Advancing nuclear Science & technology at ORNL

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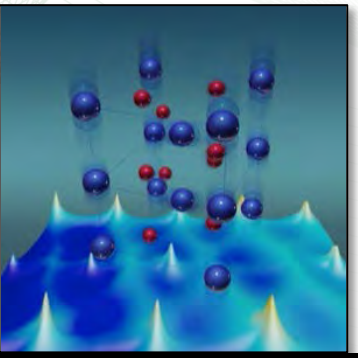
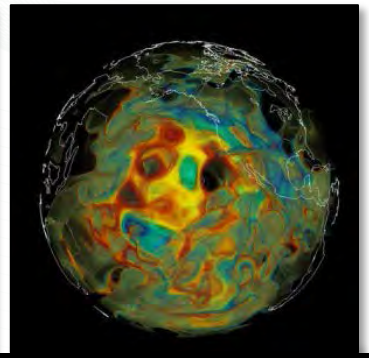
NARUC Subcommittee on Nuclear Issues
July 26, 2016

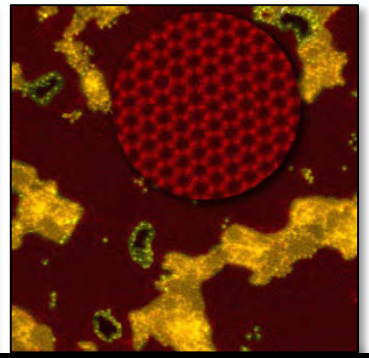
ORNL focuses resources on compelling science and technology challenges



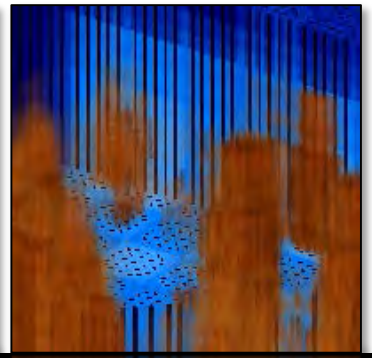
Advance the science and impact of neutrons



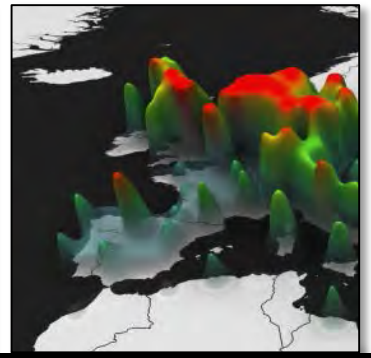
Scale computing and data analytics to exascale and beyond for science and energy



Accelerate the discovery and design of new materials for energy



Advance the scientific basis for nuclear technologies and systems: Fission, fusion, and isotopes



Advance understanding of complexity in biological and environmental systems

Discover and develop sustainable and secure integrated energy systems

Deliver science and technology to address complex security challenges

Deliver transformative impacts regionally and nationally

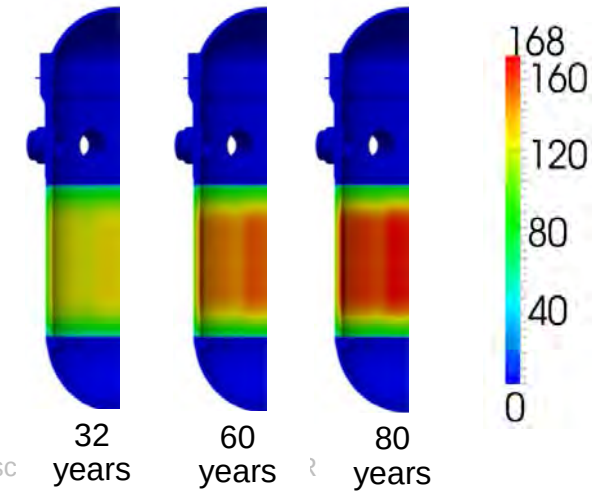
- Accelerate deployment of DOE intellectual property
- Expand strategic engagement with industry and universities

