

# AREVA Programs

## GAIN Workshop

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May 02, 2017

# Pathway to expanded partnership

▶ **Vision**

▶ **Actions**

▶ **Opportunities**



**AREVA views GAIN as an optimum pathway  
to expanded industry partnership**

# Vision for collaboration

## DOE and National Labs

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- ▶ Focus on basic research

## Industry

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- ▶ Focus on applied research

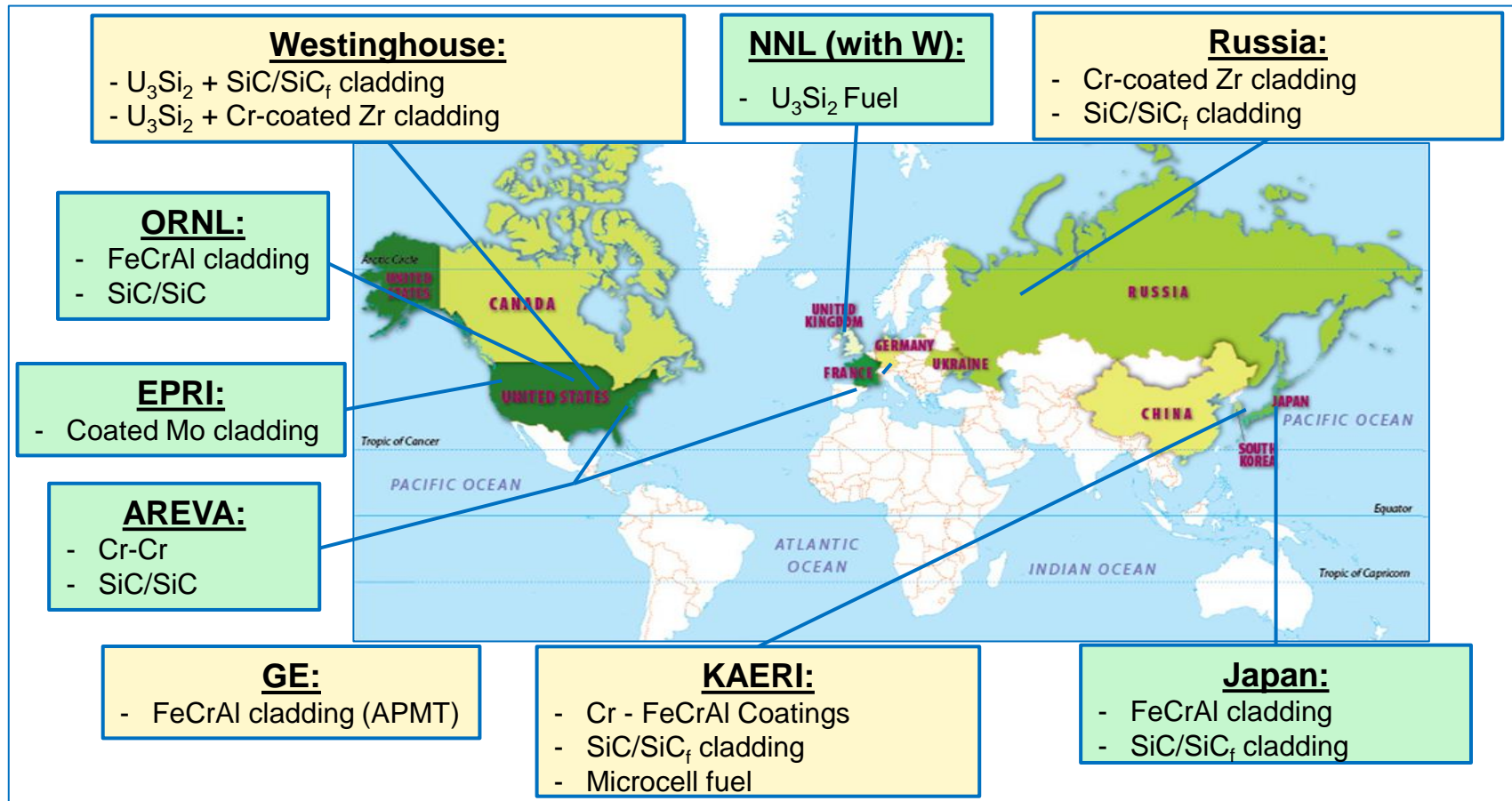
### Key questions:

- ▶ Where does basic stop and applied start?
- ▶ What is an appropriate metric?

