U.S. DEPARTMENT OF ENERGY | Office of Science

Roundtable on Science and Technology for Sustainability
Japan-U.S. Workshop on Sustainable Energy Futures

Funding for Energy Research

June 26, 2012

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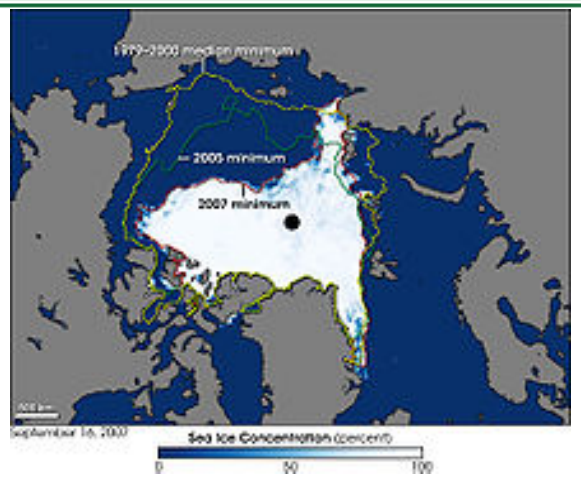
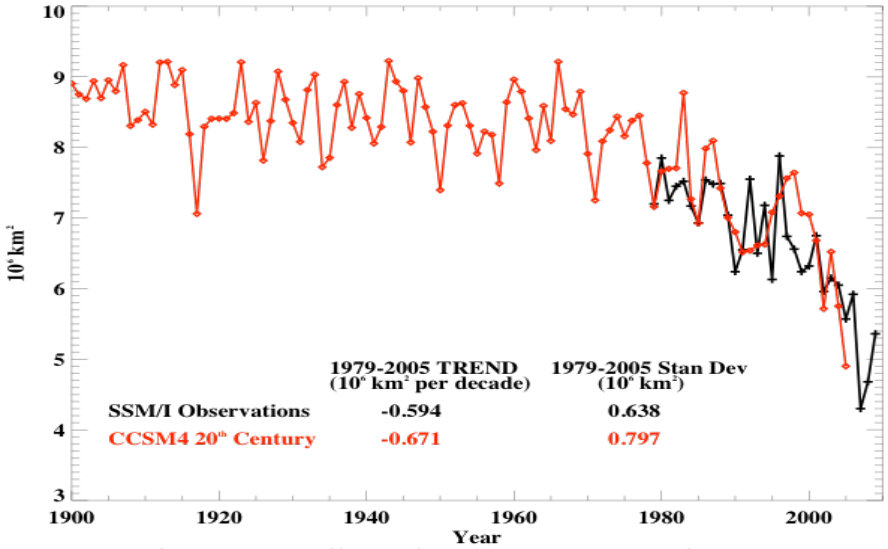
U.S. Department of Energy
www.science.energy.gov

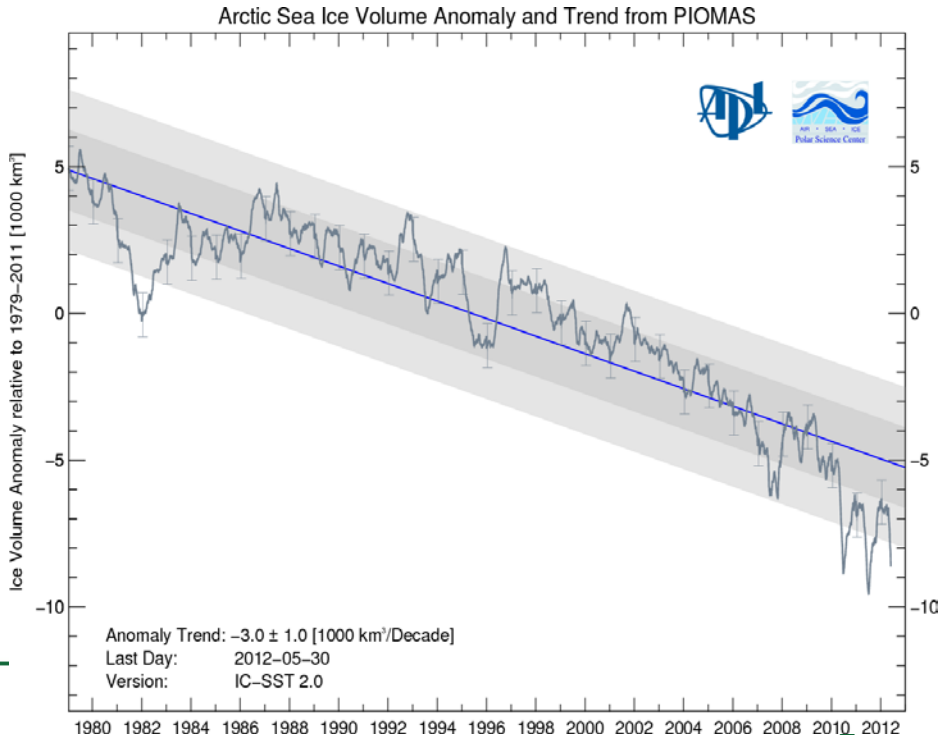
Climate change: Arctic Sea Ice Retreat

- **Arctic sea ice governs northern hemispheric climate: heat budget, water vapor, radiation balance**
- **Observations show significant sea ice retreat in recent decades**
  - **In 2007, largest sea ice loss in history (at right, and lower left)**
  - **In 2011, second largest sea ice loss in history (not shown)**
  - **In 2012, US Navy produces time series of sea ice volume (lower right), with 2012 showing largest sea ice volume anomaly**





Above: Satellite observations corroborate Community Climate System Model (CCSM) version 4, predictions



At right: US Navy measurements of sea ice volume. The CCSM4 is now tasked to simulate.