Advancing reactor design and technology

Supporting continued operation of current nuclear systems

- Addressing issues associated with materials aging, efficient operations, power uprates, licensing, digital I&C, post-Fukushima safety issues, and improved regulatory guidance
- Programmatic and materials leadership for DOE LWR Sustainability Program

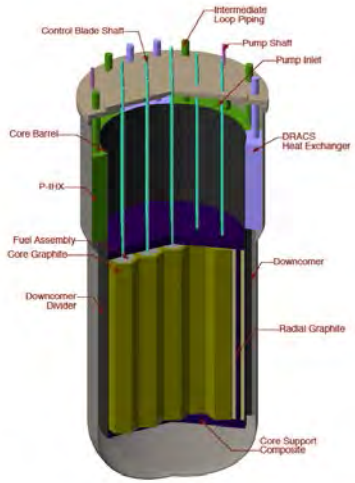
Modeling tool to predict RPV degradation, under development with INL and UT



LWRS

Supporting the replacement and future expansion of the US nuclear fleet

- Developing and evaluating advanced reactor concepts and technologies
- Supporting the development of an advanced reactor licensing framework
- Addressing key issues for advanced systems such as materials, physics, chemistry, fuels performance, economic evaluations, and siting activities related to SMRs
- Leadership for DOE Fluoride Salt Cooled High-Temperature Reactor Development



