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Advanced Reactor Overview

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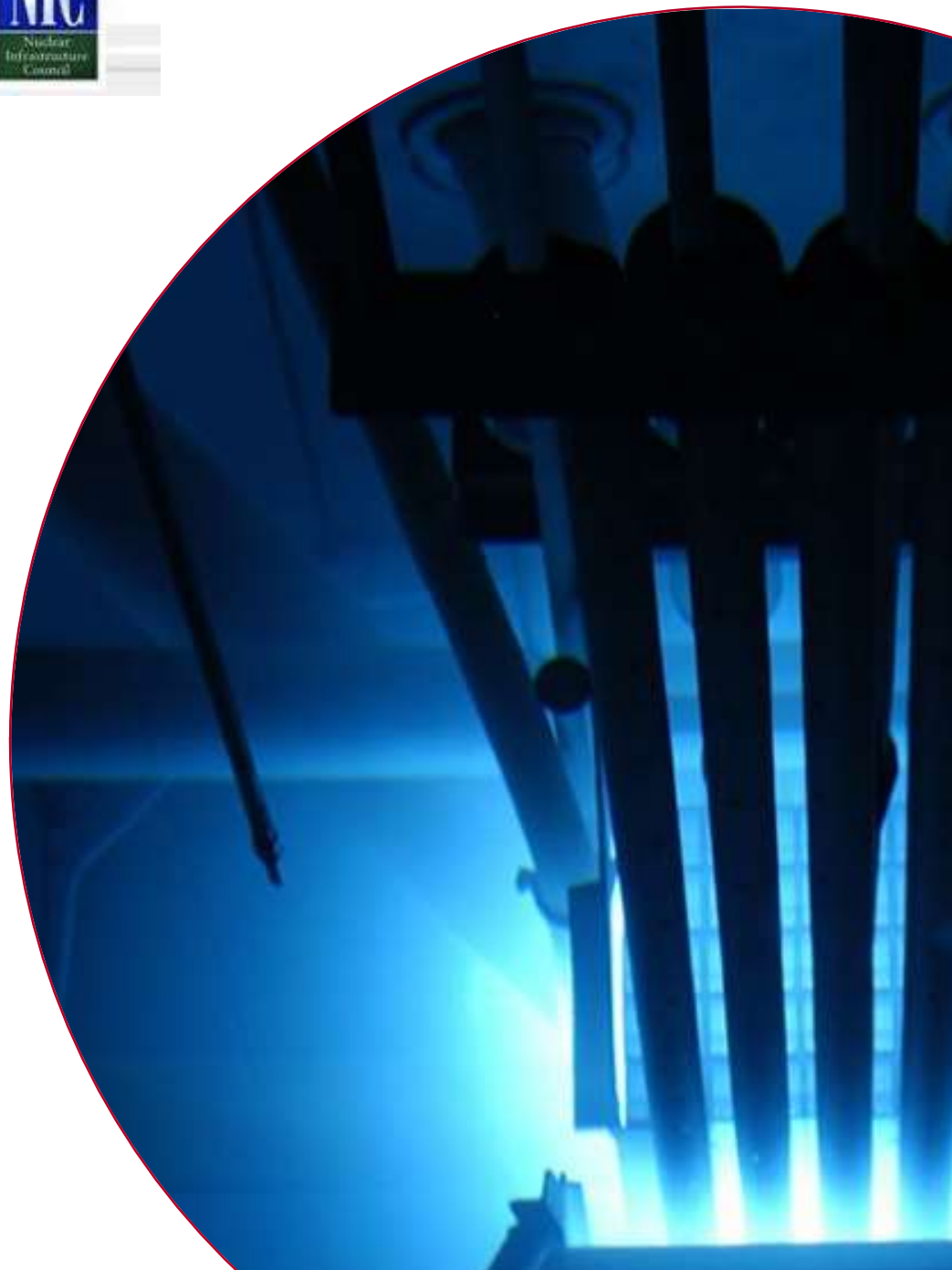
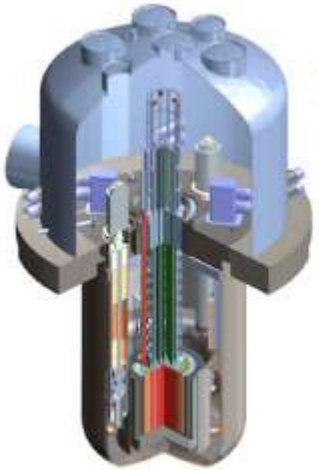


