---	15,000	---	---	**15,000**
Water Power: Hydropower Technologies	1,000	5,000	---	---	**6,000**
Total, Energy Efficiency & Renewable Energy	**1,000**	**51,000**	**---**	**---**	**52,000**
Fossil Energy Research & Development					
Crosscutting Research and Analysis: Water Management R&D	1,000	14,800	---	---	**15,800**
Total, Fossil Energy Research & Development	**1,000**	**14,800**	**---**	**---**	**15,800**
Office of Indian Energy Policy and Programs					
Tribal Energy Program: Tribal Energy Grant Program	**---**	**1,000**	**---**	**---**	**1,000**
Science					
Biological and Environmental Research: Climate and Environmental Sciences	**24,300**	**---**	**---**	**---**	**24,300**
Total, Energy-Water Nexus	**28,100**	**66,800**	**1,000**	**200**	**96,100**

Program Roles

Departmental Collaboration
The interaction of the four elements proposed under the crosscut—DMA, RDD&D, Policy Analysis, and Outreach and Stakeholder Engagement—cuts across six DOE offices: EERE, EPSA, FE, IA, IE, and SC. The bulk of the DMA investment comes from SC, with cross-office shared funding and/or collaboration spanning all of the major focus areas, including the Layered Energy Resilience Data-Knowledge System and the Regional-Scale Data, Modeling, and Analysis Test Beds. Technology RDD&D is primarily supported by FE and EERE and benefits from cross-office collaboration. Policy analysis is contributed by EPSA. Crosscutting outreach and stakeholder engagement is contributed by EPSA and IA.

Data, Modeling, and Analysis (DMA)

DMA – Layered Energy Resilience Data-Knowledge System

SC: BER ($3.0M)
SC efforts will focus on methodologies for exploring inter-layer correlations and interdependencies through time; observation-model data fusion; scalable analytics; distributed data methods; advanced algorithms for pattern recognition and identification of emergent behaviors; distributed data retrieval and data preparation and conditioning for a broad range of IAM, IAV, and Earth System Modeling domains.

FE: Crosscutting Research and Analysis ($1.0M)
FE data, modeling, and analysis (DMA) will gather and analyze data in identified gaps to characterize energy-water relationships on a state level in coordination with other offices within DOE.

EPSA ($500K)
EPSA will focus on data scoping elements and capabilities aligned with potential use for the data system in multiple domains addressing a broad range of analysis, planning, and evaluation needs. In addition, EPSA will fill data gaps and align current and historical data sets in areas such as thermoelectric cooling, produced water, and water sector energy use.

DMA – Integrated Multi-System, Multi-Scale Modeling Framework and Impact, Adaptation, Vulnerability (IAV) Modeling

SC: BER ($7.8M)
BER will focus on modeling efforts to improve understanding of complex systems dynamics and to enable next generation simulations at the energy-water nexus. BER will develop and test a model integration framework to enhance model interoperability, linking models such as Integrated Assessment Models (IAMs) and energy and other infrastructure models, including the Connected Infrastructure Dynamics Model (CIDM). Efforts will focus on the development and implementation of model couplers, coupling strategies, and scale matching challenges. There will be a major emphasis on improving spatial and temporal scales of the various component models, with a goal of adaptive resolution capabilities to increase computational efficiencies. Fine scale representations are critically important for exploring regional and local stressors, responses, and coupled behaviors at the energy-water nexus. Impacts, adaptations, and vulnerabilities modeling at the nexus requires accompanying expansions of process representations and data sets. Efforts will be designed to accommodate both changing baseline conditions and characteristics of extreme events (e.g., droughts, floods, heat waves). Improvements will enhance insights into coupled system thresholds and tipping points. Thermoelectric system dependencies on cooling water will serve as one initial focus for the IAV work and deeper model development. Broader enhancements will seek to strengthen land representations within IAMs, for example in the Global Change Assessment Model (GCAM). Land cover and land use have critical bearings on energy and water supply and use. The objective will be to take into account a wider range of variables (soils, latitude, topography, etc.).