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We must drive toward Clean Energy

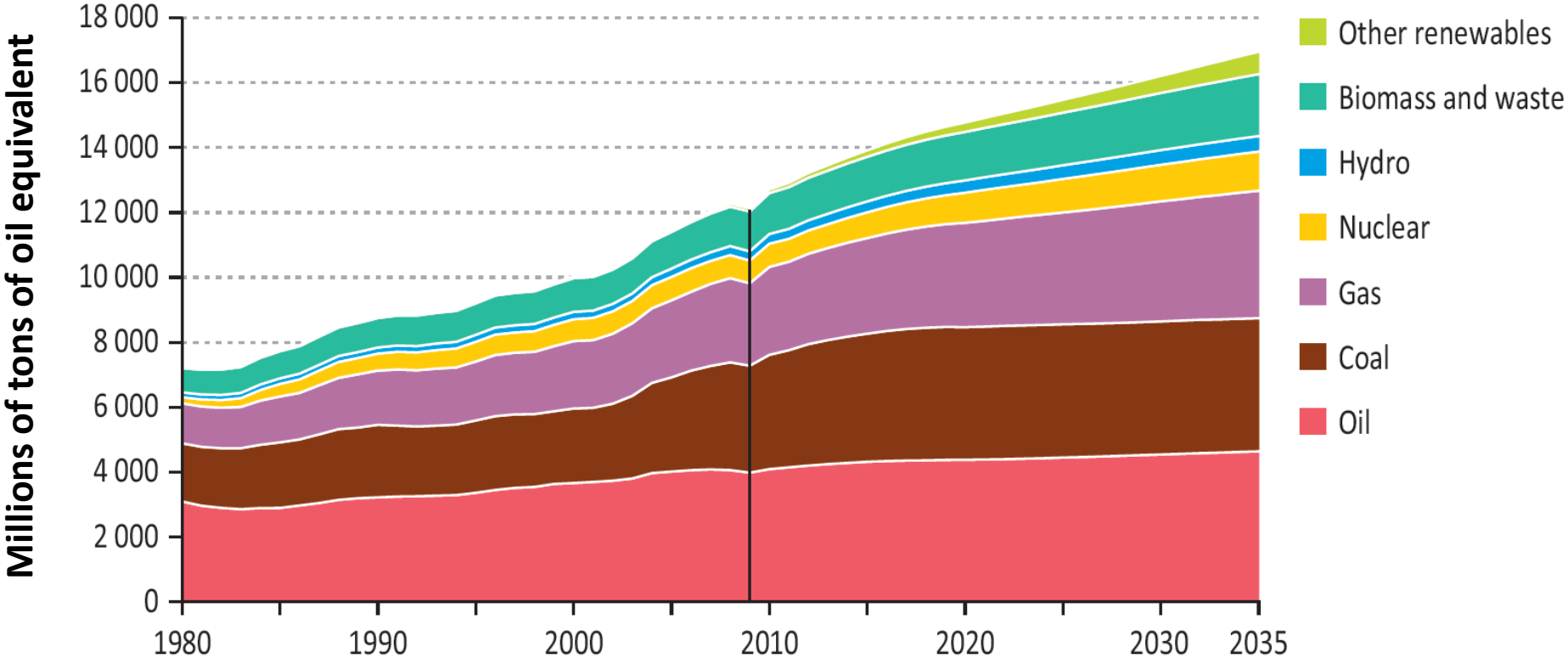
To prevent global average surface temperature from rising more than 2.5 C by 2050 . . .

. . . we must emit less than 1000 GT of CO_2 between 2000–2050 . . .

. . . but our emissions rate from 2000–2010 was 33 GT per year . . .

. . . so we must reduce our emissions by a factor of 8 between 2010-2050!

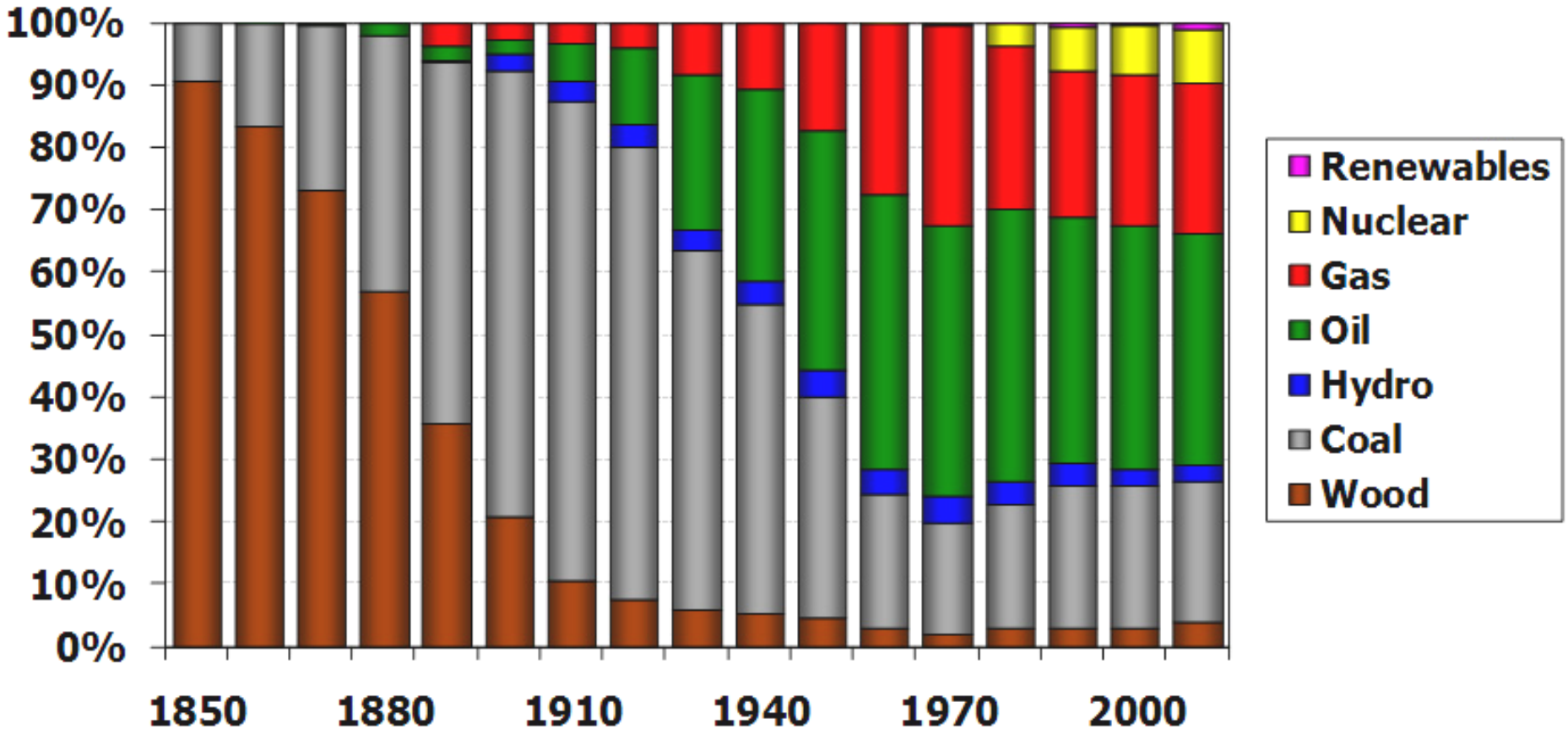
Fossil Fuels Will Continue to Dominate World Energy Supply Under Business as Usual



Source: International Energy Agency World Energy Outlook, 2011 (New Policies Scenario)

