International collaboration for development of accident-resistant LWR fuel

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Following the March 2011 multi-unit accident at the Fukushima Daiichi plant, there has been increased interest in the development of breakthrough nuclear fuel designs that can reduce or eliminate many of the outcomes of a severe accident at a light water reactor (LWR) due to loss of core cooling following an extended station blackout or other initiating event. With this interest and attention comes a unique opportunity for the nuclear industry to fundamentally change the nature and impact of severe accidents. Clearly, this is no small feat. The challenges are many and the technical barriers are high. Early estimates for moving maturing R&D concepts to the threshold of commercialisation exceed one billion USD. Given the anticipated effort and resources required, no single entity or group can succeed alone. Accordingly, the Electric Power Research Institute (EPRI) sees the need for and promise of co-operation among many stakeholders on an international scale to bring about what could be transformation in LWR fuel performance and robustness.

An important initial task in any R&D programme is to define the goals and metrics for measuring success. As starting points for accident-tolerant fuel development, the extension of core coolability under loss of coolant conditions and the elimination or reduction of hydrogen generation are widely recognised R&D endpoints for deployment. Furthermore, any new LWR fuel technology will, at a minimum, need to (1) be compatible with the safe, economic operation of existing plants and (2) maintain acceptable or improve nuclear fuel performance under normal operating conditions. While the primary focus of R&D to date has been on cladding and fuel improvements, there are a number of other potential paths to improve outcomes following a severe accident at an LWR that include modifications to other fuel hardware and core internals to fully address core coolability, criticality, and hydrogen generation concerns.

The US Department of Energy is providing substantial support for initial R&D on accident-tolerant fuel concepts with an aggressive target of a lead test assembly (LTA) in an LWR by 2022. EPRI proposes an additional stretch goal of commercialisation of a new LWR fuel by 2030. The scale of and resource demands associated with these R&D targets require a global collaborative structure to leverage resources, create an environment for innovation and co-operation, and foster necessary partnerships and arrangements among the many key players and roles spanning government, academic, and industrial sectors. EPRI is proposing a voluntary, open, and non-binding structure to quickly build momentum and to maximise early engagement and information exchange among key stakeholders. The flexibility of this organisational model offers an environment that is compatible with and encourages engagement, innovation, and development of the more formal arrangements and partnerships that will be needed to commercialise current R&D concepts. The opportunity for transformation of LWR fuel performance under normal and accident conditions is now. Accordingly, the time for action is now. Commercialisation of accident-tolerant fuel in the near future can only be realised with collaboration among governments, industry and academia on a scale commensurate with the challenges at hand.

International Collaboration for Development of Accident Resistant Light Water Reactor Fuel

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OECD/NEA Workshop on Accident Tolerant Fuels of LWRs

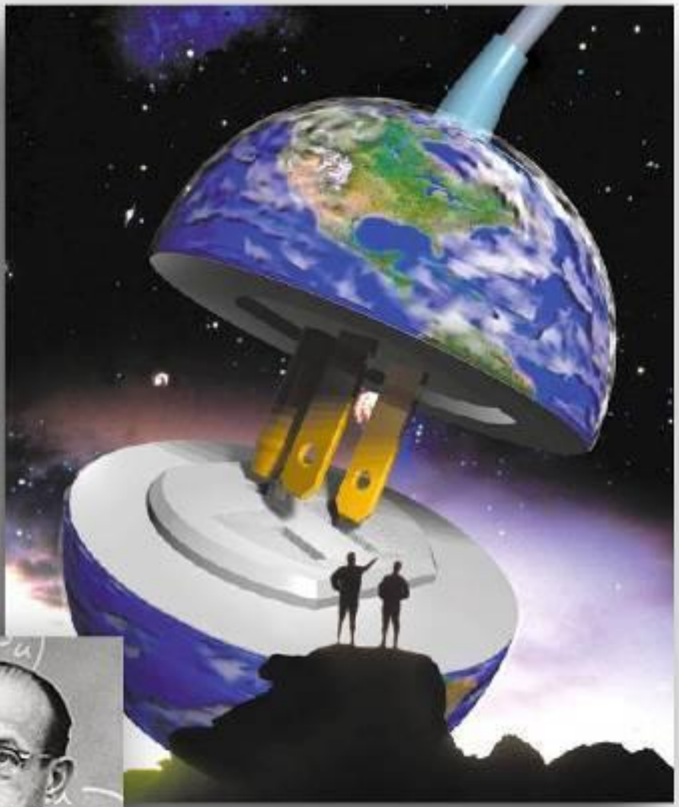
Paris, France

12 December 2012

About EPRI…

Mission – To conduct research on key issues facing the electricity sector… on behalf of its members, energy stakeholders, and society.

