INNOVATIONS AT THE NEXUS OF FOOD, ENERGY, AND WATER SYSTEMS (INFEWS) $74,960,000

Overview

Growth of the global and U.S. population has placed an ever-increasing stress on three key and interconnected resources: food, energy, and water. There is a compelling and urgent need to understand, model, design, and manage the interconnected food-energy-water system, which incorporates natural, social, and human-built components. NSF can make important contributions by building the fundamental knowledge base; developing new ways to integrate heterogeneous data; analyzing, modeling, synthesizing, and controlling complex natural systems; expanding the workforce and piloting engineered solutions.

Of particular and timely interest are the production, resilience, safety, and security of food, energy, and water resources, and the systems in place to facilitate their generation, distribution, and consumption. Efficiency and conservation will be important goals to attain as stress on this interconnected system increases from population and economic growth, changes in land use practices, and more frequent and large spatial and temporal variations in precipitation, temperatures, and key environmental variables tied to environmental change. Developing countries are under extreme pressure as they endeavor to manage the multiple stressors of poverty, resource competition, agricultural disease, and rising food costs. There are important security implications of increasing stress on this interconnected food-energy-water system.[1] Recent droughts in California and corresponding impacts on the water, agricultural (food), and energy sectors are timely examples that illustrate these concerns.

Food, energy, and water systems interact in several ways. Water is required for energy-related processes such as hydropower, cooling of electric power plants, and fuel production. Energy is needed for wastewater treatment, desalination, pumping groundwater, and for transport of water and foodstuffs. Water and energy are critical for agriculture and food production. Biofuel production consumes water and, in some instances, can result in food shortages. In addition, different land use practices, increased urbanization, and weather variability have major impacts on water, energy, and agriculture resources. These multifaceted interactions are impacted on the one hand by fundamental laws governing various physical, chemical, and biological processes, and on the other hand by social, behavioral, and economic contexts and decisions made by individuals, organizations, and institutions.

Total Funding for INFEWS

(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
-	-	**$74.96**

Goals

NSF's investment in "Innovations at the Nexus of Food, Energy, and Water Systems" (INFEWS) will:

- Support integrated experimental research towards creating a comprehensive food-energy-water socio-technical systems model;
- Advance knowledge/technologies that foster safer, more secure, and more efficient use of resources within the food-energy-water nexus, and;
- Support an integrated approach to build the next-generation INFEWS workforce.

[1] Quadrennial Defense Review 2014 (www.defense.gov/pubs/2014_Quadrennial_Defense_Review.pdf)

An interdisciplinary research effort on food-energy-water systems, including safety and security of these systems, presents a unique opportunity for NSF to work, within both a national and an international context, toward building a platform for more accurate, process-based models that incorporate relevant social, political, economic, and cultural factors, in addition to improved precipitation forecasts that have the capacity to presage tipping points in water availability and physical measurements that give real-time feedback on the effect of land, energy, and water management.

Approach

NSF is heavily invested in discovery research at a disciplinary level, as well as cross-cutting programs such as Water, Sustainability and Climate (WSC); Sustainable Chemistry, Engineering and Materials (SusChEM); Cyber Innovation for Sustainability Science and Engineering (CyberSEES); Hazards and Disasters (Hazards SEES); Basic Research to Enable Agricultural Development (BREAD); Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP); and the Dynamics of Coupled Natural and Human Systems (CNH). INFEWS offers a significant opportunity for NSF to build on these investments and experiences in order to create new and effective research programs to advance the food-energy-water system knowledge base. NSF has initiated, and proposes to continue, the following leadership and governance structure for INFEWS:

- A senior leadership committee composed of assistant directors/office heads to provide long-term planning and overall guidance;
- Working groups of division directors and program officers, each overseen by assistant directors/office heads/division directors who are most relevant to the specific activity, to manage programs or activities and to coordinate among activities; and
- Interagency working groups to coordinate interagency activities and joint solicitations, as well as arrangements for engagement and collaboration with international partners.

NSF will build on ongoing internal partnerships among participating directorates to engage in collaborative multi-year activities involving two (or more) directorates. Management agreements will define directorate-planned contributions, remaining flexible on the requirement for participation; this flexibility will allow for partnerships with other agencies and international entities. NSF's approach and planned activities will be coordinated with other agencies through the National Science and Technology Council's Committee on Environment, Natural Resources, and Sustainability (CENRS).

The implementation proposed for INFEWS will include a combination of solicitations and Dear Colleague Letters (DCLs). Support mechanisms such as workshops and networks will be employed to engage the community in defining and refining research priorities and Early-concept Grants for Exploratory Research (EAGER) will test potential new approaches. There is need for flexibility since there are a multitude of intersections and interactions in the full food-energy-water interconnected system. For example, NSF may focus efforts on water-food and water-energy sub-systems as well as infrastructure vulnerabilities, smart technologies and decision tools, sustained cyberinfrastructure, and social and behavioral contexts and constraints. Thus, the food-energy-water system creates an overarching research umbrella that can accommodate the full system, while subsystems can be studied at other levels with differing or fewer partners. In future years, there may emerge one or more flagship programs that aim for full system modeling and integration and optimization.