- ▶ A practical answer is linked to risk management
  - ◆ Financial
  - ◆ Regulatory

➤ Establish industry partnerships to manage risk and get to high value solutions!

# Overview of ATF concepts



- ▶ International community collectively working on a common set of concepts
- ▶ Synergies possible through collective efforts

# eATF DOE Phase 2 AREVA NP Project Scope

## AREVA NP eATF Concepts

### Selection focused on the data obtained in Europe

- ▶ **Priority 1:** Cr-coated M5<sup>®</sup> + Cr<sub>2</sub>O<sub>3</sub>-doped fuel to achieve the DOE objective of LFA insertion by 2022
- ▶ **Priority 2:** SiC/SiC<sub>f</sub> cladding to demonstrate the capability to insert LFRs into a commercial reactor by 2022



## Utilities Consortium: US and Europe

### Contract for LFR insertion in 2019

- ▶ Irradiation of Cr-coated M5<sup>®</sup> + Cr<sub>2</sub>O<sub>3</sub>-doped fuel LFRs
- ▶ LFR manufacturing in 2018
  - ◆ Cr-coated M5<sup>®</sup>
  - ◆ Cr<sub>2</sub>O<sub>3</sub>-doped fuel at Richland
- ▶ Licensing through 50.59 process in 2017- 2018



## Cooperation with National Labs

### Irradiation in INL test reactors

- ▶ ATF-1 (ATR): Hot-Cell examinations of rodlets irradiated during Phase 1 (UO<sub>2</sub> + SiC additives)
- ▶ ATF-2 (ATR): Irradiation of Cr-coated M5<sup>®</sup> + Cr<sub>2</sub>O<sub>3</sub>-doped fuel in PWR loop (2018)
- ▶ ATF-3 (TREAT): Transient tests (from 2018)

## ATF Value Assessment

### NEI Working Group

- ▶ Advanced Technology Fuels: Economic Benefits Task Force
- ▶ PRA (Probability Risk Assessment) sub-group to develop a list of the greatest potential benefits

# Action through AREVA R&D Plans

## Key synergies for industrial partnerships

TREAT

- ▶ Qualification of eATF concepts for beyond design basis function

HIFR

- ▶ Opportunities for Accident Tolerant Control Rods and Additive Manufacturing activities

Analytical Codes

- ▶ Expanded deployment of CASL and NEAMS in eATF concept evaluations

Hot Cells

- ▶ Evaluation and Characterization of eATF and Accident Tolerant Control Rod concepts



### Fukushima Event

Following loss of cooling due to station black-out, fast temperature increase leading to:

- Rapid oxidation of the cladding due to Zr-steam reaction
- Hydrogen release, followed by explosion
- Fission products release in the atmosphere
- Core melting

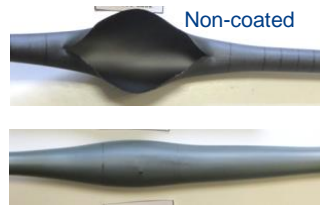
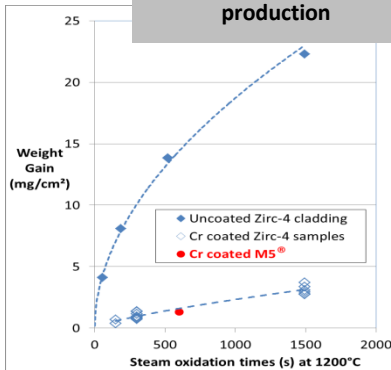
# Cr-coated M5<sup>®</sup> cladding + Cr<sub>2</sub>O<sub>3</sub>-doped fuel: Key Achievements

