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Nuclear Energy University Programs (NEUP) Fiscal Year (FY) 2013 Annual Planning Webinar

Advanced Fuels (FC-2)

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Presentation

- Overview of Fuel Cycle Technologies Mission and Role in Integrated System
- Overview of Advanced Fuel Cycle Program Structure
- Roadmap driven Long-Term Overview for Metal Fuels Area
- Rationale for Advanced LWR Fuels with Enhanced Accident Tolerance
- R&D Strategy for Enhanced Accident Tolerant Fuels
- Items of Priority Interest for Advanced Fuels FY 2013 NEUP
- Examples and References for NEUP Advanced Fuels Research

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Fuel Cycle Technologies (FCT) - Mission

Ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions.

DOE

Goal 3: Secure Our Nation

- Enhance nuclear security through defense, nonproliferation, and environmental efforts.

Advance nuclear power as a resource capable of making major contributions in meeting the Nation's energy supply, environmental, and energy security needs by resolving technical, cost, safety, security and regulatory issues through research, development, and demonstration.

NE

Develop sustainable fuel cycles and Used Fuel waste management strategies that improve resource utilization, minimize waste generation, improve safety and limit proliferation risk.

FCT

http://energy.gov/sites/prod/files/2011_DOE_Strategic_Plan_.pdf
http://www.ne.doe.gov/pdfFiles/NuclearEnergy_Roadmap_Final.pdf

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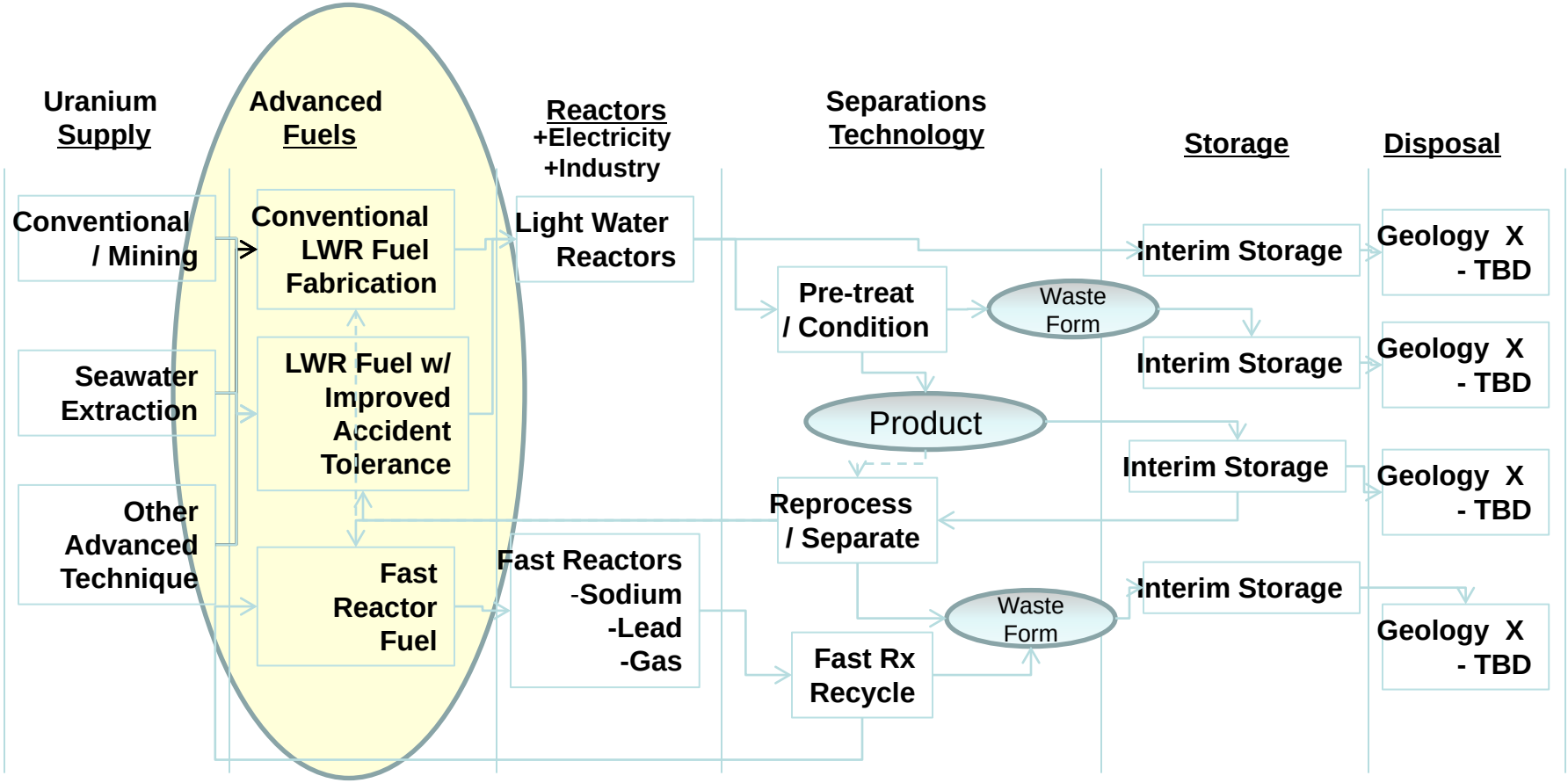
Fuels R&D is Part of an Integrated System