FHR
Fluoride Salt Cooled High Temperature Reactor

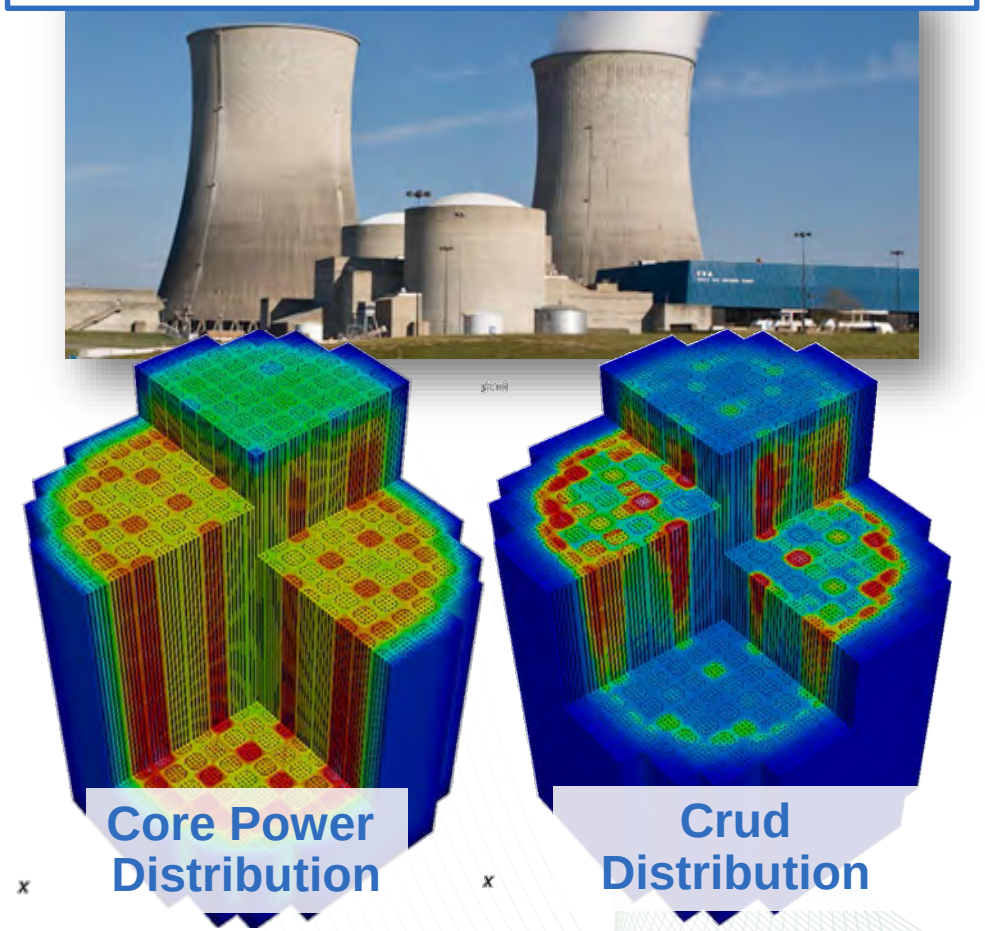
OAK RIDGE National Laboratory

Consortium for the Advanced Simulation of Light Water Reactors

- Mission is to Provide Leading-Edge Modeling & Simulation Capabilities to Improve the Performance of Operating LWRs
- University, National Laboratory, Industry Partnership:

- Simulation focused on fuel, vessel and internals to address key challenges related reactor core and fuel performance.

CASL's Virtual Environment for Reactor Applications (VERA) has been validated against Watts Bar Unit 1 and applied to Cycle 7 Crud Induced Power Shift

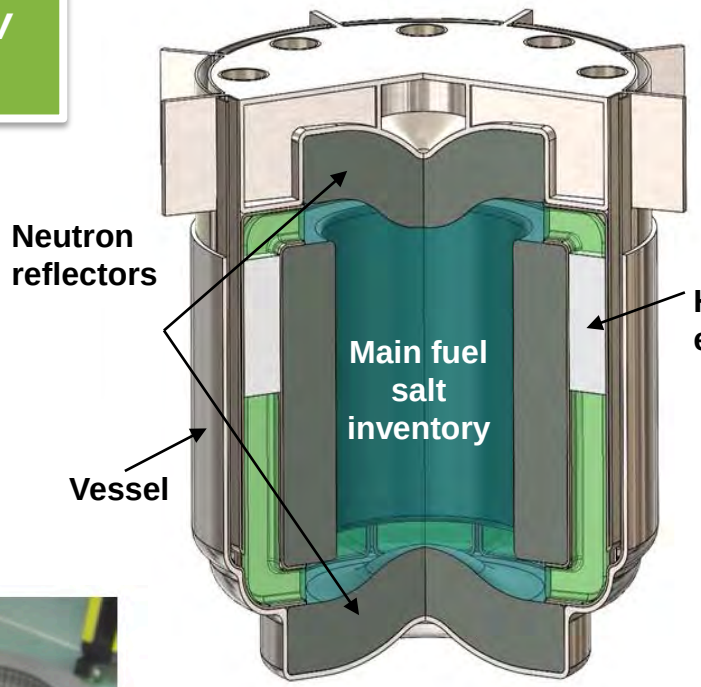


OAK RIDGE National Laboratory

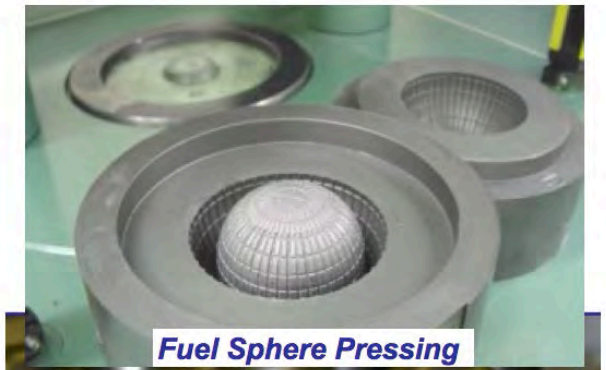
DOE Announced in 2016 Two New Investments in Advanced Reactors – ORNL Teams on Both Awards