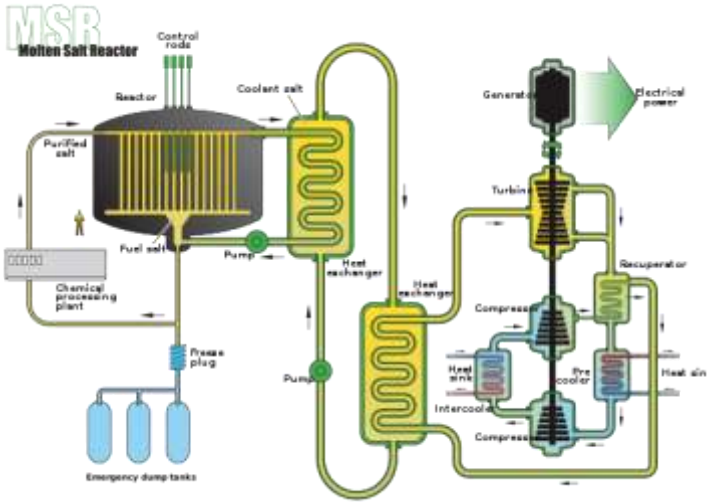
What is an Advanced Reactor?

- In General we are talking about Non-Light Water Reactors or,
  - loosely, Generation IV
- Reactor types
  - Very-high-temperature reactor (VHTR)
  - Molten-salt reactor (MSR) (MSFR)
  - Gas-cooled fast reactor (GFR)
  - Sodium-cooled fast reactor (SFR)
  - Lead-cooled fast reactor (LFR)
  - More
- AR Features:
  - Scalable from 2 MWe to 1200 MWe
  - Can have a lower operating cost, CTC: $2500 to $3900/kWe
  - Waist: Some produce 0.5 to 1 MT and can use 55 MT
  - Many designs can be “walk away safe” without operator intervention
  - Can use enriched uranium, depleted uranium, or spent nuclear fuel



Turns depleted uranium into electricity, using a simple fuel cycle without requiring separations.

SIZE	600 MWe (Prototype Plant) 1150 MWe (Commercial Plant)
TEMPERATURE	510°C
PRESSURE	Low (Atmospheric)
PRIMARY FUEL	Depleted Uranium
COOLANT	Sodium
ENERGY CONVERSION	Steam (Rankine Cycle)
WASTE REPROCESSING	Not Required



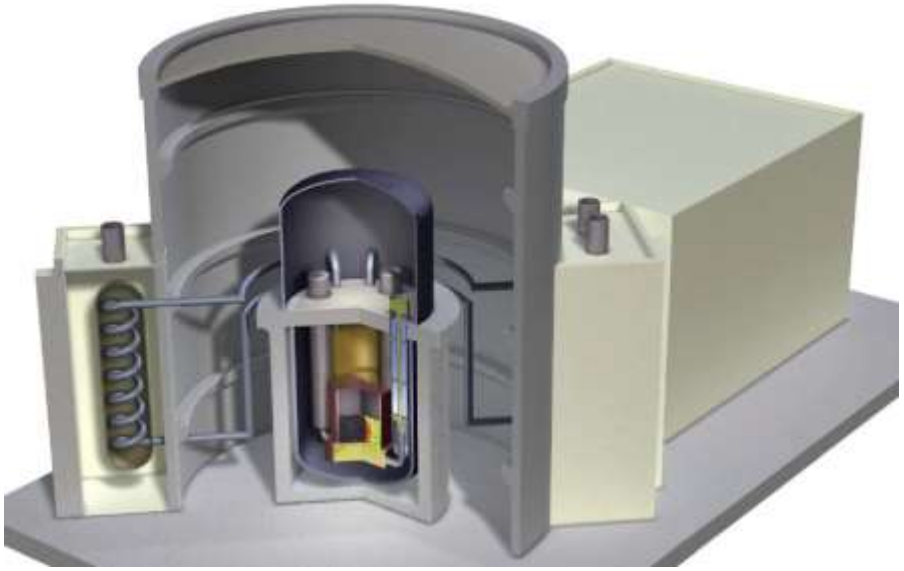
Technology Needs

- U.S. fast reactor R&D is focused on key technology innovations for performance improvement
  - Materials
  - Fuel Design and Qualification
  - I&C
  - Component design and testing
  - Chemistry Erosion corrosion

