INNOVATIONS AT THE NEXUS OF FOOD, ENERGY, AND WATER (INFEWS) $24,400,000 -$55,700,000 / -69.5%

Overview

Humanity is reliant upon the natural and physical systems of the Earth for provision of food, energy, and water (FEW) resources. With world population projected to increase to nine billion (U.S. population reaching 400 million) by 2050 and urban populations expected to double, there are expected to be major increases in demand for these resources. The Innovations at the Nexus of Food, Energy, and Water Systems (INFEWS) investment area enables interagency cooperation on one of the most pressing problems of the millennium—understanding interactions across the FEW nexus, how it is likely to affect our world, and how we can proactively plan for its consequences.

Food, energy, and water systems interconnect and are interdependent in many ways. Water is required for the production of energy—hydropower, cooling of electric power plants, energy production, etc. Energy is needed for wastewater treatment, desalination, pumping groundwater, and for transport of water. Water and energy are critical for agriculture and food production. Biofuels consume water and, in some instances, result in reductions in the production of food. In addition, different land use practices, increased urbanization, and climate variability have major impacts on all three. 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 the social, behavioral, and economic decisions made by individuals, organizations, and governments. Given the increased demand on these resources, societies can no longer sustain optimal operation for one system (i.e., food, energy, or water system), we must plan our interaction within the FEW system of systems so that no system fails even if it means that all systems operate sub-optimally.

The food, energy, and water nexus creates a grand research challenge: to understand how these complex, coupled processes and systems function now and in the future. There is also a critical need for research to enable new technologies that will enhance the productivity of the system and subsystems, maximize efficient overall usage of FEW resources, and define new means for socially and technologically adapting to future variability and demands. Investigations of this complex system will produce discoveries that cannot emerge from research on food or energy or water systems alone; the interactions among these components and the context(s) of the problem(s) they pose at the FEW nexus will produce new knowledge and technologies. NSF support of basic research in the science and engineering disciplines is needed to understand the interdependent and interconnected FEW systems and could lead to an integrated model useful not only for scientific understanding, but also informed decision-making.

INFEWS investments began in FY 2016 and are planned to continue through FY 2020. The overarching goal is to improve understanding of the interdependencies of the FEW systems, within a disciplinary and interdisciplinary context. Examples include:

- Improve understanding of FEW systems embedded in differing social contexts and the societal vulnerabilities of these systems with respect to short and long timescale events (e.g., weather, power outages, resource distribution, population pressures, and land-use changes).
- Advance scientific and engineering understanding to:
  - Improve systems models covering a range of environments, technologies, policies, individual and organizational behaviors, and relative weighting of FEW stresses/needs across the scope of the human, built, and natural environments;
  - Enable discoveries that lead to technological innovations incorporating sustainability, safety, security, efficiency, and affordability, while addressing relevant social, economic, and cultural factors; systems or models that promote efficient use of resources, as well as conversion and/or reuse of waste materials;

- Inform technologies and policies that improve food security and agricultural practices that better maintain ecosystem services;
- Strengthen partnerships with projects at the state and local levels that will test research results in real-world systems; and
- Encourage the results of modelling as well as technological and social solutions to be widely available to agencies, industries, and the public through computing interfaces that encourage interaction, contribution of additional data, and local application.

Goals

- Goal 1: Significantly advance our understanding of the food-energy-water system through quantitative and computational modeling, including support for advanced cyberinfrastructure;
- Goal 2: Develop real-time, cyber-enabled interfaces that improve understanding of the behavior of FEW systems and increase decision support capability;
- Goal 3: Enable research that will lead to innovative solutions to critical FEW system problems; and
- Goal 4: Grow the scientific workforce capable of studying and managing the FEW system, through education and other professional development opportunities.

FY 2018 Investments

In FY 2018, solicitations will emphasize: computational FEW system modeling ($11.95 million), innovative system solutions ($7.45 million), and contributing activities ($5.0 million).

Projects are significantly advancing scientific and engineering understanding and modeling of the complex FEW system and water-energy, food-energy, and food-water subsystems, as well as their interdependencies under multiple conditions. In partnership with the U.S. Department of Agriculture, projects integrate expertise from agricultural, computational, ecological, economic, energy, engineering, hydrological, mathematical, and social areas to enable technological innovations that improve security and affordability.

In FY 2018, fundamental scientific and engineering research will focus on systems models that cover a range of climates and organizational behaviors across built and natural environments. Emphasis will be placed on new design concepts and technologies that promote efficient use of resources and improve food security and agricultural practices that better maintain ecosystem services. Contributions will also be made to relevant graduate education experiences and to advanced phenotyping and microbiome technologies that have potential to translate into improved agricultural productivity and efficient use of resources such as land, water, nitrogen, and phosphorous.

Innovations at the Nexus of Food, Energy, and Water Systems
Funding by Directorate

(Dollars in Millions)

Dir/Office	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request
BIO	$7.50	-	-
CISE	8.00	-	-
EHR	8.81	-	3.00
ENG	9.84	-	5.00
GEO	5.00	-	8.00
MPS	5.02	-	-
SBE	4.50	-	2.50
IA	30.24	-	5.00
OISE	1.20	-	0.90
Total, INFEWS	**$80.10**	**-**	**$24.40**