DOE selects two companies to develop new advanced reactors - $40 M each

- Southern Company leads team to develop fast spectrum molten chloride salt-cooled reactor
  - Team includes TerraPower, ORNL, EPRI, & Vanderbilt University
  - ORNL principal roles include
    - Reactor systems & technology development
    - Safety assessment and licensing strategy
    - Materials assessment
    - Salt purification and property measurement
- X-energy formed team to develop high temperature pebble bed gas-cooled reactor
  - Team includes BWXT, ORNL, Oregon State Univ., Teledyne-Brown Engr, SGL Group, & INL
  - ORNL principal roles include
    - Development of TRISO fuel pebbles
    - Fuel characterization



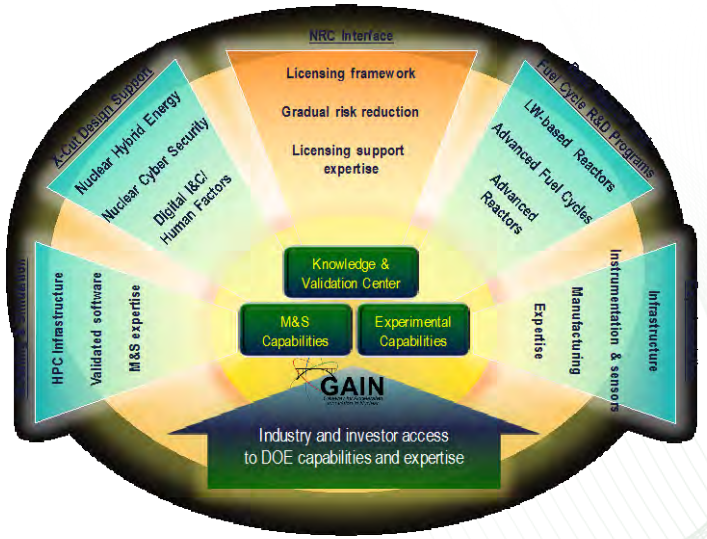
Molten Chloride Salt Fast Reactor



OAK RIDGE National Laboratory

GAIN is DOE's Response to Private Sector Needs

- GAIN's objective is to enable rapid and cost-effective development of innovative nuclear energy technologies towards market readiness
- GAIN is based on the following premise:
  - Increased demand for nuclear energy, evidenced by private investment in technology
  - Sense of urgency w.r.t. deployment
  - Effective private-publlic partnership is required
- GAIN:
  - Private-public partnership implemented as the organizing principle for relevant federally funded nuclear energy RD&D
- Status
  - Announced Nov. 2015
  - $2M initial SBVs awarded; work to begin in Aug 2016
  - 3 technology-specific workshops held July 2016
  - GAIN organization established
    - Executive Advisory Committee from industry, universities, and national laboratories
    - Leadership by INL (primarily), ORNL, and ANL
    - Execution Plan and Contracting Plan in draft form