- Collaborative, independent nonprofit center for public interest energy and environmental research
- More than 75% of worlds commercial nuclear units participate in EPRI research programs



Chauncey Starr
EPRI Founder

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Imagine Fukushima without…

Goal: Accident Resistant LWR Fuel by 2030

- Approach: Build upon proven light water reactor experience
  - Transformational results via incremental implementation
  - Compatible with commercial operation of reactors
- Perspective: Continued confidence in nuclear technology demands commitment to continuous improvement
- Applicability: Global

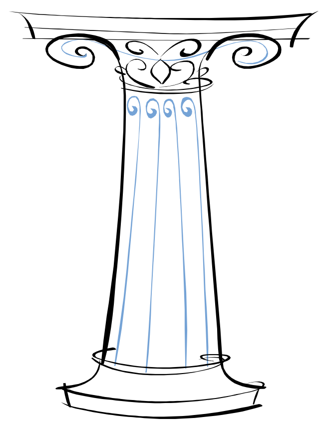
Challenges are many. Barriers are high. A billion $ effort? No single entity or group will succeed alone.

How Do We Define Success?

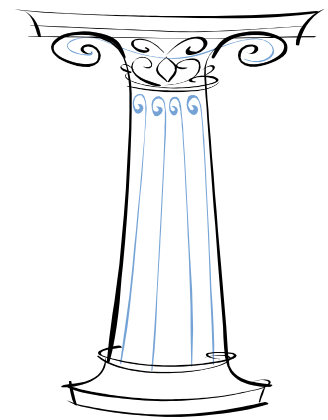
Three Pillars

Extend core coolability under loss of coolant conditions

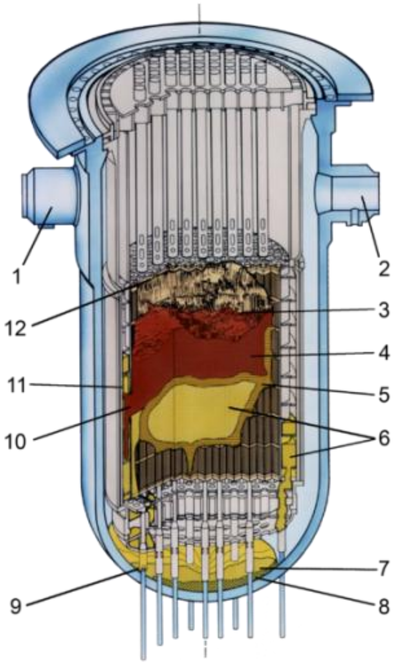
Eliminate or significantly reduce hydrogen generation



Maintain acceptable or improve fuel performance



Broader View: Accident Resistant Cores?



TMI-2 Core End-State Configuration (Source: NRC)

- Priority has been cladding and fuel
- Other relevant components and hardware:
  - BWR fuel channels (significant Zr inventory)
  - PWR control rods and BWR control blades (criticality control)
  - Fuel assembly hardware (grids, guide tubes, nozzles, etc.)
  - Reactor internals susceptible to loss of integrity and affecting desired outcomes and functions (*e.g.*, core coolability)