EERE: Water Power ($1.0M)
Understanding how reservoirs and water releases through hydropower facilities and other major dams affect water quality in downstream rivers is extremely complicated, but very necessary for modeling the linkages between the nation's energy and water systems, simulating water dependencies and the implications of extreme meteorological events, and identifying potential tipping points or vulnerabilities. There are thousands of hydropower plants and other major dams within the U.S.,

and these facilities can have significant effects on water quality, which in turn can affect aquatic ecosystems and the operations of other energy facilities (like coal and nuclear thermal generating plants). Some effects of hydropower operations can be negative, such as inadequate dissolved oxygen or alterations to the natural pattern of water temperature fluctuations in streams. Other effects of hydropower operations are beneficial, such as the management of reservoir storage to maximize the supply of cool water during hot, dry extremes. Improvements in operational water-quality models can help minimize impacts and could potentially allow hydropower facilities to improve water quality management. All of these issues become more complicated as precipitation, runoff, and temperature patterns change, further affecting generation capacity and power system flexibility. In FY 2017, the Water Program will build on its work in FY 2016 to improve accurate representation of hydropower systems in integrated energy assessment models, with the aim of identifying any significant future water and energy systems-level risks. This work will be closely coordinated with SC and other offices to improve integrated assessment and vulnerability models.

DMA-IAV Strategic Research and Analysis

SC: BER ($3.5M)

SC will pursue scientific analyses and supporting analytic methodologies to improve understanding of the complex forces that influence and shape evolution of the energy-water system. Forces include land use and land cover change, population/migration, regional economics, evolution of settlements (the built environment and connected infrastructures), energy and related technology developments and deployments, and changes in weather patterns and extremes. Complementary efforts will focus on development of scenario methodologies. Emphasis will be directed toward multi-scale challenges (e.g., global, national, and regional nesting of scenarios) and techniques for developing consistent, integrated scenarios that take into account the combined forces/factors identified above. SC will also advance regional climate, multi-model inter-comparison methods and downscaling capabilities in coordination with other research agencies, focusing on precipitation and other parameters of particular interest at the nexus. Modest funding will also support research analytic efforts for DOE's role in Interagency Working Groups of the U.S. Global Change Research Program that are presently engaged or seeking to engage in research at the energy-water nexus and on impacts of water cycle extremes.

IA ($300K)

In collaboration with other nations, IA will pursue a platform incorporating modeling and analysis that enables nations to better understand the effects of water stress on energy systems at multiple scales and the energy footprint of water systems.

DMA-Regional-Scale Data, Modeling, and Analysis Test Beds

SC: BER ($10.0M)

In FY 2017, SC will design and deploy three regional-scale data, modeling, and analysis test beds. These test beds will accelerate the synthesis of integrated toolsets, identify and capitalize on diverse topical and place-based DMA capabilities, and explore predictive limits and gaps in DMA capabilities for a set of regions and predictive challenges at the energy-water nexus. DOE laboratory-led research teams will be tailored to the unique DMA challenges of each test bed and corresponding set of topics and systems configurations. Each team will include participation from one to several national laboratories and engage and support strategic collaborations with universities. In general, the approach will build on DOE capabilities and leverage, as appropriate, additional assets/capabilities at the federal, state, and local levels. Informed by science community workshops and recent reports that highlight opportunities for test bed designs, selection of topics and regions will focus on water stressed regions and/or areas undergoing rapid change that can benefit from and "stress test" multi-model frameworks built around regional-scale integrated assessment models; multi-sector impact, adaptation, and vulnerability (IAV) models; and connected infrastructure dynamics models. Moreover, the test beds will seek to illuminate various current and possible future mixes of energy supply and demand and the implications of "water for energy" (e.g., thermoelectric cooling) and energy for water (e.g., pumping and treatment); issues surrounding predominantly mountain-fed versus intermittent rain-fed water supplies and co-dependencies and vulnerabilities with groundwater; implications of changing weather patterns and extremes; changing technology insertion opportunities; and implications and challenges for dense settlements (e.g. urban) versus distributed settlements and associated connected infrastructures. The selection of three test beds provides the necessary and sufficient basis to explore different types of integrated systems configurations and sub-regional processes, heterogeneity in regional-scale DMA resources/capabilities, and the analysis of trans-regional intersects, for example involving the electricity grid, oil and natural gas supplies and distribution, watersheds, population