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Revised AFC Structure

Next generation LWR fuels with enhanced performance and safety and reduced waste generation

Metallic transmutation fuels with enhanced proliferation resistance and resource utilization

Crosscutting Capability Development supporting the Science-based Approach to Fuels RD&D
-Advanced characterization and PIE techniques
-Advanced in-pile instrumentation
-Irradiation testing (steady-state & transient)
-Fuel performance modeling
-Analytic techniques

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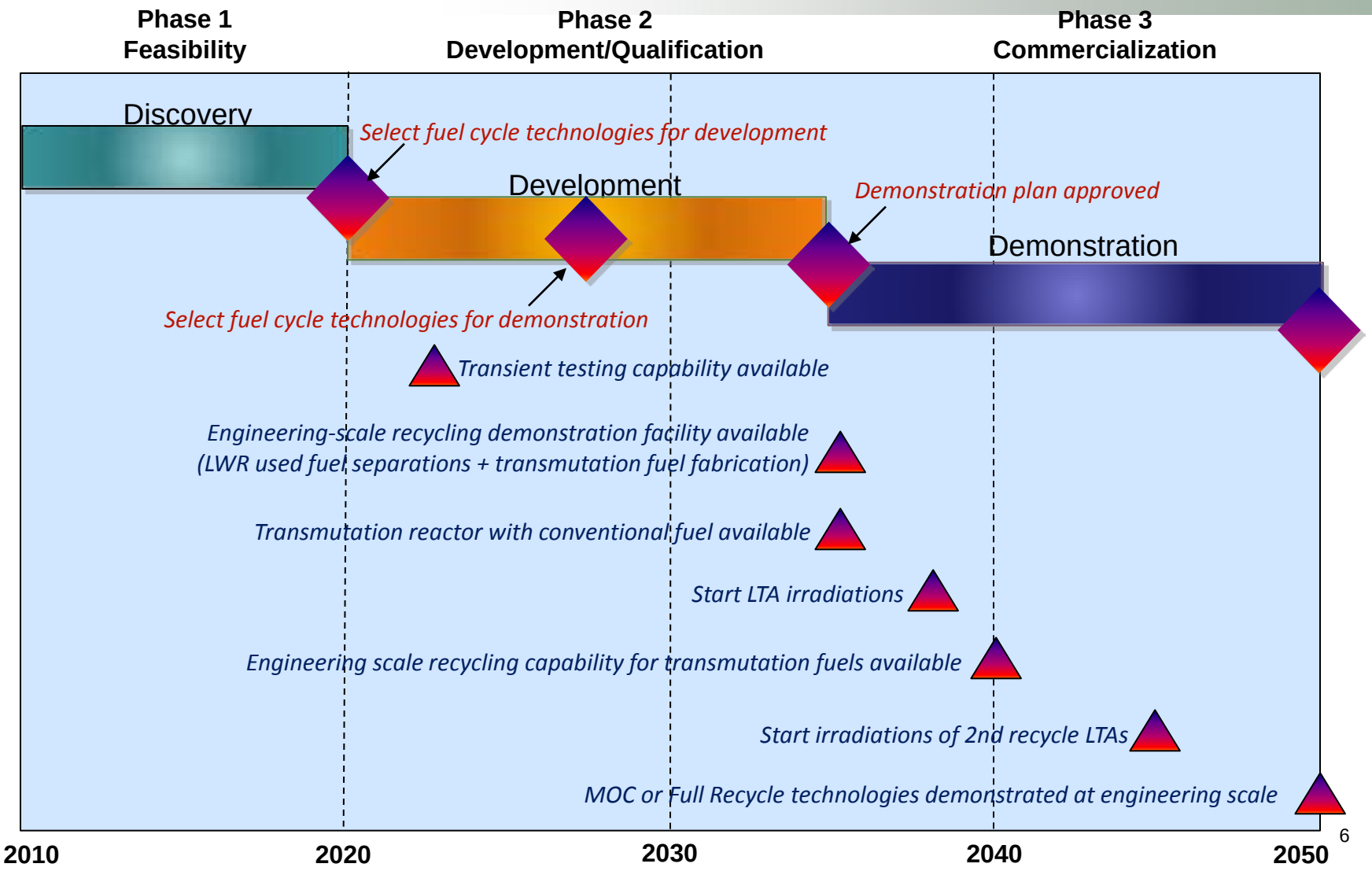
Full-Recycle for Metallic Fuels RD&D - long term Roadmap driven



