OneNSF INVESTMENTS
SCIENCE, ENGINEERING, AND EDUCATION FOR SUSTAINABILITY

OVERVIEW

A sustainable world is one in which human needs are met without harm to the environment, and without sacrificing the ability of future generations to meet their needs. Meeting this formidable challenge requires a substantial increase in our understanding of the integrated system of resource and supply chains, society, the natural world, and the alterations humans bring to Earth. Given the pressing national and global need to realize a sustainable human future, the National Science Foundation (NSF) has developed a coordinated research portfolio spanning the entire range of scientific domains at NSF: the Science, Engineering, and Education for Sustainability (SEES) program.

SEES is a broad investment in the scientific underpinnings of sustainability at numerous temporal and spatial scales. Multiple perspectives and areas of expertise are required to increase our understanding of integrated systems of human society and the natural world. Thematic programs are aimed at building the knowledge base, while simultaneously encouraging interdisciplinary linkages, new partnerships, and education and outreach efforts.

Goals

SEES has three main goals to advance sustainability:
1. Support interdisciplinary research and education to facilitate the move towards global sustainability (Research and Education);
2. Build linkages among existing projects and partners and add new participants in the sustainability research enterprise (Collaboration); and
3. Develop a workforce trained in the interdisciplinary scholarship needed to understand and address the complex issues of sustainability (Workforce).

Approach

SEES is planned to be a decade long effort across NSF to coordinate and grow research and education associated with the environment, energy, and sustainability. NSF's work under SEES will be a blend of activities – formal solicitations and informational announcements of interest (e.g., Dear Colleague Letters) that span across scientific disciplines and require input and oversight from multiple NSF directorates. Research in such areas as complex environmental and climate-system responses and pathways will continue to be supported and emphasized across NSF and will be matched by increased emphasis on activities focused on sustainable materials and clean energy technologies. NSF will also work with other federal agencies and national and international stakeholder groups whose function and mission complement NSF's role to ensure that sustainability goals are carried forward.

The portfolio approach – as opposed to a large single program – facilitates coordination, monitoring, and impact across the major investment areas and also across NSF, as SEES activities are complex and highly interdisciplinary. The SEES organizational structure includes:
- A senior leadership committee composed of assistant directors/office heads to provide long-term planning and provide overall guidance;
- A cross-agency integration group composed of division directors and lead program directors, who develop consistent guidelines, provide internal and external communication, and shape evaluation plans; and

- Working groups of program directors, each overseen by assistant directors/office heads/division directors who are most relevant to the specific activity to manage programs or activities. When interagency or international partnerships, such as with the European Union (EU), have been established, then members of those entities may also be members of the working group to facilitate preparation of joint solicitations, establishment of MOUs/MOAs, or other arrangements for collaboration.

INVESTMENT FRAMEWORK

FY 2010-FY 2012

In FY 2010, NSF developed SEES in response to numerous major community reports, including the August 2009 National Science Board (NSB) report *Building a Sustainable Energy Future*, which emphasized the need for a coordinated program. Initial efforts focused on developing and coordinating a suite of research and education programs at the intersection of climate and environment, with specific attention to human behavior. These solicitations (Dimensions of Biodiversity; Regional and Decadal Earth System Modeling; Ocean Acidification; Water Sustainability and Climate; and the Climate Change Education program) resulted in awards totaling approximately $70.0 million.

In FY 2011, NSF requested an increment of $105.0 million for new SEES activities. Facing budgetary uncertainties, NSF maintained momentum in the SEES investment area by augmenting existing interdisciplinary programs (Coupled Natural and Human Systems, Research Coordination Networks) and issuing a Dear Colleague Letter (DCL) that advanced the research and education activities proposed for 2011 and laid the groundwork for programs proposed for continuance and expansion in FY 2012. An additional approximately $24.0 million in SEES activities was supported from existing 2011 resources through these activities.

In its FY 2012 Budget Request, NSF proposed to expand SEES by $233.0 million above the FY 2011 Request, through significant investments in programs related to energy and collaborative networks. During FY 2011, interdisciplinary working groups drafted and NSF released solicitations consistent with those plans, although at reduced scope and funding levels, for four new activities totaling approximately $60.0 million. The four new activities initiated in FY 2012 were: the NSF SEES Fellows program, at the postdoctoral level; Sustainability Research Networks (SRN), that include existing and new centers of collaboration; Sustainable Energy Pathways (SEP) focused on integrated energy resource utilization; and SEES-focused Partnerships for International Research and Education (PIRE), which advances international networks.

FY 2013 Request

In FY 2013, NSF plans to initiate five SEES programs that complement existing programs, including those recently developed for FY 2012. In addition, the five programs are consistent with long-term planning for the SEES investment area, and focus on environmental, technological, and societal resilience; dissemination of results; responsiveness to societal needs; and workforce development. These five programs are:

Two programs related to complex interactions in rapidly changing geographic areas:

- *Coastal SEES* is designed to enable place-based system-level understanding of vulnerable coastal systems; yield outcomes with quantitative predictive value; identify pathways to enhance coastal resilience; and communicate outcomes and develop international connections.

- *Arctic Regions (ArcSEES)* seeks fundamental research that improves our ability to evaluate the sustainability of the Arctic human-environmental system as well as integrated efforts that will provide community-relevant sustainability pathways and engineering solutions.