migration, etc. One of the test beds will be designed and developed to be more detailed and robust, paving the way for growth into an Integrated Field Laboratory (IFL) that incorporates observatories and data networks as determined necessary through the initial DMA-focused efforts. This latter test bed, and ultimately the IFL, will serve as a flagship, providing the deepest scientific insights while serving as the central node for the others. As such, it will lead methodology development, for example in integrated test bed design, uncertainty quantification, scenario development, and testing and evaluation.

EPSA ($1.0M)
EPSA will develop a suite of policy and systems analysis questions underlying, use-inspired dimensions of the testbeds, thereby complementing the basic research focus and questions posed by SC. Topics that will be pursued include 1) the exploration of the interaction among climate regimes, water variability, grid operations, and water utility operations under different carbon emissions pathways and strategies, and the relation to reliability and resilience; 2) resilience and risk reduction options for energy infrastructure under extreme events; 3) impact of water constraints on energy facility siting decisions; 4) the interaction of evolving energy and water markets; and 5) systemic energy implications of emerging strategies to deliver water in water-stressed regions. EPSA will augment the science-driven risk and uncertainty visualization methods developed by SC for its mission-focused applications. In addition, EPSA will develop, test, and apply uncertainty and risk communication methods with testbed communities to support integrated decision-making at the Nexus.

Technology Research, Development, Demonstration, and Deployment (Technology RDD&D)

Technology RDD&D -- Low-Carbon, low-energy, low-cost desalination energy innovation hub
The Department proposes to establish a low-carbon, low-energy, low-cost Desalination Energy Innovation Hub focused on RD&D on new technologies to dramatically lower the cost, energy use, and carbon footprint of water desalination. The Hub will be supported and managed by EERE's Advanced Manufacturing Office (AMO). Next generation desalination is high impact, energy-related RD&D which, if addressed, would provide the technical foundation for significant benefit for society grappling with sustained drought, groundwater depletion, and saltwater intrusion. The Desal Hub will pursue "pipe-parity" with existing water sources and/or treatment and disposal options and will address multiple water uses, including for drinking water and agriculture and multiple water sources such as produced water from oil and gas. Consistent with the criteria for a hub published by DOE's Science Advisory Board, the work within the Hub will span across disciplines and from basic and applied research to development and demonstration. The Hub will provide shared resources for development of foundational scientific understanding, enabling technologies, and testbeds of sufficient scale to demonstrate the technical potential of new desalination technology approaches. Establishment of the Hub will provide a public-private partnership framework for the subsequent scaling of individual desalination technologies. The Hub will also provide a connection point for researchers working on related technologies in water infrastructure, including others supported by complementary investments in DOE. A workshop was held in the fall of 2015 to begin to refine the technical scope for a future Hub through dialog with stakeholders from industry, academic researchers and national laboratories.

EERE: Advanced Manufacturing ($25.0M)
Through its management of the Hub, the Advanced Manufacturing program will support technical areas such as high-thermal flux and high corrosion resistance heat exchangers from low-cost materials (for example, based on polymers rather than metal alloys); high-volume production of membranes with low cost/area, long lifetimes (>15 years), low propensity for fouling (biological or non-biological), controlled thermal properties (both high and low thermal conductivity), superior transport properties (high flux, high selectivity, low cross-over) and robust chemical and mechanical stability; fabrication of complex flow-field structures for mass transfer with low boundary layer resistance; and materials and structures that cost-effectively enable higher distillation temperatures and therefore more efficient heat utilization while preventing chemical scaling in thermal technologies (currently caused primarily by dissolved calcium and magnesium salts).

Technology RDD&D – Energy-Optimized Treatment, Management, and Beneficial Use of Non-Traditional Waters

EERE: Geothermal Technologies ($2.0M)
In FY 2017, the Geothermal Technologies program plans to complete prototypes of technologies and processes for low temperature geothermal water desalination in preparation for field demonstration.

