New Approaches to Clean Energy Innovation at DOE

Pathways to Climate Solutions: Assessing Energy Technology and Policy Innovation Workshop

February 25th, 2014

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Deputy Under Secretary
Office of the Under Secretary for Science & Energy
The Office of the Under Secretary for Science and Energy

- Science and Energy-Core Focus Areas
  - Energy and science program integration and technology transfer
  - Innovating lab functions and integration with programs – improving the relationship: expectations, roles, authorities, and accountabilities
  - Improving lab management
The DOE Science and Energy Enterprise

HQ
- Policy
- Budget
- Administration
- Oversight
- Stakeholder Engagement

Programs
- Implementation
- Lab Ops/Stewardship/Field
- Stakeholder Engagement
- Impacts

S4

S& E Labs
- Mission
- S&T Infrastructure
- RDD&D
- Users and Partners
- Links to Economy
- Stakeholder Engagement
- Impacts
The Department of Energy Lab Complex

- Pacific Northwest National Laboratory
- National Energy Technology Laboratory
- Lawrence Berkeley National Laboratory
- SLAC National Accelerator Laboratory
- Lawrence Livermore National Laboratory
- Sandia National Laboratories
- Los Alamos National Laboratory
- Pantex Plant
- Office of Science
- NNSA
- Energy
- National Renewable Energy Laboratory
- Kansas City Plant
- Ames Laboratory
- Argonne National Laboratory
- Fermi National Accelerator Laboratory
- National Energy Technology Laboratory
- Brookhaven National Laboratory
- Princeton Plasma Physics Laboratory
- Thomas Jefferson National Accelerator Facility
- Oak Ridge National Laboratory
- Savannah River National Laboratory
- Y-12 National Security Complex
- Environmental Management
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<th>Laboratory</th>
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<th>Postdocs</th>
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Energy Innovation Hubs

• History: An initiative of former Secretary Chu, Hubs address research challenges that have been resistant to solution by conventional R&D management structures.

• Establishment of Hubs: Proposed throughout the period FY 2010-FY 2014 for initial 5-year terms with the following characteristics:
  – a lead institution with strong scientific leadership;
  – a central location;
  – if geographically distributed, state-of-the-art telepresence technology to enable long distance collaboration;
  – a strong organization and management plan to effect goals.
Five DOE Energy Innovation Hubs

- Fuels from Sunlight
- Nuclear Modeling and Simulation
- Energy Efficient Buildings
- Batteries and Energy Storage
- Critical Materials
A2e is a new, multi-year, multi-stakeholder DOE R&D initiative tasked with improving wind plant performance, mitigating risk and uncertainty to achieve substantial reductions in the cost of wind energy.
Tech Teams: A new crosscutting paradigm

- Tech Teams are composed of staff throughout DOE’s program offices tasked with identifying an overarching, techno-economic goal (e.g. Sunshot)
- Varying degrees of structure but all provide value in convening technical experts from across the Department
- Collaboration on a variety of products:
  - Strategy documents (e.g. Water-Energy Program Plan, Energy Storage Strategy)
  - Workshops (e.g. Grand Challenges of Advanced Computing for Energy Innovation in 2012)
6 Tech Teams Formed Around Key Secretarial Priorities

- Advanced Computing
- Grid
- Manufacturing
- Subsurface
- Supercritical CO$_2$
- Water-Energy
Tech Teams Enable Higher Impact Solutions

- Information Exchange
- Collaborative Roadmapping / Workshop Development
- Program Coordinated FOAs / Investments
- Crosscutting Budget Proposals

Implementation Challenges vs. Potential Impact Diagram:
- Low vs. High Implementation Challenges
- Low vs. High Potential Impact

- Information Exchange (Low, Low)
- Collaborative Roadmapping / Workshop Development (High, Low)
- Program Coordinated FOAs / Investments (Medium, Medium)
- Crosscutting Budget Proposals (High, High)
Advanced Computing Tech Team

- **Objective:**
  - Support the next generation of high fidelity, multi-scale, multi-physics modeling and simulation tools that incorporate the underlying physics & phenomenology of large multi-array wind plants

- Implemented a New DOE Initiative: “Atmosphere to Electrons” Addressing Wind Plant Optimization

- Formulating an International Team of HPC Experts to Develop Integrated Multi-Year Program Addressing Multi-Scale, Multi-Physics Challenges

- Establishing Collaborative with ASCR, DOE/SC, NOAA, National Laboratories, Universities, OEMs, Open Source Development Exploiting Peta- and Exascale Computational Resources

- Coordinated Experimental Campaigns
Grid Tech Team

• The GTT is a DOE inter-office work group established in April 2011 by the Undersecretary of Energy to:
  – Coordinate and leverage DOE grid resources and activities
  – Identify pathways to enable grid modernization
  – Develop a long-term strategic vision of the U.S. electricity grid

_value to the DOE_

• Holistic systems perspective
• Align internal grid activities
• Minimize duplication of effort
• Optimize the use of funding
• Effective collaboration
  • forum to convene stakeholders
  • coordinated internal/external interactions
Grid Tech Team’s Holistic Approach: technologies, markets, and policies

- Changes to the grid require an intricate balance of technologies, markets, and policies
- When finding solutions to grid challenges, all aspects need to be considered simultaneously

**The Grid**

- **Policies**
  - state RPS,
  - federal CES,
  - FERC, PUCs,
  - environmental regulations,
  - siting, etc.