GAIN
Gateway for Accelerated Innovation in Nuclear

OAK RIDGE National Laboratory

Thank you

Small Modular Reactors

Jeff Perry

July 26, 2016

Tennessee Valley Authority

Public power provider

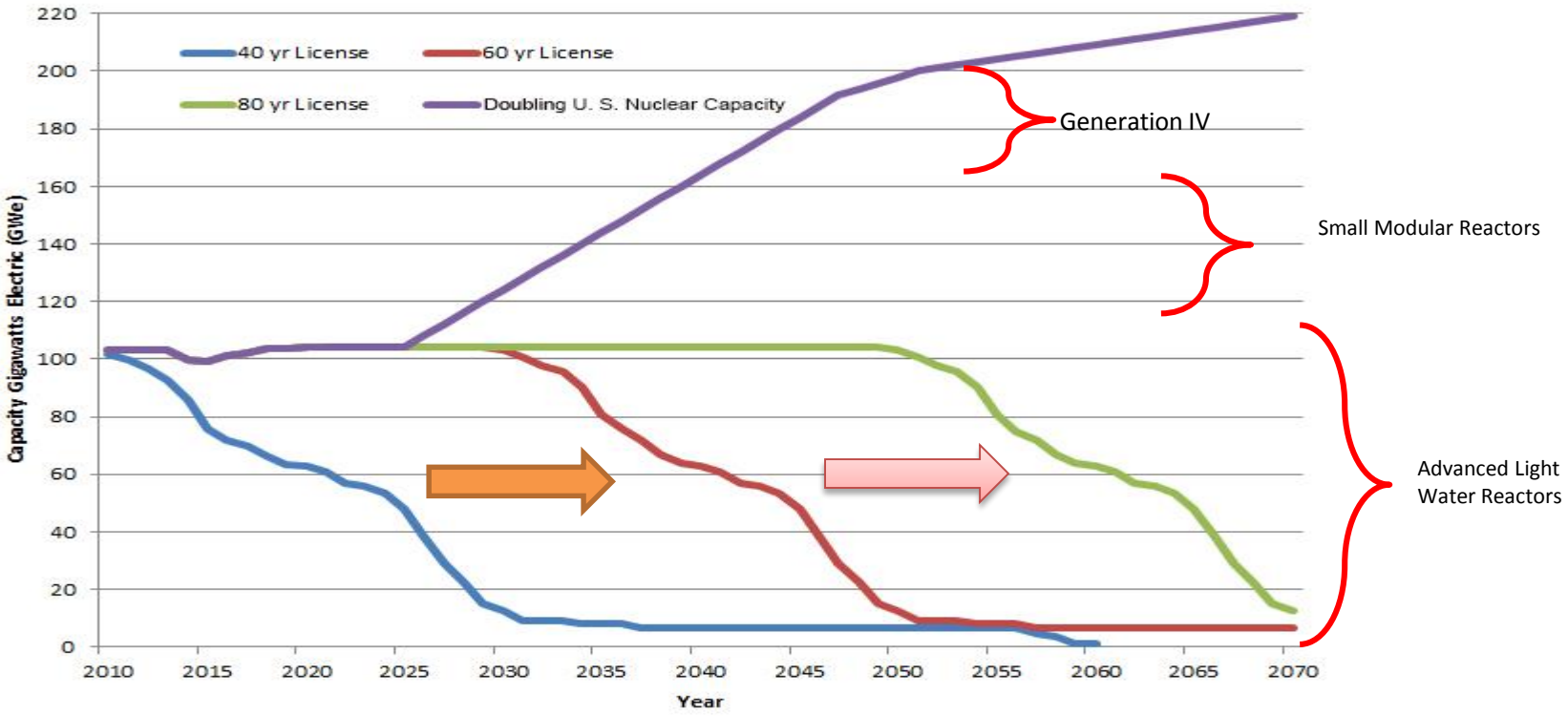
- 7-state region
- 80,000 square miles
- 9 million people

Our Mission

- Reliable and affordable electricity
- River & natural resource management
- Economic development & technology innovation
- National defense & environmental stewardship

Established in 1933 as "a corporation clothed with the power of government but possessed of the flexibility of a private enterprise"

Nuclear Power Capacity needed to meet Clean Power Goals



Industry's View: Portfolio of Nuclear Technologies

Large Light Water Reactors

- ~1,000 MWe
- Advantages
  - Use proven technology
- Applications
  - Baseload electricity
  - Large stable grids
- Available: today

Light Water Small Modular Reactors

- <300 MWe
- Advantages
  - Enhanced safety
  - Incremental addition of capacity
- Applications
  - Small to large grids
  - Secure power source
  - Locate at retired fossil plants
- Available: 2020's

Non-Water Cooled Reactors

- Large or small
- Advantages
  - Enhanced safety
  - Fuel cycle options
- Applications
  - Electricity
  - Industrial input
  - Isotopes
  - Hydrogen
  - Remote locations
- Available: mid-2030's