EERE: Solar Energy ($15.0M)
In FY 2017, the Solar Energy program will support applied R&D for the use of low temperature concentrating solar power for desalination.

FE: Crosscutting Research and Analysis ($9.15M)
In FY 2017, FE Crosscutting Research and Analysis will field test promising technologies and processes for treating water produced by injection of carbon dioxide in deep saline aquifers through a Brine Extraction Storage Test (BEST). This R&D will focus on innovative multi-stage filtration technologies including membrane-based, evaporative, chemical, electrochemical, and biological systems.

Technology RDD&D – Sustainable Low Energy Water Utilities

EERE: Bioenergy Technologies ($4.0M)
In FY 2017, the Bioenergy Technologies program will continue R&D for technologies that allow for the conversion of wet waste feedstocks. These technologies include: hydrothermal liquefaction to produce biofuels from biosolids in support of DOE's 2017 and 2022 goals, using biogas as a feedstock to make bioproduct precursors with carbon conversion efficiency above 50%, and exploring new alternatives processes to anaerobic digestion that produce longer chain hydrocarbons that are competitive with existing biopower applications.

EERE: Water Power ($5.0M)
In FY 2017, the Water Power program will focus on a new initiative to develop and demonstrate innovative technology by investing in demonstrations and performance/reliability testing in partnership with water utilities. This effort will focus on small (i.e. kilowatt to megawatt scale), modular hydropower systems appropriate for recovering excess energy from the nation's thousands of municipal water supply and water treatment systems. National labs will be involved to validate and publish testing results, with the ultimate goal of increasing the confidence of water utility managers in the reliability and economic viability of these new technologies.

IE ($1.0M)
The Office of Indian Energy Policy and Programs (IE) will work with tribal stakeholders and their utility service providers to identify priorities and provide technical assistance. The Office will convene collaborative processes aimed at integration of innovative technologies and approaches that improve energy efficiency of drinking water and waste water systems on tribal lands. The Office will also competitively fund a small number of demonstration projects.

Technology RDD&D –Water-Efficient Cooling for Electricity Generation

FE: Crosscutting Research and Analysis ($5.65M)
In FY 2017, FE will pursue research on increased efficiency in heat exchangers for plant cooling and support development of second-generation and transformational cooling systems.

Policy Analysis

EPSA ($1.0M)
EPSA's policy analysis will draw upon and inform work in DMA and Technology RDD&D. The foundation of the policy analysis is a set of systems analyses addressing water and energy flows, energy infrastructure and technology deployment, energy and water systems operations, market analysis and finance, and regulations at multiple scales. EPSA will continue to develop relevant and appropriate policy scenarios that bridge between energy and water domains at the federal and state level that incorporate potential energy technology deployment trajectories and societal developments. Additional efforts will analyze energy system resilience under water constraints and also examine key federal, state, and local policies that affect energy system resilience under variable water conditions. EPSA will continue to identify and implement opportunities to leverage existing energy and water infrastructure investment programs, such as State and Tribal Assistance Grants, State Energy Programs, and the Water Infrastructure Finance Center. Efforts will also be directed toward region-specific analyses of the regulatory, economic, and market aspects of thermoelectric cooling and sustainable water utilities. Similar efforts will

be devoted to the topics of desalination and treatment of produced water from oil, gas, geothermal, carbon underground storage, and other sources.

Outreach and Stakeholder Engagement

EPSA ($100K)
Engaging with stakeholders of all types and at all levels is critical in understanding the relevant science, technology, business, and policy landscapes. Stakeholder engagement will inform and be informed by DMA, technology RDD&D, and policy analysis. EPSA's objectives in this area include 1) informing and effectively utilizing data, models, and analysis; 2) informing technology specifications and improving the direct impacts of potential RDD&D investments; 3) informing and communicating policy analysis and design; 4) developing collaborative relationships at the state, local, tribal, and private sector levels in order to achieve constructive results. The proposed work includes targeted workshops hosted collaboratively with universities, State Energy Offices, and regional stakeholders.