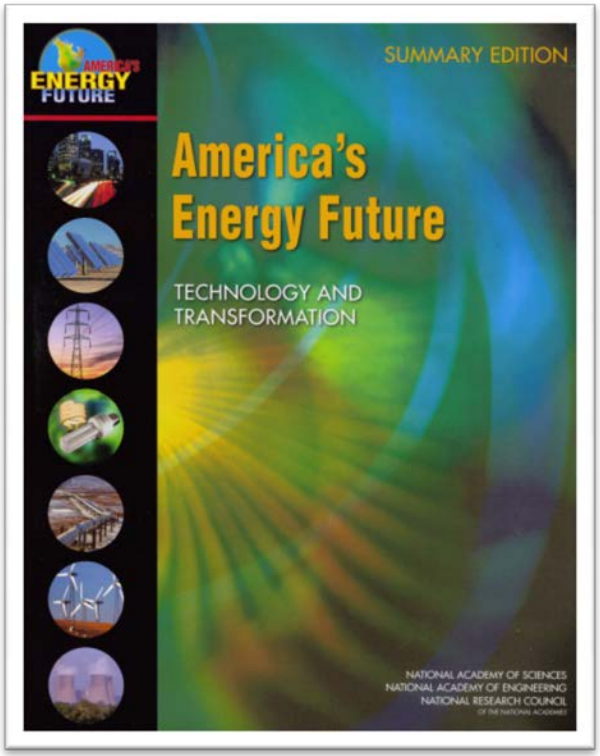
Energy Technologies Change Slowly

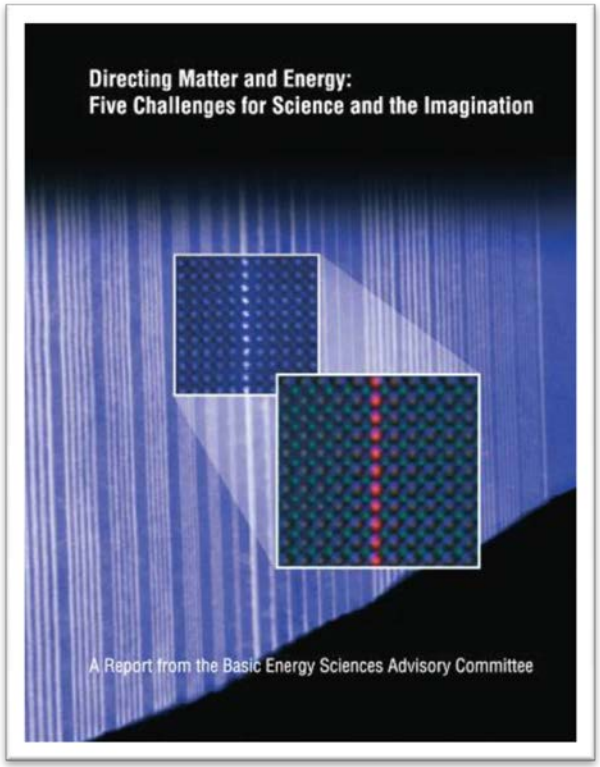
US energy supply since 1850

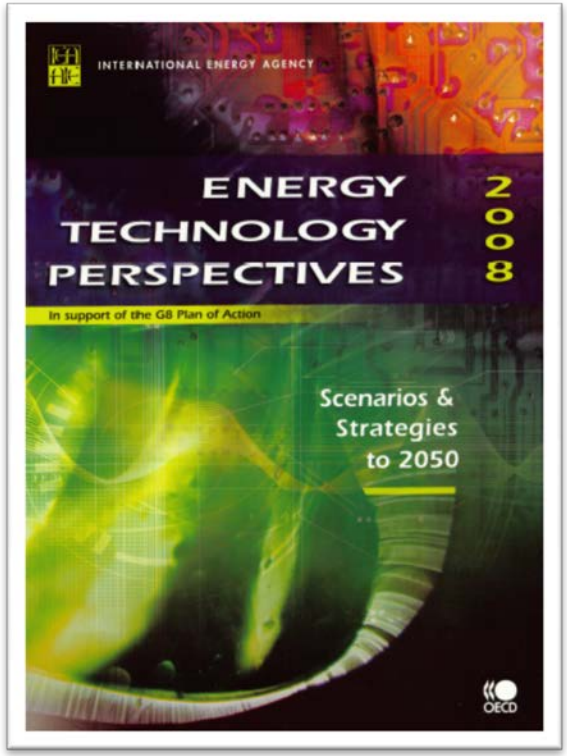


Broad Expert Consensus on the Need for Scientific Research

Scientific and technological advances will be required to make major changes to the energy system