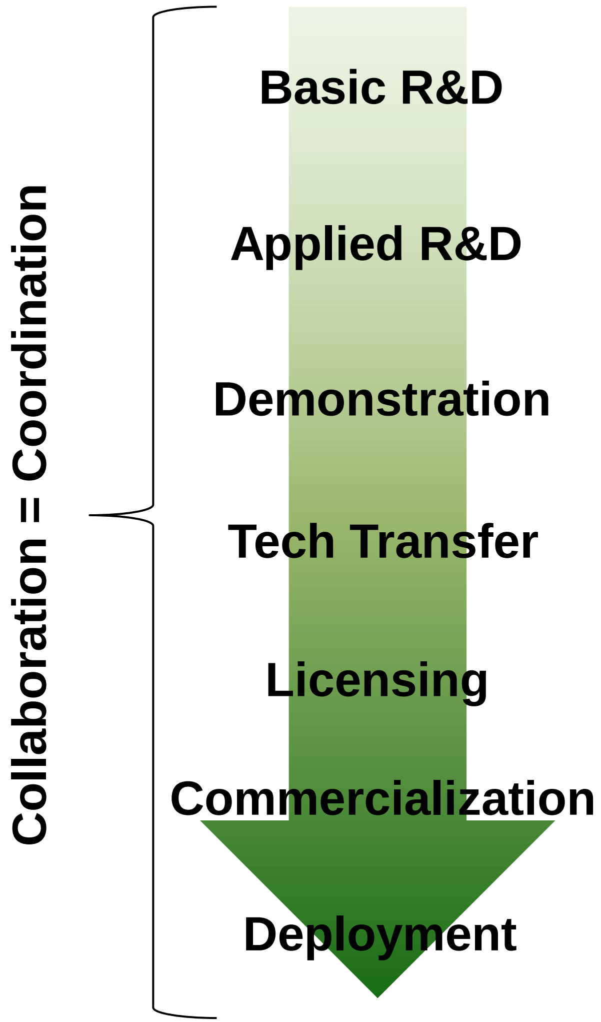
Potential for multiple paths to "success" that are also compatible with deployment in commercial reactors.

Global Collaboration for a Global Challenge

- Leverage resources on a global scale
- Facilitate sharing of information, insights and experience
  - Who is doing what?
  - What are technology gaps?
  - What R&D is needed to fill gaps?
- Create an environment for innovation and cooperation
- Foster necessary partnerships and arrangements

Eventually, must develop a compelling case for commercial investment in new technology.

Many Potential Players and Roles

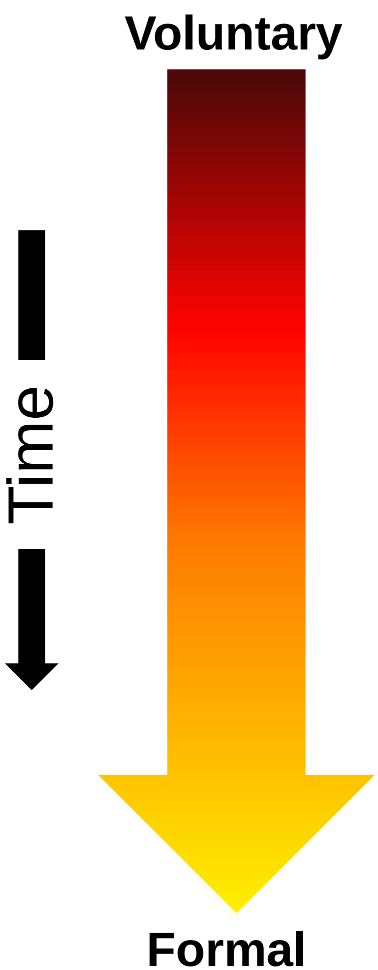


- International organizations
- Governments
- Academia
- Government, industry, and independent research organizations
- Technology vendors
- Regulators
- Utilities