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Advanced LWR Fuels with Enhanced Accident Tolerance

Vision

LWR fleet using fuels with enhanced accident tolerance to provide a substantial fraction of the nation's clean energy

Mission

Develop the next generation of LWR fuels with improved performance, reliability and safety characteristics during normal operations and accident conditions while minimizing waste generation

Must be acceptable to vendors/utilities

- ***Better safety performance (e.g. during normal, design-basis accidents and beyond design-basis accidents)***
- ***Reliability and fuel configurations similar to current fleet***
- ***Acceptable economics***
- ***Favorable neutronics and licensing characteristics***

10-year Goal

Insert a LTA/LTR into an operating commercial reactor

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Definition and Challenge For Fuels With Enhanced Accident Tolerance

Definition of Fuels with Enhanced Accident Tolerance

Fuels with enhanced accident tolerance are those that, in comparison with the standard UO_2 – Zircaloy system currently used by the nuclear industry, can tolerate loss of active cooling in the reactor core for a considerably longer time period (depending on the LWR system and accident scenario) while maintaining or improving the fuel performance during normal operations, operational transients, as well as design-basis and beyond design-basis events.

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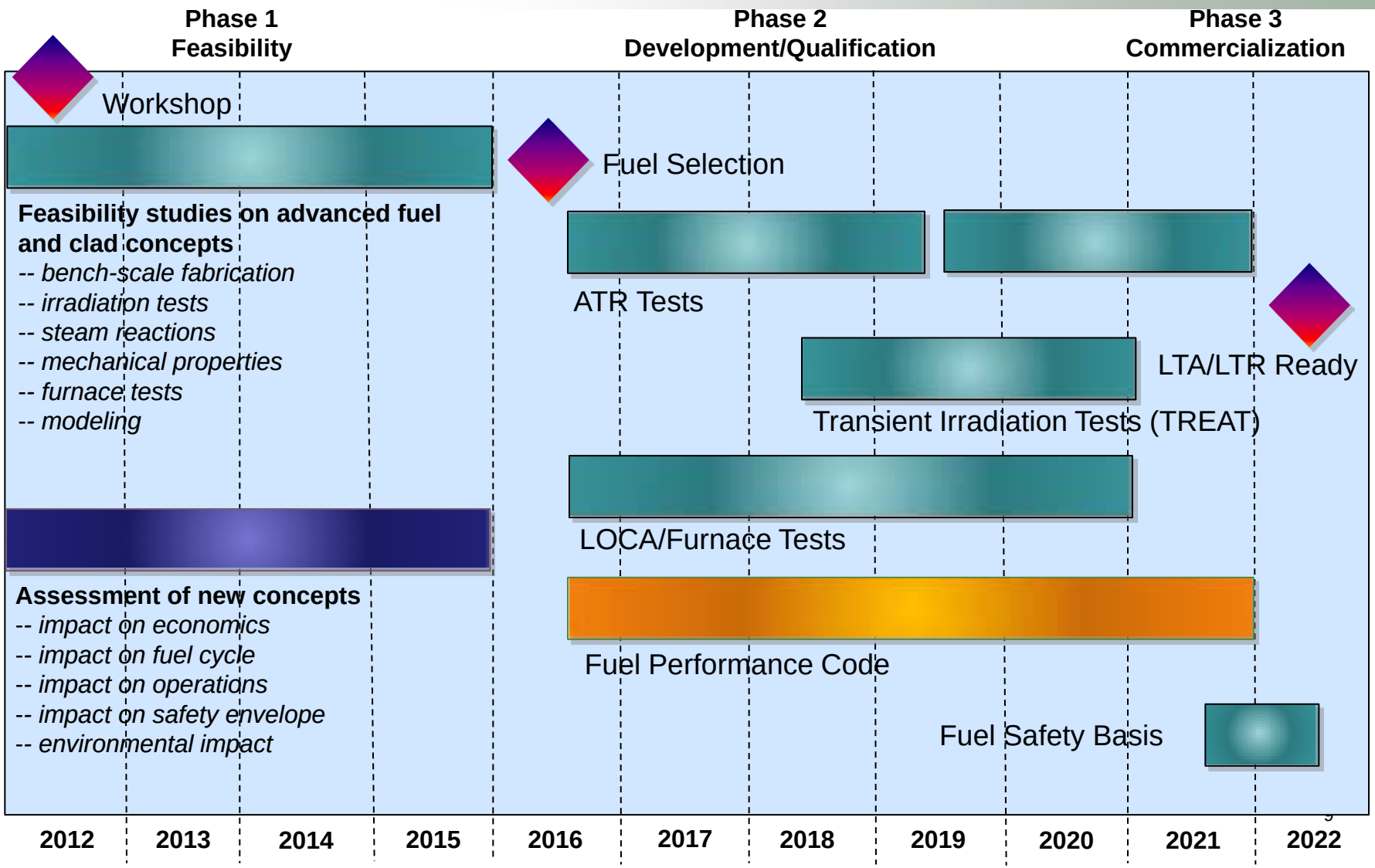
RD&D Strategy For Enhanced Accident Tolerant Fuels



