U.S. DEPARTMENT OF ENERGY

Advanced Fuels Campaign

Update on U.S. Accident Tolerant Fuel Program

Nuclear Regulatory Commission Briefing

Office of Nuclear Energy

Jon Carmack

National Technical Director

Idaho National Laboratory

February 9, 2016

In the U.S. in the Fall of 2011 – The Public asked for "Meltdown Resistant Fuel"

In the Consolidated Appropriations Act, 2012, Conference Report 112-75, the Department of Energy, Office of Nuclear Energy was:

- Directed "to give priority to developing enhanced fuels and cladding for light water reactors to improve safety in the event of accidents in the reactor or spent fuel pools,"

- Urged " that special technical emphasis and funding priority be given to activities aimed at the development and near-term qualification of meltdown-resistant, accident-tolerant nuclear fuels that would enhance the safety of present and future generations of Light Water Reactors,

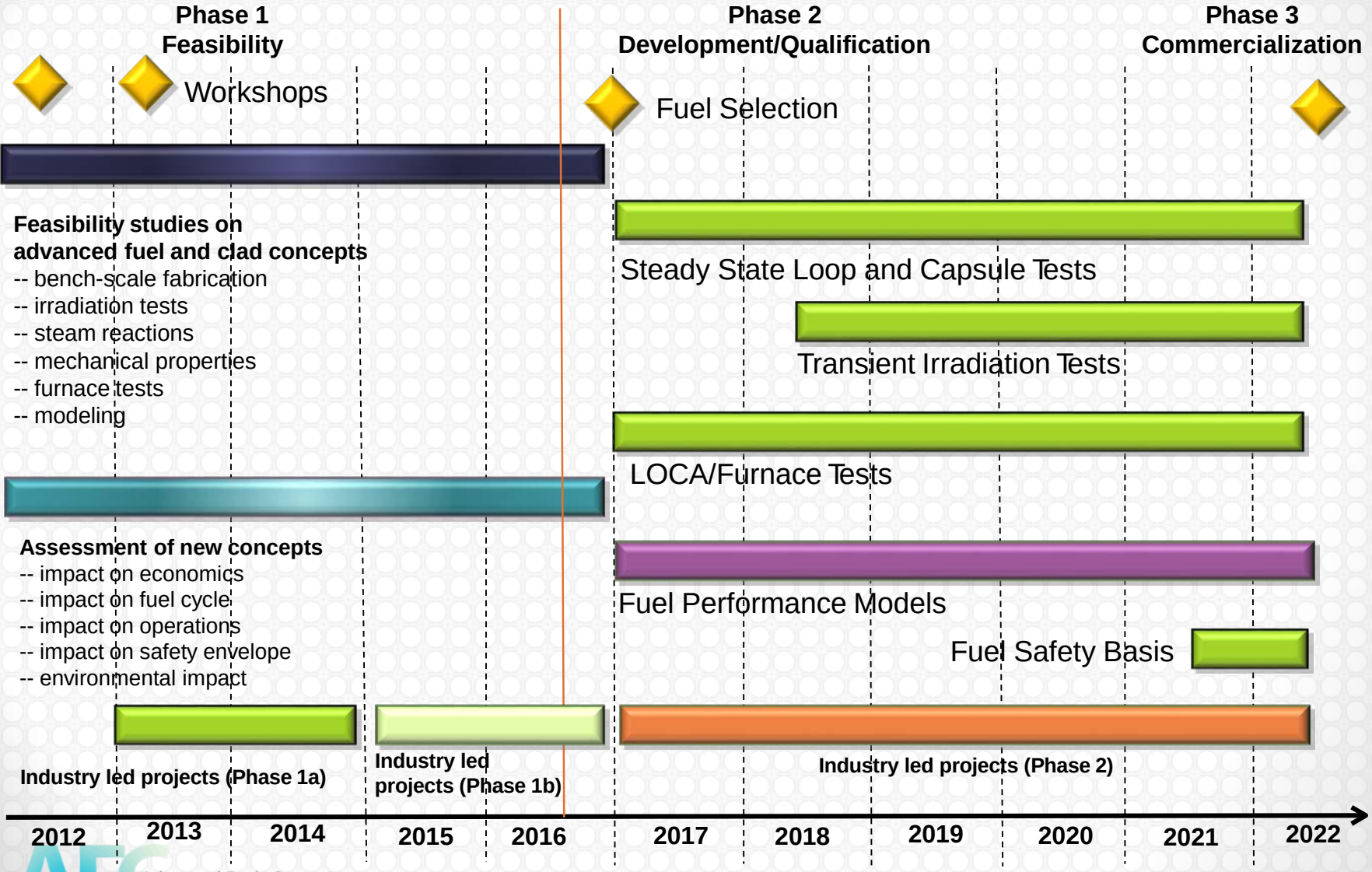
- And requested "to report to the Committee, within 90 days of enactment of this act, on its plan for development of **meltdown resistant** fuels leading to reactor testing and utilization by **2020**."