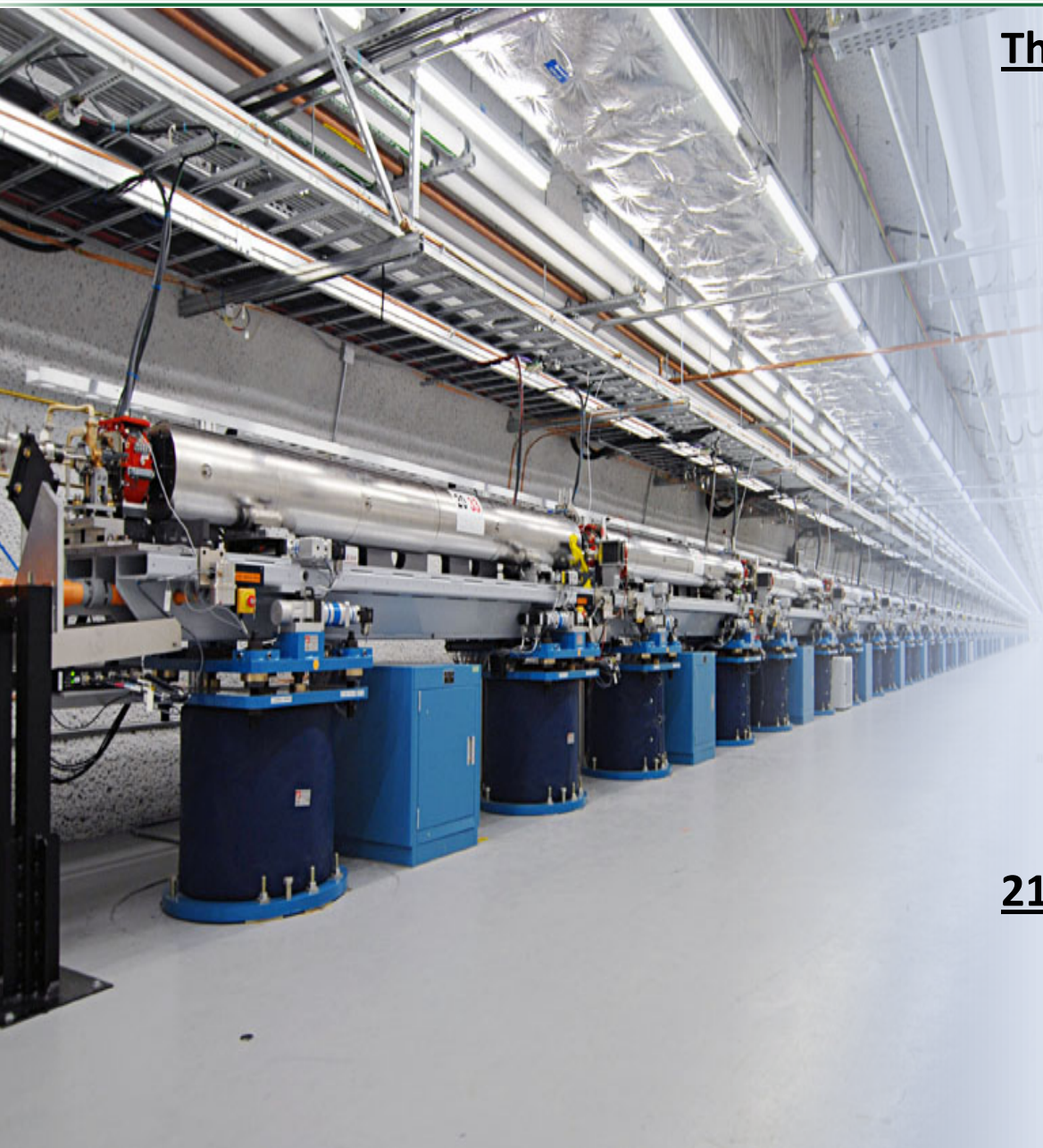






Office of Science

Science to Meet the Nation's Challenges Today and into the 21st Century



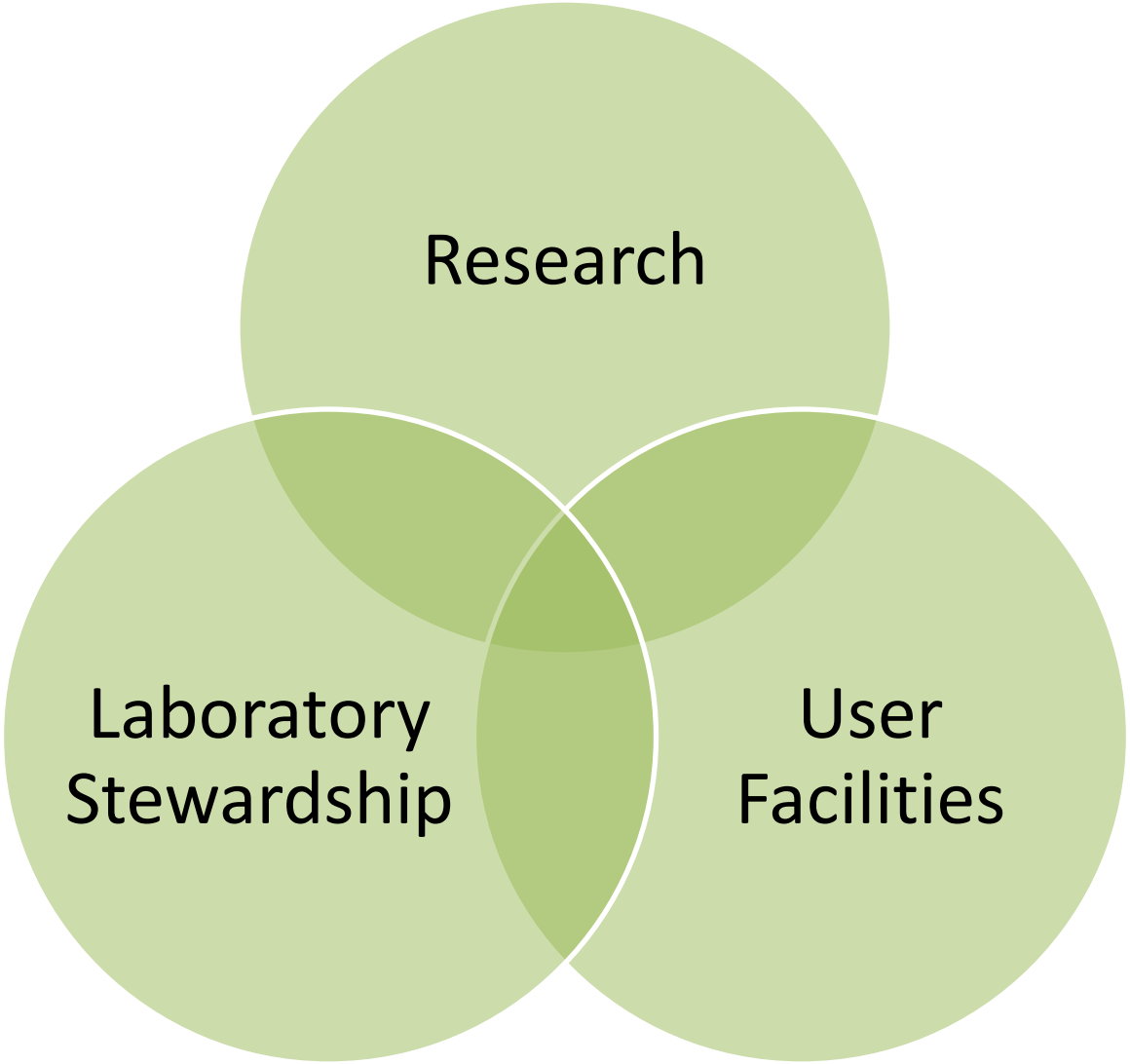
The Frontiers of Science

- Supporting research that led to over **100** Nobel Prizes during the past **6** decades—more than **20** in the past **10** years
- Providing **45%** of Federal support of basic research in the physical and energy related sciences and key components of the Nation's basic research in biology and computing
- Supporting over **25,000** Ph.D. scientists, graduate students, undergraduates, engineers, and support staff at more than **300** institutions