## Cr-coated M5<sup>®</sup>



Prototype for long tubes coating

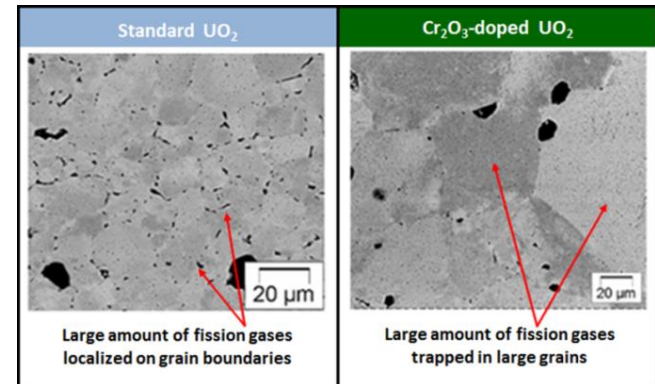
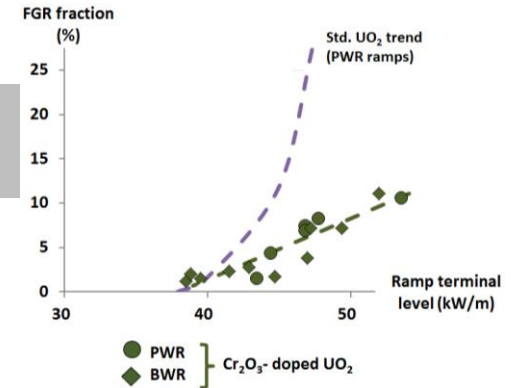
### Reduced heat and hydrogen production



Temperature Ramp Tests

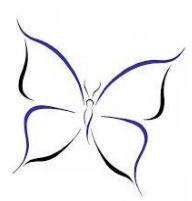
## Cr<sub>2</sub>O<sub>3</sub>-doped fuel

Fission gas release during ramp tests on irradiated fuel rods

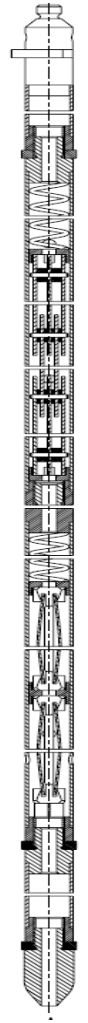


### Promising trends regarding safety:

- Potential reduction in ballooning–burst
- Reduced high temperature oxidation
- Reduction of fission gas release with Cr<sub>2</sub>O<sub>3</sub> doped fuel

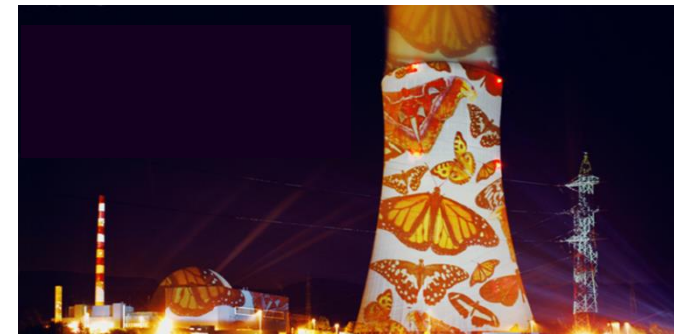


# IMAGO: Irradiation of Materials for ATF in Europe



- ▶ Long-term R&D Partnership European utility(s)
- ▶ Objectives:
  - ◆ To acquire in-reactor material data under representative PWR conditions: corrosion kinetics, evolution of microstructure, mechanical and physical properties under irradiation
  - ◆ To get in-reactor data for the justification of future fuel rod/assembly insertion
- ▶ Irradiation of Material Test Rods (MTRs):
  - ◆ eATF samples inside MTRs inserted within guide tubes of a fuel assembly: Cr-coated zirconium alloys, SiC/SiC<sub>f</sub> composite tube samples
  - ◆ Hot Cell examinations after each cycle

First irradiation of eATF concepts in a commercial PWR Plant: Insertion Mid-2016 for 7 cycles





# Challenges and Opportunities

## Challenge

## Opportunity

Regulations

- **Material limits on spent fuel in Idaho**
  - Vendors and utilities need support from government agencies to dispose of waste

- **SNF has extended research uses beyond the initial application**
  - Deploy material through INL to other states to balance storage and disposal volume

Availability

- **ATR downtime or reprioritization**
- **Recent requests for quotes declined**

- **Close communication**

Cost

- **Recent quotations significantly higher than international labs**

- **Monitor progress and communicate**
- **Update scope if possible**

### Main challenges:

- **Cost control over exam period**
- **Availability of labs**

# Enhanced Accident Tolerant Fuel Summary

- ▶ **The development of eATF concepts has become a must for fuel vendors, especially in USA with interest from the utilities**
  - ◆ **The benefit of the early eATF development efforts are beginning to be visible**
  
- ▶ **eATF development efforts successfully completed on time will help keep industry interest high**
  - ◆ **Multiple opportunities to qualify R&D concepts through GAIN initiative**
  
- ▶ **eATF could offer an opportunity to optimize Reactor / Fuel Design for New Builds beyond 2030**
  - ◆ **Availability but also access critical for successful deployment through GAIN**