Engineers Defined Accident Tolerant Fuel Attributes and Metrics - Enhanced "Grace Time" or "Coping Time"

Fuels with **enhanced accident tolerance** are those that, in comparison with the standard UO_2 – Zr system, can **tolerate loss of active cooling** in the 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.

Major Goal of the OECD EATFWG in the International Community

RD&D Strategy For Enhanced Accident Tolerant Fuels – 10 Year Goal

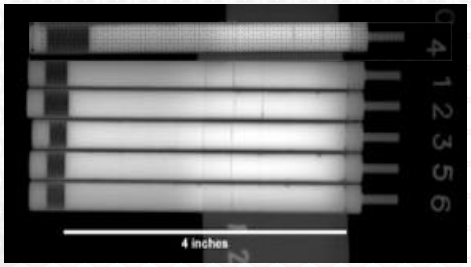


Advanced Fuels Campaign

U.S. DOE-Supported Industry Teams Will Complete Phase 1 in September of 2016

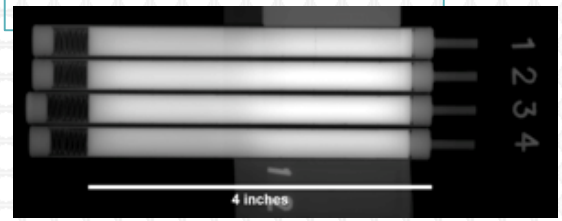
AREVA

- **Cr coated Zr**
- **SiC-SiCf**
- **Increased fuel p conductivity**
- Additives
  - SiC powder or whiskers
  - Diamond
  - Chromia dopant



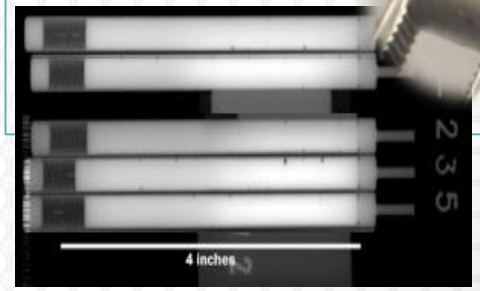
GE

- Develop advanced **ferritic/martensitic steel alloys (e.g., Fe-Cr-Al) for fuel cladding** to improve behavior under severe accident scenarios
- Objectives:
  - Characterize candidate steels
  - Study tube fabrication methods, neutronics, fuel economy, thermo-hydraulic calculations, regulatory approval path
  - Initiate ATR testing with UO_2 and two cladding materials.



Westinghouse

- **Cladding** concepts:
  -**SiC** and SiC ceramic matrix composites;
  - **coated Zr alloys**
- **High density/high thermal conductivity fuel pellets**
- First batch of U_3Si_2 pellets were sintered using finely ground powder
- Pellets were pressed using pressures of 6,000-10,000 psi and sintered at temperatures of 1400° C



U_3Si_2 Pellet

Looking Forward to Phase II

- We will transition into Phase II of the DOE ATF program in Oct 2016.
- Recently, utility representatives asking for Accident Tolerant Fuel technology that can:
  - 1. Provide impactful coping time for the current fleet
  - 2. Make GENII reactors on par with GENIII+ designs that provide coping time before operator actions are required.
- To take full advantage of ATF technologies, all core and reactor components need to be considered.