

Institute for Nuclear Energy Science and Technology

### Nuclear Hybrid Energy Systems

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# CORE MISSION

- Develop novel approach(es) and enabling technologies that advance U.S. clean energy objectives through expanded deployment of nuclear energy systems
  - Enable efficient, stable renewable energy deployment
  - Enable conversion of fossil & biomass carbon to energy commodities (e.g. transportation fuels)
  - Enable deployment of nuclear energy beyond baseload electricity
  - Enable system flexibility to accommodate transition in energy product consumption (e.g. transition from liquid hydrocarbons to electricity for transportation)
- Outcome: Impact & leadership to advance deployment of advanced hybrid systems
  - o Influence federal RDD investments / advance value proposition for nuclear
  - o Assist industry
  - Develop capability (talent + infrastructure + programs)

### CORE VISION

- Nuclear hybrid systems deployed and demonstrably advancing US energy security objectives
- DOE partnership to advance integrated systems approach (NE+EERE+FE+OE partnership)
  - Driver / enabler for focused, well supported advanced reactor program
  - Enabling R&D (controls, H2 processes, etc)
  - Non-nuclear hybrids

- International partnership in research / demonstration
- DOE-NE program focused on integrated nuclear energy systems
- Attractor for new talent for INL/Universities

CURRENT STATE						
Co-Gen, CHP Loosely coupled syster	Biomass-Coal, Biomass-Cenerat Poly product, i.e.	ion electricity Solar-Coal, N Wind-Coal, N Single product, i Single product, i	Nind-Ou Nind-O	Coan Gas Nuclear Gas Nuclear Products Nultiple Products Nultiple Products Nultiple Products Intermittent Renewable Intermittent Renewable		
<ul> <li>✓ Thermodynami c efficiency</li> <li>✓ Byproduct management</li> </ul>	<ul> <li>✓ GHG mitigation</li> <li>✓ Conversion efficiency</li> <li>✓ Improved financial performance</li> </ul>	<ul> <li>✓ Significant GHG mitigation</li> <li>✓ Capital lifetime extension</li> <li>✓ Resource extension</li> </ul>	<ul> <li>✓ Grid stabil</li> <li>✓ Efficient In renewables</li> <li>✓ GHG mitig</li> <li>✓ Resource of Energy con optimization</li> </ul>	lity ntegration of ation optimization nversion		

✓ Foreign source

mitigation/price stability

Attributes

# **OPPORTUNITIES**

(Including funding opportunities)

### Near-Term

- Industry engagement (GE, B&W, AREVA, others)
- International cooperation, e.g. DOE-CAS
- DOE-NE project (problematic but desirable)
- Non-nuclear hybrid funding (fossil-bio hybrids) advanced nuclear hybrid value proposition
- University-national laboratory (multi-laboratory?) collaboration
- DARPA (including enabling technology, e.g. grid management, etc)

### Long–Term

- Hybrid program in DOE– NE/EERE/FE
- Phased deployment of testing and demonstration infrastructure
  - Component testing, sub-system testing, pilot scale
  - International partnership in demonstration / Industry involvement

# CAPABILITIES

### ► INL

- Collection of LDRD focused on development of design/analysis computational suite
- Leverage additional grid / control systems LDRD suite
- High temperature H2 program
- Facilities for thermal, and electrical heating systems testing and demonstration (non-nuclear related work)
- Facility for systems reactions dynamics testing and demo
- New Energy Systems Laboratory
- Consistent infrastructure development plan to accommodate testing / demo

- University (include all universities—NUC and others)
- Reactor design and analysis
- Methods development
- Enabling RDD, e.g. advanced controls, materials, life-cycle analyses
- Advanced concepts R&D

# COMPETITORS / COLLABORATORS

- Private Sector (collaborators)
  - Reactor vendors
  - Energy equipment suppliers (non-nuclear)
- International (collaborators)

- CAS
- Interest from others
- National Laboratories
  - NREL (competitor / collaborator?)
  - SRNL
  - Sandia

# FY 2011 GOALS AND OBJECTIVES

- LDRD call released / projects funded in January
- Workshop early December

• DOE engagement

# FY 2011 ACCOMPLISHMENTS

- Concept developed / accepted
- Steering Committee established

- First steering committee meeting (spring 2011)
- Strategic plan draft
- Significant progress in non-CORE LDRD, partnerships, etc

### STEERING COMMITTEE (USA)

- Daniel M. Kammen
  - World Bank
- Bruce E. Dale
  - Michigan State University
- James Bartis
  - RAND Corporation
- Charles Forsberg
  - Massachusetts Institute of Technology
- Steven E. Aumeier
  - Idaho National Laboratory

### STEERING COMMITTEE (INTERNATIONAL)

- > Zhiyuan Zhu
  - Chinese Academy of Sciences
- Michel Lecomte
  - AREVA

### FY 2011 CORE FUNDING

	Allocation	How Used
CORE Management	30K	
LDRD	N/A	
Program Development	N/A	
University Contract	N/A	

#### **\*\*No-2011 Funds\*\***

### UNIVERSITY CONTRIBUTIONS

- As this is a new start, the only CORE funds expended by universities thus far supported the Steering Committee meeting
- Non-CORE, but related, LDRD at MIT

### FY 2012 GOALS AND OBJECTIVES

- Mid year FY12 and FY13 LDRD call
  - FY2012 mid year to focus on architecture design, economical analyses, and lifecycle assessments and related methods

#### • R&D workshop

- o Socialize concepts / approach
- Better define RD&D challenges and opportunities

#### • Partnership development

- o US / international
- Leverage / inform potential sponsors / deployers
- o Industry / congressional engagement plan

# FY 2013/2014 GOALS AND OBJECTIVES

- LDRD focused on:
  - Development of tools / techniques to help industry understand if/when/to what extend hybridization makes sense
  - Tools / techniques to operate integrated systems
  - Enabling technology R&D, e.g. interface engineering, advanced controls, materials, H2 systems, reactor simulator, etc
- Technology gap assessment and roadmap

- Implications for reactor design and control?
- Partnership(s) to engage DOE re program based on data to date (mid-late FY2012)
- Development and use of infrastructure for testing / demonstration of components, subsystems, enabling technologies

### NEEDS

#### Industry Engagement / Partnership – International Partnership – Value Proposition for NE/EERE -- Program



Monitoring & Control

#### **Nuclear Energy Technology**

### **RISKS AND RISK MANAGEMENT**

Complexity / dimensions of NHES

- Focus on development of tools & techniques that will define the value proposition
- Clearly defined roadmap / technology gaps
- DOE Stovepipes
  - Industry / international / lab / university partnership
  - Clear engagement plan
- Fiscal direction of DOE
  - .... Good luck !

- Leverage non-nuclear hybrid interest
- Congressional engagement plan

### **MEASURES OF SUCCESS**

- Funded partnerships / program that advance the value proposition for advanced nuclear energy RDD
- Peer-reviewed publications of impact
- Student interest / activities (degrees sponsored, etc)
- International interest / engagements
- Industry engagement (nuclear and non-nuclear)
- Curricula impact / benefit
- New staff / post doctoral appointees



#### A new way to view nuclear energy and energy security.



Transportation Fuels, Electricity and Process Heat