IA ($100K)
IA will pursue strategic international collaborations balanced between targeted bilateral projects that connect to DOE's overall R&D agenda and multilateral initiatives. The collaborations will build on extensive relationships with international stakeholders in recognition that the energy-water nexus is a global issue with ubiquitous data, modeling and analysis; technology RDD&D; and policy analysis interests. Collaboration with other nations gives the U.S. the opportunity to share resources to address shared issues.

Key Accomplishments and Objectives

FY 2015 Key Accomplishments
- Convened a series of six Secretarial roundtables soliciting broad input on different aspects of the energy-water nexus, including fuels, water infrastructure, electricity, and systems integration. These roundtables have informed Departmental prioritization of current and future work.
- Created a new modeling capability to balance water supplies within the GCAM integrated assessment modeling framework. This capability allows analysis of how constraints on supplies will interact with evolving energy and agricultural demands.
- Made a major advance within the Integrated Global Systems Model to incorporate water quality, with important implications for projecting water temperature and its implications for power plant cooling.
- NREL has developed a series of maps highlighting geothermal resource quality and the availability of multiple types of water (fresh surface water, fresh groundwater, municipal wastewater, brackish groundwater) that could be used in geothermal operations at a high spatial resolution (USGS HUC-8 regions).
- In FY 2015, the Bioenergy Technologies program initiated a resource assessment to identify the availability and geographic distribution of wet waste streams, including biosolids, animal wastes, residential and commercial food wastes, organic industrial wastes and wastewaters, as well as biogas produced from any of these sources.

FY 2016 Planned Activities
- Convened workshop to begin scoping the Desalination Hub.
- Developments to tune temporal and spatial resolution of models including GCAM to better characterize water supply, water allocation and storage, linkage of land use to river basin characteristics, and water technology options.
- Conduct a series of interagency workshops to advance ideas and plans for a multi-scale, multi-sector modeling framework for the energy-water nexus and strongly coupled impacts, adaptations, and vulnerabilities.
- Develop the initial scope and conceptual design for the layered energy resilience data knowledge framework through an inter-laboratory development meeting and a subsequent workshop to assess the broader research and analytic needs of various user communities.
- Create a coordinated plan for the conceptual framework, criteria, and path forward for Regional-Scale Data, Modeling, and Analysis Test Beds, building around and synthesizing from foundational DMA FY 2016 funded focus areas and investments that lays the foundations for a competitive FOA.
- Develop the scientific foundations for a focused set of sub-regional scenarios of the United States, linking various data layers, including regional economics, demographics, land use and land cover, energy, and water.

- Complete initial studies on the implications of climate impacts on the resilience of the US power system due to changes in air and water temperatures and water availability using a reduced form power plant modeling capability.
- Develop technologies and processes for treating water produced by injection of carbon dioxide in deep saline aquifers.
- Incorporate results from ANL and NREL's integrated assessment and life cycle analysis of geothermal water use into the Geothermal Vision Study
- Field prototype of advanced energy-efficient hybrid membrane system for industrial water reuse.
- Build off of the Bioenergy Technologies program's workshop series from FY 2015 to produce a waste-to-energy (WTE) roadmap, including quantitative targets for at least two pathways, which will in turn inform R&D directions in FY 2017.

FY 2017 Key Objectives

- Launch Desalination Hub.
- Initiate build-out of the first stage of the layered energy resilience data-knowledge system focused initially on diverse DOE data layers and a small but critically important set of other agency data layers.
- Conduct initial evaluation of a leadership-class multi-system, multi-scale modeling framework for IAV modeling at the Nexus, working closely with a broad coalition of interagency partners led through a DOE initiated subgroup of the Interagency Group on Integrative Modeling.
- Reduce power plant consumption of water and provide options for use of nontraditional waters/fluids.
- Complete design, select topics and regions, engage various federal, state, and local research partners, and compete competitive awards to begin deployment of three to four regional-scale DMA test beds, including one leading test bed that can eventually evolve into an Integrated Field Laboratory.
- Complete testing of desalination prototypes at INL, LBNL, and NREL and prepare for field demonstrations.