- **Markets**
  - business models,
  - cost allocation,
  - wholesale power trading, utilities, vendors, etc.

- **Technologies**
  - generation, infrastructure,
  - smart grid, electric vehicles,
  - storage, etc.
Subsurface energy sources including coal satisfy over 80% of total U.S. energy needs

Potential for increases in domestic gas and oil supplies, as well as 100+ GWe of geothermal energy

The subsurface is a vast storage reservoir for CO2, hazardous materials, and other energy waste streams

The subsurface can also serve as a reservoir for energy storage

Primary Energy Use by Source, 2012 (EIA)
Quadrillion Btu and percent

Total U.S. = 95.1 Quadrillion Btu
Discovering, Characterizing, and Predicting
Efficiently and accurately locate target geophysical and geochemical responses, finding more viable and low-risk resource, and quantitatively infer their evolution under future engineered conditions

Accessing
Safe and cost-effective drilling, with reservoir integrity

Engineering
Create/construct desired subsurface conditions in challenging high-pressure/high-temperature environments

Sustaining
Maintain optimal subsurface conditions over multi-decadal or longer time frames through complex system evolution

Monitoring
Improve observational methods and advance understanding of multi-scale complexities through system lifetimes
Supercritical CO$_2$ Tech Team

Comparison

• Rankine efficiency is 33%
• Supercritical CO$_2$ (sCO$_2$) potential to surpass 40% efficiency
• Greatly reduced cost for sCO$_2$ compared to the cost of conventional steam Rankine cycle
• sCO$_2$ compact turbo machinery is easily scalable

20 meter Steam Turbine (300 MWe) (Rankine Cycle)

1 meter sCO$_2$ (300 MWe) (Brayton Cycle)
Water-Energy Tech Team: Exploring the Water-Energy Nexus
Water-Energy Tech Team’s Strategic Focus

• Water for energy: Optimize the freshwater efficiency of energy production and electricity generation

• Energy for water: Optimize the energy efficiency of water treatment and distribution systems

• Enhance the reliability and resilience of energy and water systems

• Increase productive use of nontraditional water sources

• Facilitate responsible energy operations with respect to water quality and seismic impacts

• Exploit productive synergies among water and energy systems
Clean Energy Manufacturing Tech Team

1. Increase U.S. competitiveness in the production of clean energy products

   - Products that generate clean energy
   - Products that save energy and increase efficiency

2. Increase U.S. manufacturing competitiveness across the board by increasing energy productivity and use of clean and low-cost fuels and feedstocks

   - Advanced Manufacturing Technologies
   - Industrial Energy Efficiency
   - Combined Heat & Power
   - Low-Cost Natural Gas
National Network for Manufacturing Innovation

A network of “Manufacturing Innovation Institutes”

- $70-$120M investments, matched by applicant
- Shared use facility, applied research, education and workforce development
- Academic, Industrial, Governmental members

Pilot Institute
National Additive Manufacturing Innovation Institute

- $40M investment from USG, $20M from Industry
- Center in Youngstown OH, housing several state-of-the-art industrial additive manufacturing tools
- Consortium of public and private sector stakeholders

EERE’s Next Generation Power Electronics Manufacturing Institute
Wide Bandgap Semiconductor Device Manufacturing

- $70M investment, matched by applicant
- Facility will focus on manufacturing devices
- Applications: Solar inverters, motor drives, grid integration
BACKUP
Tech Team Departmental Representation

Science & Energy Programs
• EERE, FE, IE, NE, OE, SC

Bridging Valleys
• ARPA-E, LPO

Policy Systems & Data
• EPSA, EIA

Budget Discipline
• CFO

External Engagement
• CI, IA

Where relevant, other programs such as
• EM, NNSA
Energy Frontier Research Centers (EFRCs)
Office of Science/Basic Energy Sciences (SC/BES)

- History: 12 community workshops with 1,500 participants describing “basic research needs” for energy applications and “grand-challenge science”

- Establishment of EFRCs:
  - $2-5M each for a 5-year term; size about right for multiple investigators.
  - Couple “grand challenge science” with research needs from any of the energy workshops.
  - Multiple investigators to enable significant scope and complexity.
  - Strong central management to shift resources among investigators as needed.
46 Energy Frontier Research Centers were Awarded in 2009

- $155M/yr ($100M/yr from BES; $55M/yr from Recovery Act);
- ~850 senior investigators
- ~2,000 students, postdoctoral fellows, and technical staff
- ~115 institutions
- >260 scientific advisory board members from 13 countries and >40 companies