- Advanced Modeling and Simulation
  - Development of advanced neutronics, thermal-hydraulics, and mechanical analysis tools to provide credible capabilities to design advanced concepts, and understand the design margins
- Lack of a test facility for fast neutron

Who's doing this

- In the U.S. and Canada more than three dozen firms, representing about $1.3 billion in impatient investor money, are currently pursuing technological innovations in nuclear energy.
- These firms include large, big-name projects, with deep pockets, and small startups like with Series A funding.
- Start-up models adapted from Silicon Valley are being used to organize the efforts with venture capital funding in the mix.
- Some reactor design efforts will stop at the stage where intellectual property can be licensed by a developer to a deep pocket reactor vendor or state-owned corporation.
- Creating a "culture of innovation" globally



Who

- Advanced Reactor Concepts
- AREVA
- Elysium Industries Ltd
- Flibe Energy
- GE-Hitachi
- Gen4 Energy
- General Atomics
- Hybrid Power Technology
- Kairos
- Moltex
- Muons, Inc/GEMSTAR
- Next Generation Nuclear Plant Alliance
- Oklo
- TerraPower
- Terrestrial Energy
- ThorCon
- Transatomic
- Urenco U-Battery
- X-Energy

Advanced Reactor Licensing

- U.S. Nuclear Regulatory Commission (NRC) draft regulatory guide (DG),
  - DG-1330, “Guidance for Developing Principal Design Criteria for Non-Light Water Reactors.”
  - guidance for developing principal design criteria (PDC) to designers, applicants, and licensees of advanced reactors.
- "NRC Vision and Strategy: Safely Achieving Effective and Efficient Non-Light Water Reactor Mission Readiness," which was published in the Federal Register on July 21, 2016,
- Nuclear Innovation Alliance (NIA) has proposed a staged licensing process
- Utility driven licensing process lead by Southern Nuclear
  - Modernization of the technical requirements of Advanced Non-Light water Reactors
  - Risk-Informed Performance Based Licensing Process
- The goal is to find ways to streamline the licensing process while avoiding new rulemaking
- The current licensing work done for NuScale will be a litmus test for the NRC’s internal streamlining

National Labs and NGO's

- DOE
  - In 2013 Provided matching funds to X-energy and SNC/Terrapower to support development.
    - multi-year cost share of up to $80 million for both companies, will support work to address key technical challenges to the design, construction, and operation of next generation nuclear reactors.
  - Gateway for Accelerated Innovation in Nuclear (GAIN) initiative is a public-private partnerships
    - Provides the nuclear energy community with access to the technical, regulatory, and financial support
    - accelerate the commercialization of advanced nuclear energy systems.
  - Investigating the construction of a fast flux test reactor
- NEI and EPRI are sponsoring working groups to help determine needs of AR developer
- US NIC created a AR working group and a Road Map project to support industry suppliers

- UK and Canada are pursing advanced reactor
- China has an "all of the above" strategy funding universities and labs

Advanced Reactor Road Maps Project

- Develop a generic AR Road Map applicable across designs
  - Identification of generic gaps requiring analysis and resolution
  - Provide Suppliers with an understanding of what will be needed when by the AR Developers
  - Provide an understanding of AR industry outlook and drivers to Manufacturing and Supply Chain Working Group Members
- Project leaders:
  - Steven Freel, Studsvik Scandpower
  - Vince Gilbert, NIC
- Phase I: Listing of major activities for a generic AR Road Map with generic milestone definitions for both USA and Canada.
- Phase II: Identification and description of gaps in areas recommended by the project team
- Phase III: Development of gap analysis and recommended action plans for gap resolution as project time allows.

- Final Results and Next steps: December 15, 2017

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