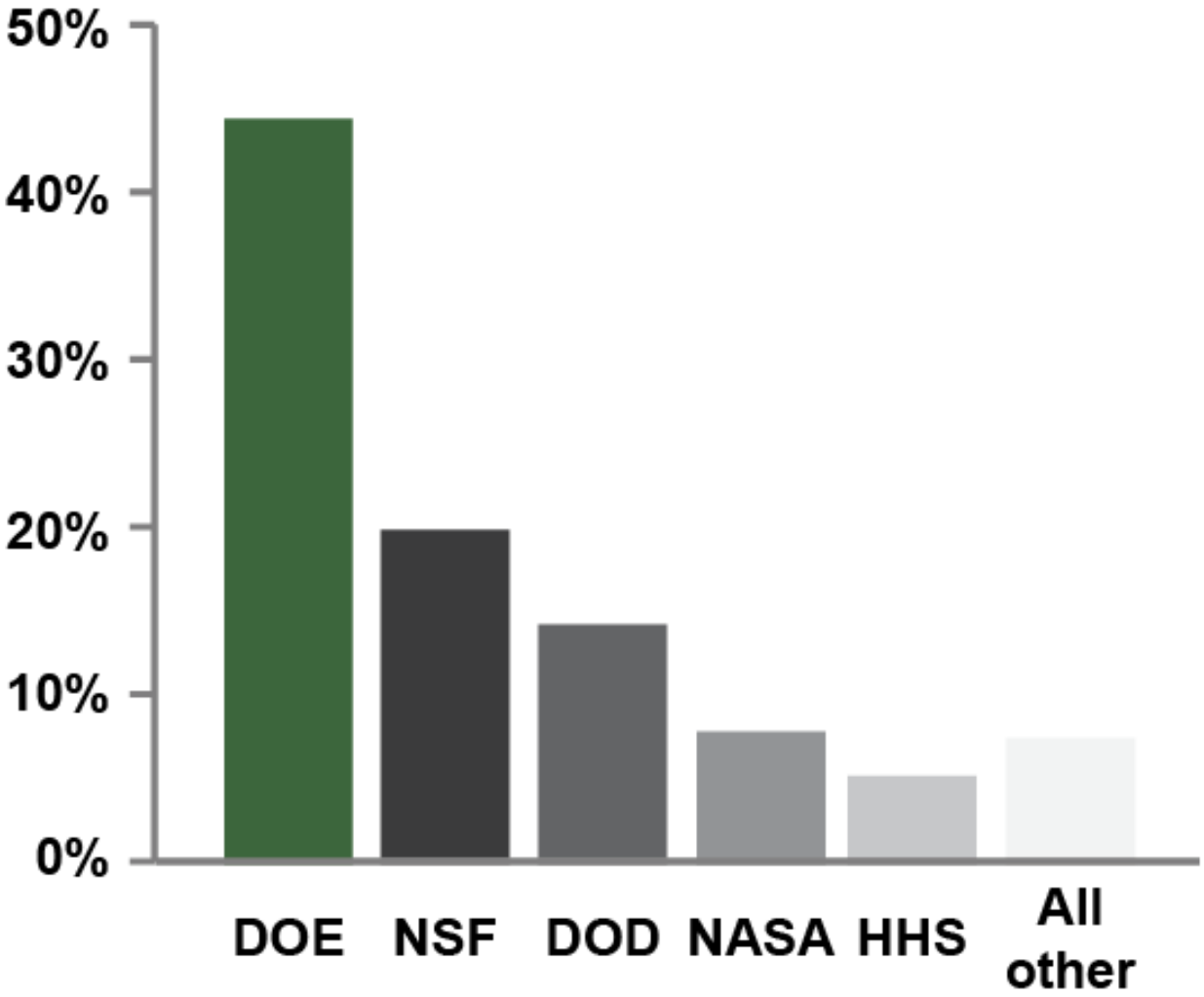
21st Century Tools of Science

- Providing the world's largest collection of scientific user facilities to over **26,500** users each year

The Three Pillars of the Office of Science



DOE is the Largest Federal Supporter of Physical Sciences Research



Source: *NSF Science and Engineering Indicators 2012*

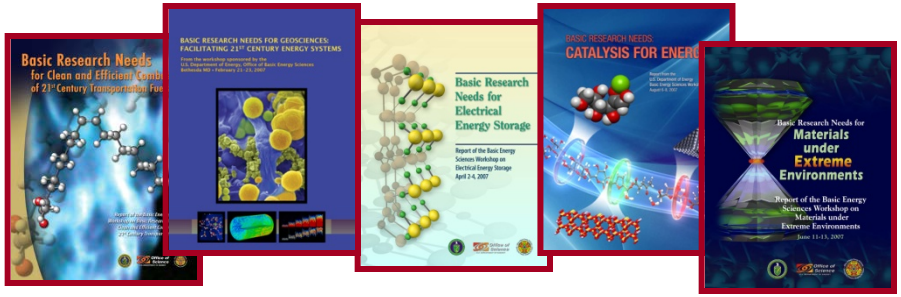
Funding: from scientific needs to appropriations

The Office of Science prioritizes its funding based on:

- **National Priorities**

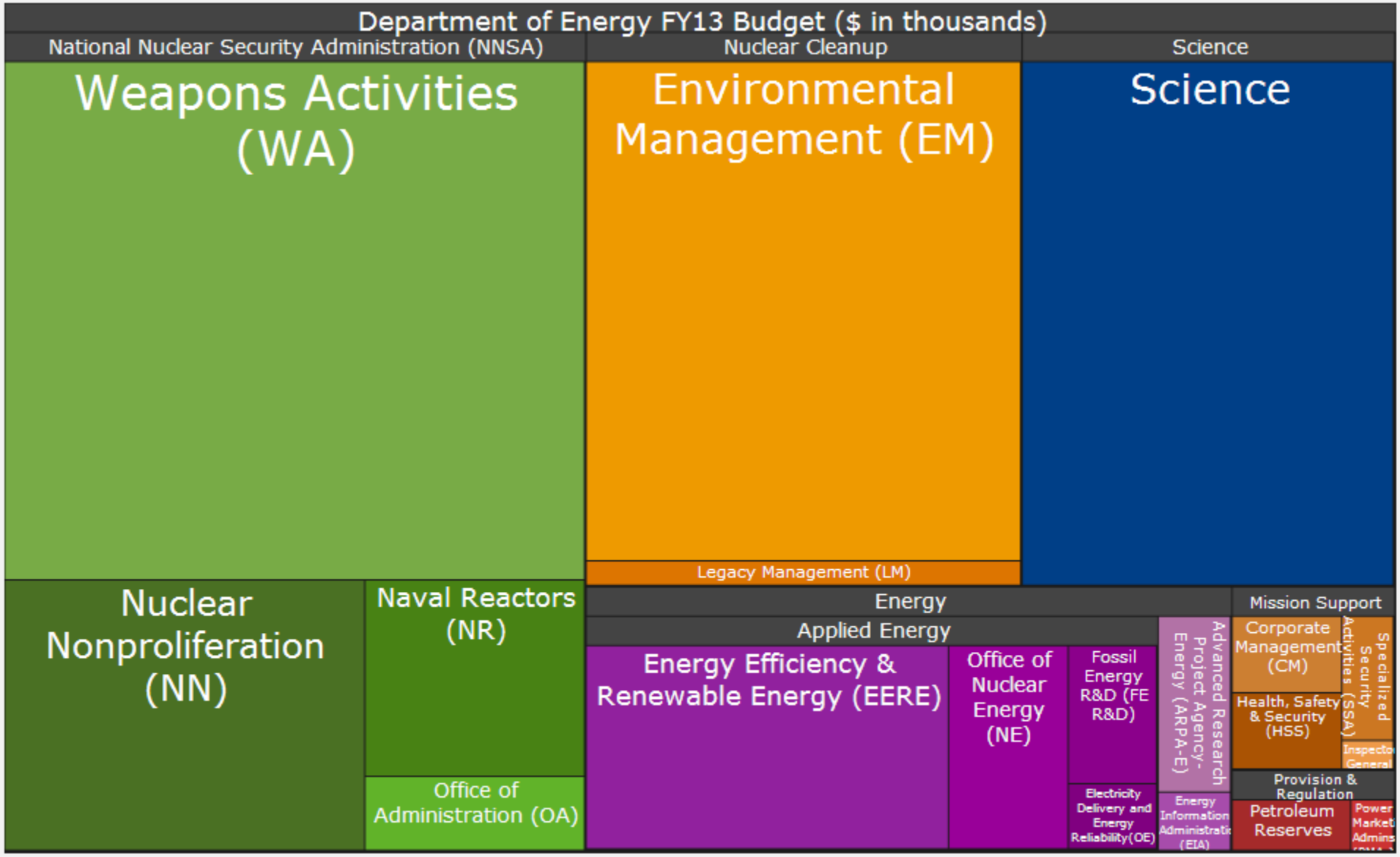
- **DOE Mission Needs**

- **Scientific Advisory Committees**



- **Workshops**

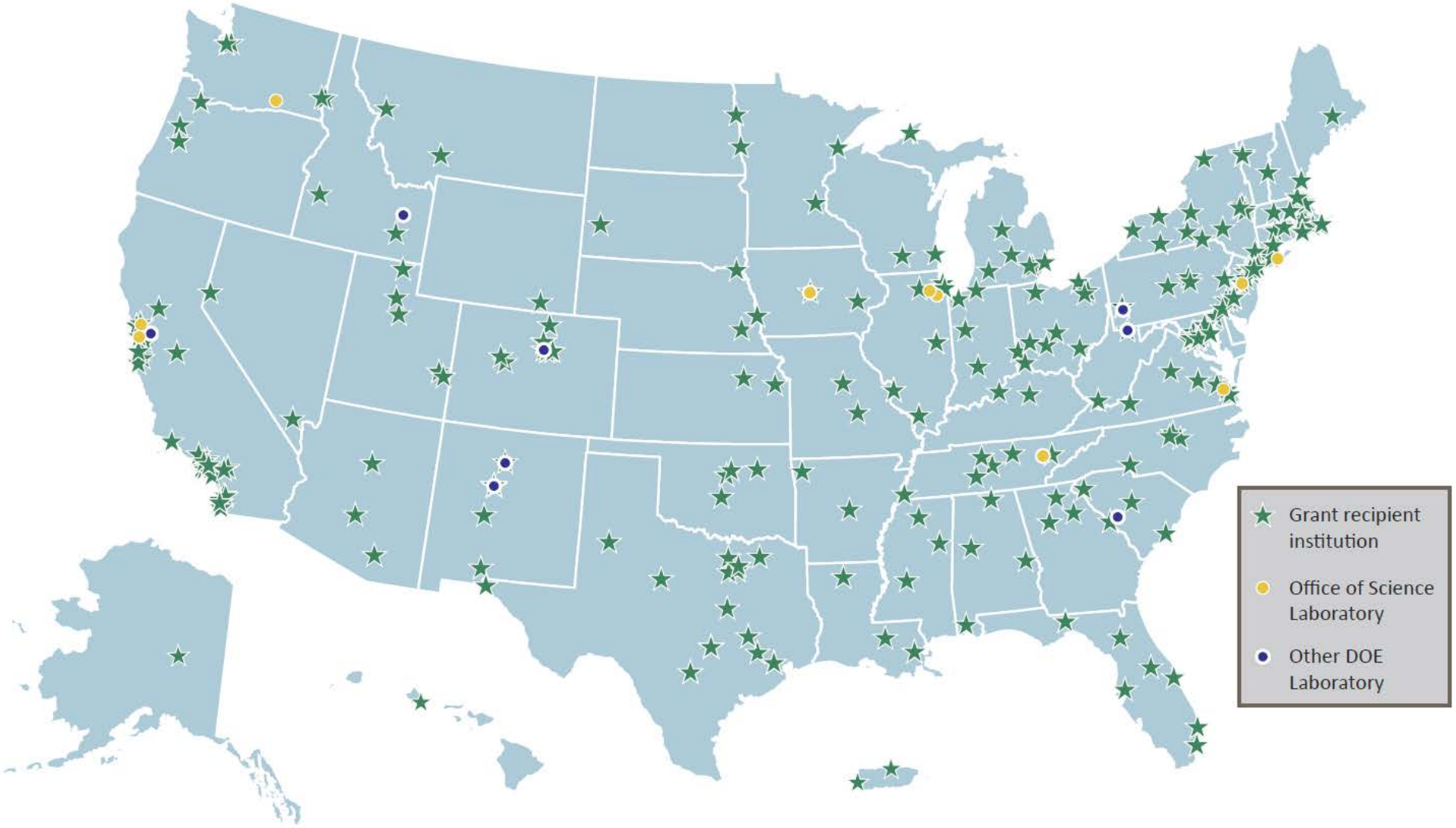
The DOE Portfolio Today: FY 2013 budget request to Congress