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Advanced fuels FY 2013 NEUP - Priority Topics of Interest

- **Fuel related core materials that provide enhanced tolerance to accidents for light water reactors, e.g. nano - technology applications to cladding;**
- **Development of in-pile instrumentation, novel characterization techniques and innovative out of pile testing that supports the goal of understanding the behavior of and predicting the performance of the nuclear fuel system at a microstructural level;**
- **Supporting the development of predictive, physics-based fuels performance models at a micro- structural level by developing and conducting separate effects tests to provide the required fundamental physical and chemical data;**
- **Improving nuclear data relevant to the development of advanced fuels with higher enrichments/burnups.**

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Research NEUP site to review successful past advanced fuels related projects

- **Examples: NEUP Program Supporting R&D Awards in FY12 related to accident tolerant fuel:**
  - Testing of Sapphire Optical Fiber and Sensors in Intense Radiation Fields, when Subjected to Very High Temperatures (Ohio State Univ.)
  - Improved Accident Tolerance of Austenitic Stainless Steel Cladding through Colossal Supersaturation with Interstitial Solutes (Case Western Reserve Univ.)
  - Development of Innovative Accident Tolerant High Thermal Conductivity UO2 Fuel Pellets with a Diamond Dopant (Univ. of Florida)
  - Better Radiation Response and Accident Tolerance of Nanostructure Ceramic Fuel Materials (Univ. of Tennessee)
  - (also check www.neup.gov, using Archive tab for FY 2009 - 2012 award recipients)

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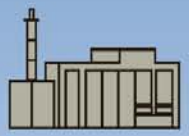
Fuel Cycle Technologies: an Integrated approach

Front End | **Back End**

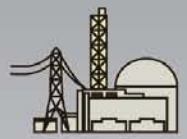
Uranium Resources

- Conventional production
- Innovative approaches
  - U Seawater

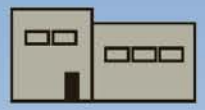


Fuel Fabrication

- Safety enhanced LWR fuel
  - Accident tolerance
- Higher performance
  - Improved burnup

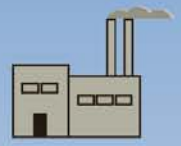


Reactors



Interim Storage

- Evaluating extended time frames
- Transport after storage



Recycle

- Separations
- Recycled fuel
- Secondary waste treatment

Disposal

- Alternative geologies
- Alternative waste forms

Remember, advanced fuels ideas ultimately must be acceptable as realistic to utilities and vendors