Emerging R&D Picture

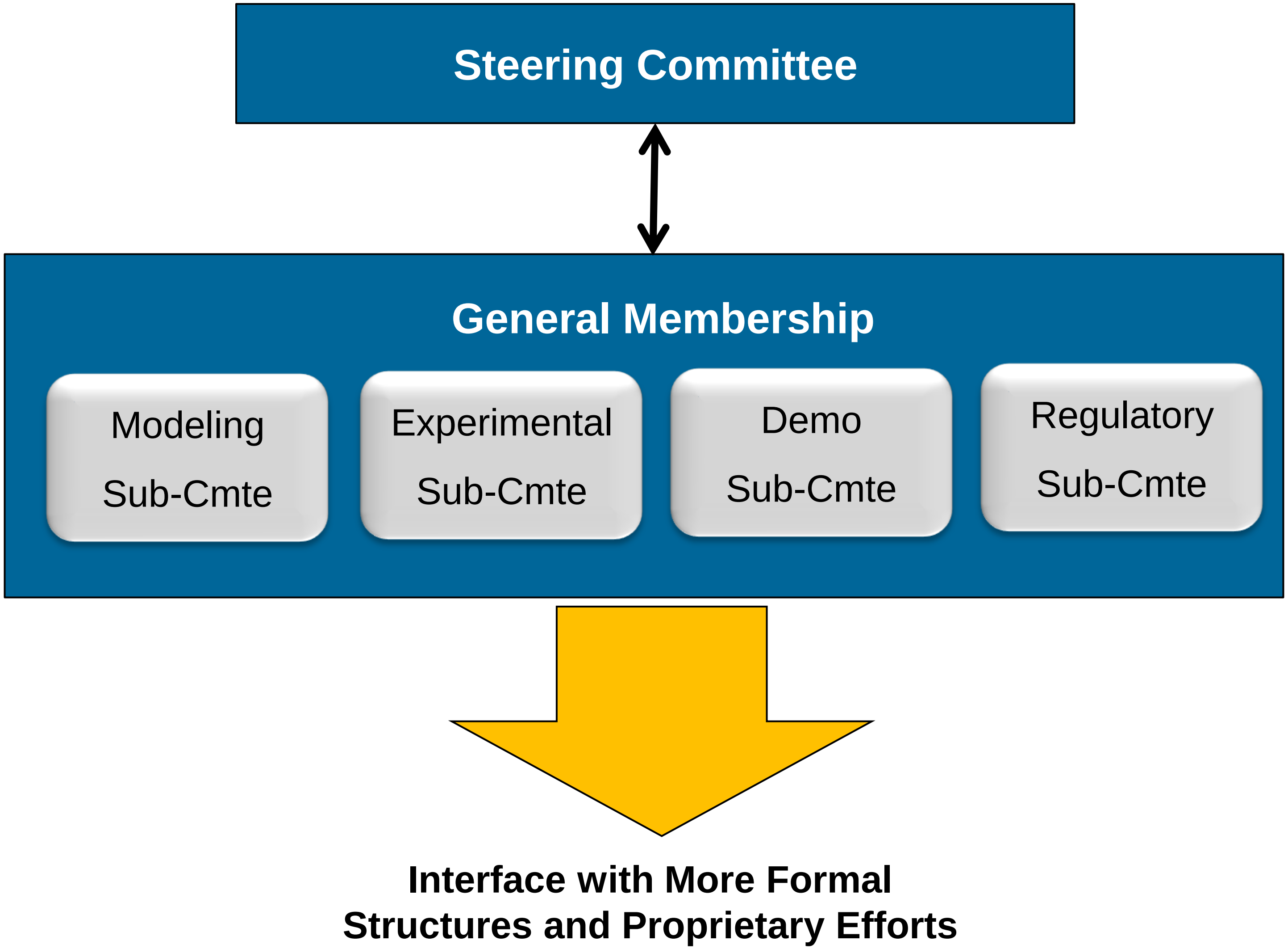
- U.S. Department of Energy – targeting lead test assembly (LTA) in a commercial reactor within 10 years
- EPRI – funding independent work on Mo-based alloys and layered-cladding concepts and SiC BWR channels
- OECD/NEA Nuclear Science Committee (NSC) and Committee on Safety of Nuclear Installations (CSNI)
- IAEA Nuclear Fuel Cycle and Materials Section – potential topic for IAEA Coordinated Research Project (CRP)
- Others…

Expected Evolution of Collaboration



- Initially: voluntary, non-binding, open, flexible structure
- Transition: create environment for engagement, innovation, and more structured arrangements
- Maturity: more formal arrangements, agreements, partnerships

Proposed Structure for Collaboration



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Time for Action is Now: Proposal for Early 2013

- January or February: convene initial meeting of "core" players - embryonic Steering Committee
  - Define vision
  - Map out acceptable collaborative model/structure
  - Establish roles
  - Develop participant target list for first collaborative workshop
- February or March: Steering Committee launches broader communication and outreach effort
- March or April: host first collaborative workshop
  - Define action plan and road map

Accident resistant fuel by 2030:
Collaboration is the path to success.

Together…Shaping the Future of Electricity