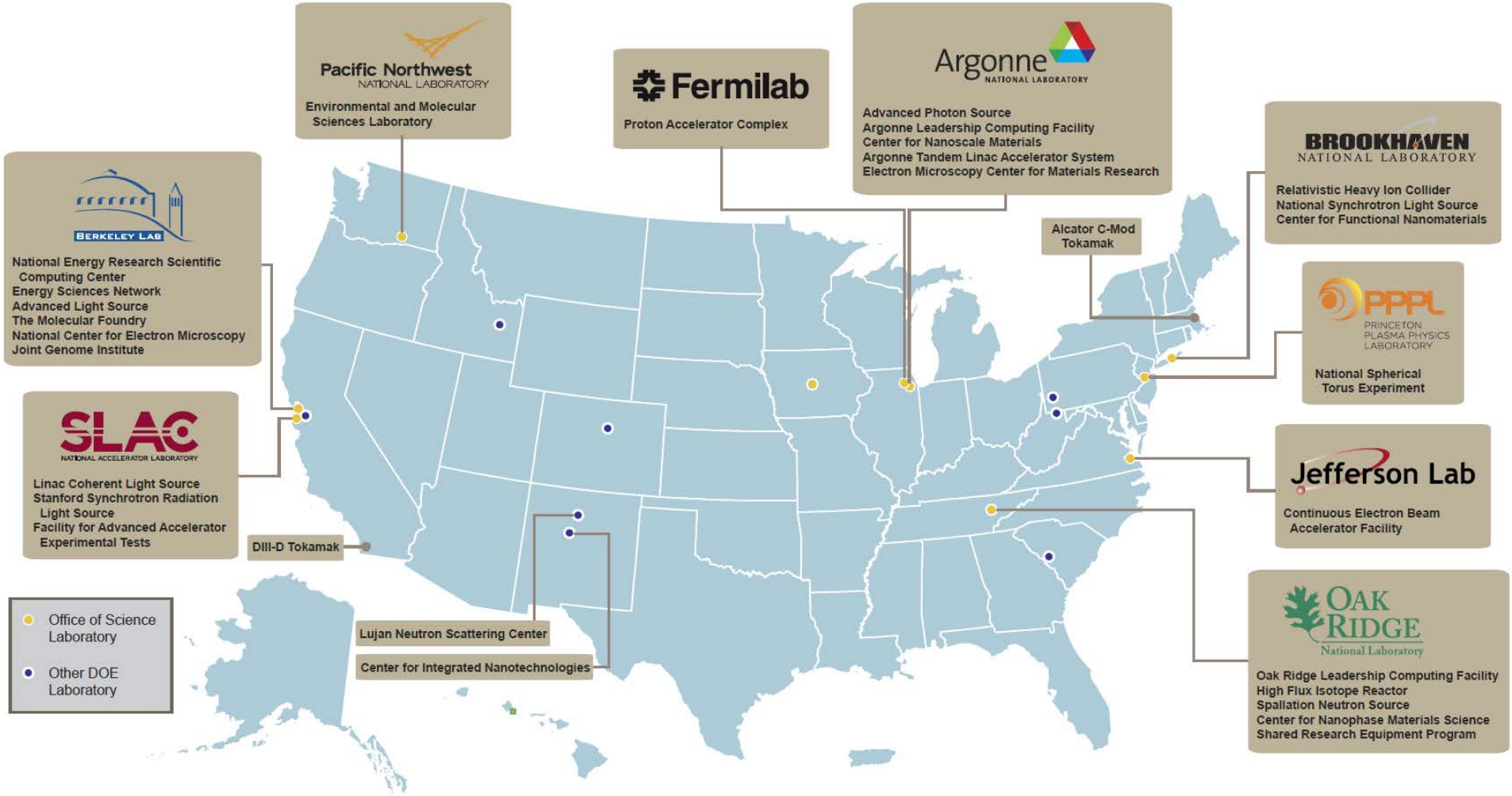
The Office of Science Research Portfolio

Basic Energy Sciences	• **Understanding, predicting, and ultimately controlling matter and energy flow at the electronic, atomic, and molecular levels**
Advanced Scientific Computing Research	• **Delivering world leading computational and networking capabilities to extend the frontiers of science and technology**
Biological and Environmental Research	• **Understanding complex biological, climatic, and environmental systems**
Fusion Energy Sciences	• **Building the scientific foundations for a fusion energy source**
High Energy Physics	• **Understanding how the universe works at its most fundamental level**
Nuclear Physics	• **Discovering, exploring, and understanding all forms of nuclear matter**

FY 2011 Funding Recipient Institutions

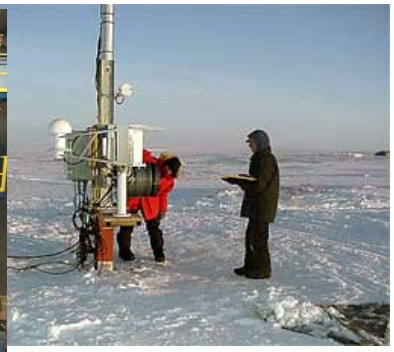


Office of Science Laboratories and User Facilities



Map reflects FY 2012 status. See http://science.energy.gov/user-facilities/ for more information.

Office of Science User Facilities



32 world-leading facilities serving over 26,500 researchers

- **Open access (to U.S. and foreign scientists)**
- **Access and participation determined through merit-based peer reviews of research proposals**
- **Free for non-proprietary work published in the open literature**
- **Full cost recovery for proprietary work**
- **Resources provided for users to conduct research safely and efficiently**

Mechanisms for supporting research

- **Core Research (Grant and National Laboratory)**

  Support single investigator and small group projects to pursue their specific research interests

- **Energy Frontier Research Centers (46)**

  $2-5 M/yr research centers, established in 2009, focus on fundamental research related to energy

- **Energy Innovation Hubs (2 in Basic Energy Sciences)**

  $20 M+/yr research centers focus on integrating basic and applied research with technology development to enable transformational energy innovations

New in FY 2012: Science for Clean Energy

Applications of 21st century science to long-standing barriers in energy technologies: employing nanotechnology, biotechnology, and modeling and simulation. Examples include:

Examples:

- **Materials by design** using nanoscale structures and syntheses for: carbon capture; radiation-resistant and self-healing materials for the nuclear reactor industry; highly efficient photovoltaics; and white-light emitting LEDs.

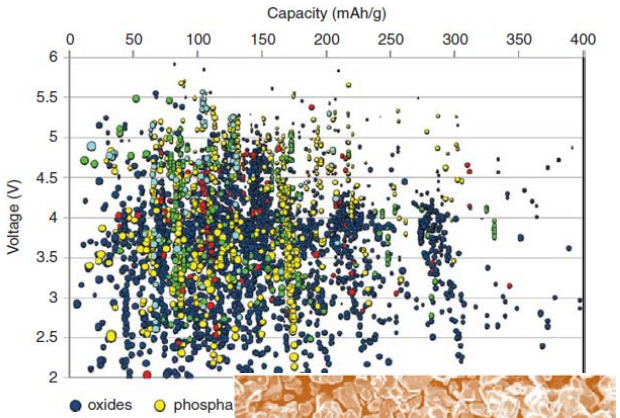
- **Biosystems by design** combining the development of new molecular toolkits with testbeds for the design and construction of improved biological components or new biohybrid systems and processes for improved biofuels and bioproducts.

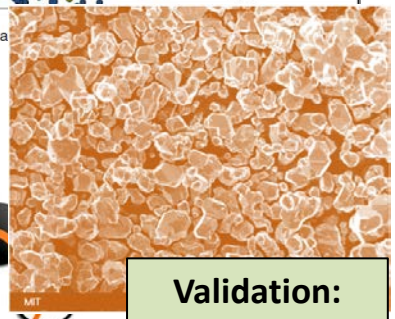
- **Modeling and simulation** to facilitate materials and chemistry by design and to address technology challenges such as the optimization of internal combustion engines using advanced transportation fuels (biofuels).