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Program Contacts

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- **Core Materials Development - Stuart Maloy - maloy@lanl.gov**
- **Metal Fuel Development - Rory Kennedy - rory.kennedy@inl.gov**
- **Ceramic Fuels R&D - Ken McClellan - kmcclellan@lanl.gov**
- **Microencapsulated Fuel R&D - Lance Snead - sneadll@ornl.gov**
- **Modeling - Steve Hayes - steven.hayes@inl.gov**

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Fuels Related NEUP Projects

Title	Organization	University Funding	Contract Award Date
Improved LWR Cladding Performance by EPD Surface Modification Technique	University of Wisconsin, Madison	$303,794	9/8/09
Fabrication of Tungsten-Rhenium Cladding Materials via Spark Plasma Sintering for Ultra High Temperature Reactor Applications	University of Idaho	$682,258	8/6/09
Development of Diffusion Barrier Coatings and Deposition Technologies for Mitigating Fuel Cladding Chemical Interactions (FCCI)	University of Wisconsin, Madison	$478,709	7/24/09
Simulations of the Thermodynamic and Diffusion Properties of Actinide Oxide Fuel Materials	University of Michigan	$479,558	7/15/09
Bulk Nanostructured FCC Steels with Enhanced Radiation Tolerance	Texas A&M University	$633,830	7/13/09
Atomistic Calculations of the Effect of Minor Actinides on Thermodynamic and Kinetic Properties of UO2+x	Georgia Institute of Technology	$482,426	8/31/09
Advanced Elastic/Inelastic Nuclear Data Development Project	Idaho State University	$1,497,500	9/17/09
Developing a High Thermal Conductivity Fuel with Silicon Carbide Additives	University of Florida No Cost Extension	$383,148	8/10/09
Computational Design of Advanced Nuclear Fuels	University of California, Davis	$1,178,644	9/8/09
Improvements to Nuclear Data and Its Uncertainties by Theoretical Modeling	Rensselaer Polytechnic Institute	$871,060	9/17/09
Ab Initio Enhanced Calphad Modeling of Actinide Rich Nuclear Fuels	University of Wisconsin, Madison	$486,338	8/26/09
Neutron Damage and MAX Phase Ternary Compounds	Drexel University	$664,359	9/8/09
Fuel Performance Experiments and Modeling: Fission Gas Bubble Nucleation and Growth in Alloy Nuclear Fuels	Texas A&M University	$1,473,930	9/15/09
Simulations of Failure via Three-Dimensional Cracking in Fuel Cladding for Advanced Nuclear Fuels	University of Texas- Dallas	$881,949	9/17/09

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Fuels Related NEUP Projects cont'd

Title	Organization	University Funding	Contract Award Date
Freeze-casting as a Novel Manufacturing Process for Fast Reactor Fuels	Dartmouth University	$1,149,327	9/15/2010
Development of a Innovative High Thermal Conductivity UO2 Ceramic Composites Fuel Pellets with Carbon Nano-Tubes Using Spark Plasma Sintering	University of Florida	$894,042	7/12/10
Fuel Performance Experiments on the Atomistic Level, Studying Fuel Through Engineered Single Crystal UO2	Idaho State University	$1,333,676	9/22/10
Development of Advanced High Uranium Density Fuels for Light Water Reactors	University of Wisconsin-Madison	$1,189,483	11/17/11
Nanovision	Idaho State University	$1,199,990	11/7/11
Elastic/Inelastic Measurement Project	University of Kentucky	$880,523	
Improved Accident Tolerance of Austenitic Stainless Steel Cladding through Colossal Supersaturation with Interstitial Solutes	Case Western Reserve University	$850,000	
Testing of Sapphire Optical Fiber and Sensors in Intense Radiation Fields, when Subjected to Very High Temperatures	Ohio State University	$885,000	
Better Radiation Response and Accident Tolerance of Nanostructured Ceramic Fuel Materials?	University of Tennessee	$815,000	7/1/12
Reducing Actinide Production Using Inert Matrix Fuels	University of Texas-Austin	$586,944	
Microscopic Fuel Particles Produced by Self-Assembly of Actinide Nanoclusters on Carbon Nanomaterials	University of Notre Dame	$440,000	7/1/12
Development of Innovative Accident Tolerant High Thermal Conductivity UO2 Fuel Pellets with a Diamond Dopant	University of Florida	$800,000	8/15/12