Given extant partnerships and community interest, solicitations will be issued for the first awards to be made in FY 2016. INFEWS is planned to run from 2016 – 2021, and periodic reviews and assessments will be used to determine the life-span of particular investments and activities under the INFEWS umbrella. As the investment area evolves, decisions will be made regarding changes in emphasis areas, the need to assimilate INFEWS efforts into core programs, and timing for sunsetting of specific investments.

Investment Framework

INFEWS Funding by Directorate

(Dollars in Millions)

Dir/Office	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request
BIO	-	-	$7.50
CISE	-	-	13.50
EHR	-	-	6.00
ENG	-	-	13.00
GEO	-	-	14.78
MPS	-	-	8.90
OISE	-	-	1.28
SBE	-	-	5.00
IA	-	-	5.00
Total, INFEWS	**-**	**-**	**$74.96**

Totals may not add due to rounding.

FY 2014 – FY 2015

INFEWS represents a natural segue from many NSF programs, including those under the SEES investment area. As such, INFEWS planning and development activities began in FY 2014 and will continue throughout FY 2015. NSF senior management is planning for the new investment area as community interest grows and is expressed in workshops and reports in a variety of disciplines. NSF senior management discussions with other federal agencies about common research interests and professional workforce needs will continue. NSF will support and organize regional workshops to promote interdisciplinary collaborative approaches to food-energy-water challenges. In FY 2015, NSF will continue with planning meetings and workgroup formation to develop solicitations and other funding mechanisms.

NSF will employ the DCL mechanism for INFEWS to support the wide variety of disciplines and interest in this broad investment area. FY 2015 workshops – including scientists from Department of Energy (DOE), U.S. Department of Agriculture (USDA), U.S. Geological Survey (USGS), and other agencies – will help inform DCLs. An NSF working group will be formed to define two to three specific topics for emphasis, such as critical research problems in the water-food or the water-energy subsystem, that are ready to be explored.

FY 2016 Request

In FY 2016, NSF will issue a multi-directorate INFEWS solicitation to support integrated research towards creating a comprehensive food-energy-water socio-technical systems model; to advance knowledge/technologies that foster more efficient, safe, and secure use of resources within the food-energy-water nexus; and to support an integrated approach to build the next-generation INFEWS workforce.

NSF will also issue one or more DCLs to include: consideration of how the food-energy-water system is embedded in social, political, economic, and cultural contexts; innovation in the safety and protection of food, energy, and water resources, and the systems in place to facilitate their generation, distribution, and/or consumption; computational capacity and cyberinfrastructure needs for analysis of large-scale data, including modeling and simulation; and integration of research with education and training of the next generation workforce.

The food-energy-water theme may be emphasized in NSF-wide programs, such as Research Experiences for Undergraduates (REU), Dynamics of Coupled Natural and Human Systems (CNH), Macrosystems biology, and those related to data science (e.g., BIGDATA and Data Infrastructure Building Blocks (DIBBs)). In FY 2016, INFEWS will also be one of the priority research theme areas for the NSF Research Traineeship (NRT) program as part of an effort to create innovative graduate education efforts in areas of national need. In addition, NEON (National Ecological Observatory Network) will continue to phase into operations, including full implementation of the stream ecology experiment (STREON) with the potential for broad impact on this NSF-wide investment.

FY 2017 – FY 2021

In FY 2017 – 2021, NSF will continue to make awards under the INFEWS solicitation and related DCLs. NSF expects to enhance interagency and international partnerships and to foster cross-disciplinary knowledge-sharing and networking through awards, meetings, workshops, and other activities.

Evaluation Framework

The progress of the implementation of this investment will be monitored and reviewed quarterly to ensure that it is on track as part of a FY 2016 performance goal. For more information about monitoring key program investments, see the FY 2016 Annual Performance Plan in the Performance chapter. All specific investments under INFEWS will be subject to rigorous peer review using NSF's merit review processes, and under the review of cross-NSF teams from staff level to program and division director-level to an agency senior management steering committee. NSF will use lessons learned from large, cross-NSF investment areas (e.g., SEES, I-Corps™) to inform evaluation planning and design for INFEWS. Planned evaluation activities include:

- Consulting internally and externally regarding evaluation strategy and methodology;
- Characterizing the initial portfolio, using new NSF portfolio management tools;
- Developing evaluation research questions;
- Analyzing NSF project reports for indications of advancement/growth of research; and
- Collecting and analyzing workforce development metrics.

Planning for evaluation is being initiated. Contract support will be engaged as soon as practicable to ensure objectivity of evaluation design and implementation, and the collection of relevant baseline data across the entire food-energy-water system.