Two programs related to environmental and societal resilience:

- *Creating a More Disaster-Resilient America (CaMRA)* aims to catalyze basic research and education efforts in hazard-related science, engineering, risk assessment and decision making in order to improve forecasting and prediction of natural and technological hazards, mitigate their effects, and prepare communities to respond to, and recover from disasters.
- *Sustainable Chemistry, Engineering and Materials (SusCHEM)* responds to the America COMPETES Reauthorization Act of 2010 (P.L. 111-358 Section 509), which called for NSF to establish a Green Chemistry Basic Research program that embraces concepts such as renewable feed stocks, atom economy, less hazardous chemical syntheses, life cycle planning and designing safer chemicals. Consistent with the goals of SEES, SusCHEM aims to enable the basic science and engineering discoveries that will reduce dependence on non-renewable resources and improve the efficiency of industrial processes. Example research goals are to utilize new (non-petroleum based) sources of important raw materials; replace toxic chemicals and materials with benign alternatives; economically recycle chemicals that cannot be replaced, such as phosphorus; and devise chemical reactions and processes that require little energy, water and organic solvents, and minimize undesirable by-products.

One program related to energy conservation:

- *Role of Information Sciences and Engineering in SEES (RISES)* addresses the goal of decreasing energy consumption, which can be advanced by information technologies through improved hardware and software, increased use of renewable energy sources, and optimization strategies that minimize energy usage and reduce impacts on the environment. Along with many other efforts, SEES research and communication that is computationally intensive will benefit directly from the efficiencies discovered.

These five programs will total $76.70 million in FY 2013, and are primarily responsible for the $45.50 million increase over the FY 2012 Estimate. Funding for the five programs is partially offset by the Sustainable Energy Pathways (SEP) solicitation, which is released in alternate years (FY 2012 and FY 2014). The FY 2013 programs have strong support throughout all of NSF's directorates and offices. The remaining $125.80 million, which brings SEES to a total of $202.50 million in FY 2013, supports SEES programs that were initiated in prior years.

FY 2014 – FY 2019

In FY 2014 and beyond, it is anticipated that SEES will focus on further development and refinement of the investments that were established in FY 2011, 2012, and 2013. Additional focused five-year emphasis areas may be initiated in FY 2014 and FY 2015. Future years will emphasize consolidation and coordination of existing activities; incorporation of any new emphasis areas; dissemination of information from the rapidly growing SEES knowledge base to the scientific community, policy-makers, and the public; and the workforce development critical for producing the next generation of sustainability scientists and engineers.

At the conclusion of SEES, NSF, in collaboration with its partners across government, academia, and industry, expects to have made significant progress towards a sustainable human future. With respect to the three over-arching SEES goals, NSF expects to achieve the following three outcomes:

1. Goal 1, Research and Education: the sustainability science and engineering knowledge base is available and accessible to scientists, decision-makers, and society at large;
2. Goal 2, Collaboration: the private sector will be able to more rapidly identify and deploy technologies and methods to address sustainability issues; and
3. Goal 3, Workforce: transdisciplinary approaches to sustainability education are common practice; the U.S. has a robust and appropriately sized cadre of early career scientists and engineers to address sustainability issues.

As programs have been phased into SEES each year, it is expected that the various programs will not necessarily end simultaneously. Based on the results of rolling assessments, programs will have variable lifetimes, and successful programs of continued relevance will be folded into core research in directorates and offices. Thus, while the SEES portfolio has a planned conclusion, the critical research, engineering, and education on sustainability that has been catalyzed by the initiative will continue to have impact throughout NSF.

SEES Funding

(Dollars in Millions)

Directorate/Office	FY 2011 Actuals	FY 2012 Estimate	FY 2013 Request
BIO	$24.59	$27.25	$34.75
CISE	2.25	8.00	11.50
ENG	3.28	19.25	20.00
GEO	28.85	44.25	70.75
MPS	2.72	16.50	27.20
SBE	6.25	7.75	8.75
OCI	5.61	1.50	3.00
OISE	1.33	12.00	11.55
OPP	7.00	14.50	14.50
EHR	6.08	6.00	0.50
Total, NSF	**$87.96**	**$157.00**	**$202.50**

Totals may not add due to rounding.

EVALUATION FRAMEWORK

NSF will employ a variety of tools to evaluate the scientific impact and progress of the various programs in the SEES portfolio. The senior leadership will consider a matrix of assessment methods and measures that captures a range of outcomes and impacts. Planned evaluation activities include, by main SEES goal:

Goal 1: Research and Education

- *Short-term:* Conduct a portfolio analysis to examine the representation of multiple disciplines in proposals, and project reports. Use the portfolio analysis to identify gaps.
- *Long-term:* Engage an external group to conduct an independent assessment of the legacy of funding through SEES.

Goal 2: Collaboration

- *Short-term:* Monitor indicators of collaboration such as the number of new international collaborations, private and public sector participants in networks, papers in publications, or fora applicable to private and public sector concerns.
- *Long-term:* Use a network analysis to measure changes in nodes and links through time.

Goal 3: Workforce

- *Short-term:* Develop and baseline a monitoring system to collect metrics associated with the goals of SEES workforce development programs (such as SEES Fellows)
- *Long-term:* Use monitoring data to determine if a formal impact evaluation for large investments is indicated.

As solicitations are a key component of the SEES portfolio, NSF program directors will be looking for success indicators such as increased number of highly-rated proposals received, representation of multiple disciplines in proposals, and development of new international collaborations. NSF is particularly interested in measuring results in terms of new and productive connections made between researchers in a range of disciplines; development of new knowledge and concepts that advance the over-arching goal of a sustainable human future; and development of a workforce capable of meeting sustainability challenges.