A Few Highlights

- **Materials by design**
  - Research to establish design rules to launch an era of predictive modeling, changing the paradigm of materials discovery to rational design.
    - New software tools and data standards to catalyze a fully integrated approach from material discovery to applications
  - Discovery of new materials has been the engine driving science frontiers and fueling technology innovations. Research would utilize the powerful suite of tools for materials synthesis, characterization, and simulation at DOE's world-leading user facilities
  - Integrated teams to focus on key scientific knowledge gaps to develop new theoretical models
    - Long-term: realization in reusable and broadly-disseminated software
    - Collection of validated experimental and modeling data for broader community use

Prediction: New battery materials starting from first principles theory





Validation: Materials fabrication

MATERIALS PROJECT

http://materialsproject.org/

End Use: Software on-line for general community use

A Few Highlights

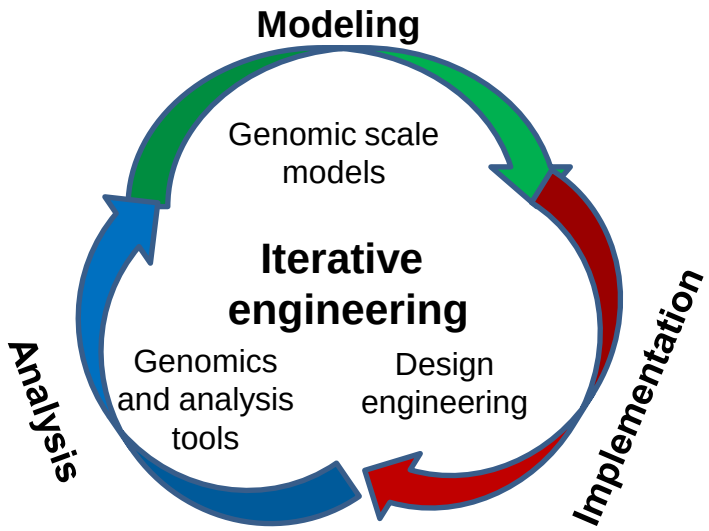
- **Biosystems by design**

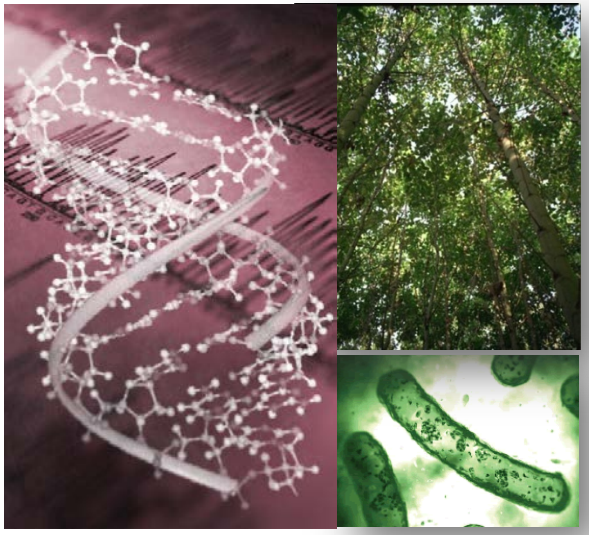
Research to establish biological design rules will enable the predictive design of innovative natural and hybrid systems for clean energy production.

Discovery and synthetic redesign of plant and microbial systems advances science understanding and paves the way for sustainable production of biofuels and bioproducts.

Research areas of emphasis:

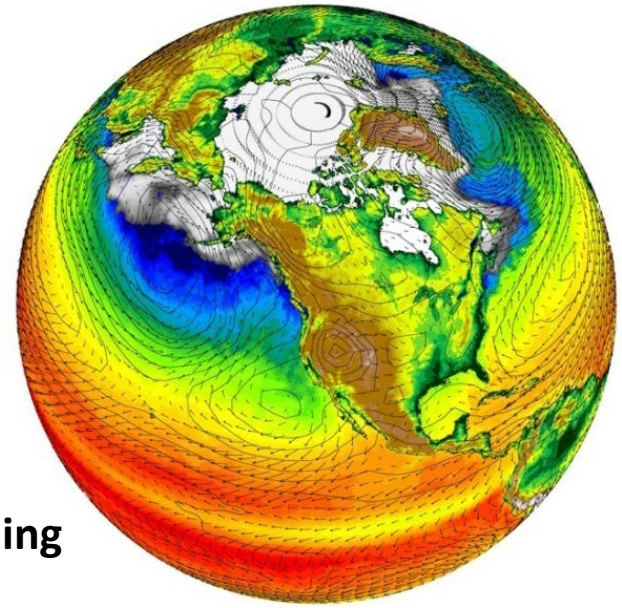
- Biosystems by Design
  - New synthetic biology methods—genome-scale engineering of plants and microbes
  - New genetic toolkits
  - Development of functional modules and platform organisms
  - Predictive integration of components and processes
  - Verify & validate computer-aided design toolkits
  - New testbeds to prototype performance and function





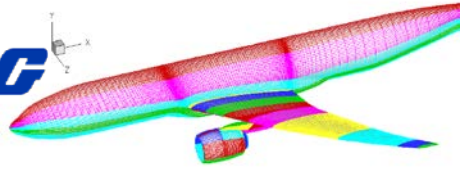
A Few Highlights

- **Modeling and simulation** using SC's Leadership Computing Facilities and production computing facilities to advance materials and chemistry by design and to broadly address energy technology challenges.



Climate and Earth System Modeling

- **GE** determined the effects of unsteady flow interactions between blade rows on the efficiency of turbines.
  - Provided engineers with the analytical tools to extract greater design efficiency and fuel savings.
  - Results provided substantial ROI justification for GE to purchase its own Cray supercomputer



- **Boeing** demonstrated the effectiveness and accuracy of computational fluid dynamics simulation tools and used them in designing their next generation of aircraft.
  - Significantly reduced the need for prototyping and wind tunnel testing.

Advances Through International Collaboration

Advances in science increasingly require greater data sharing, access to research facilities, and larger, more complex, and higher cost experiments. The Office of Science leverages international collaborations by establishing legal frameworks, facilitating scientist mobility, and joining large scale international projects such as ITER and LHC.

ITER site, April, 2012

LHC

To sustainably power the future…

We are delivering the scientific discoveries and scientific tools, today, that advance:

Energy
Leading Basic Research
for a Sustainable Future

Environment
Understanding Climate Change and
Improving the Environment

Innovation
Building Research Infrastructure and
Partnerships that Foster Innovation

Discovery
Unraveling Nature's
Deepest Mysteries