{Presentation Descriptor}

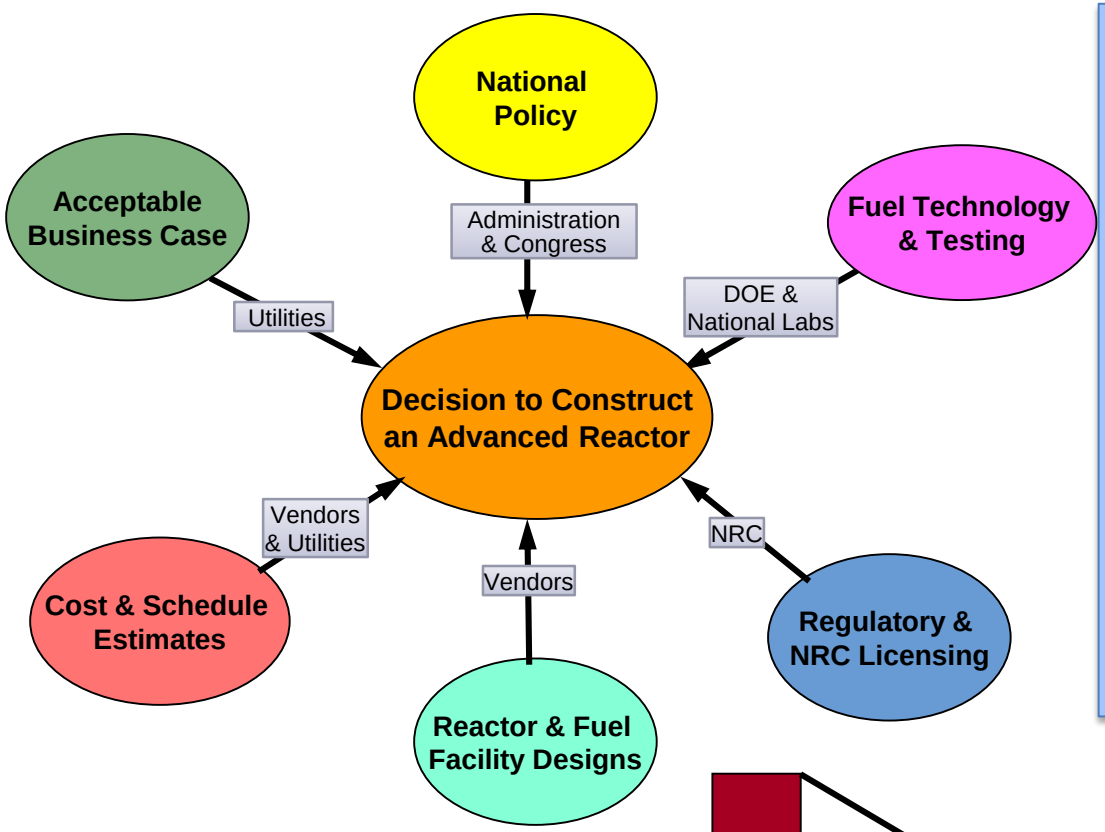
Source: NEI Presentation at DOE SMR Workshop (6/22/2016)

Attractive Features of SMRs

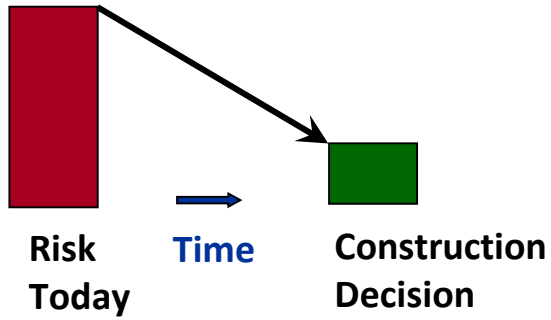
- Enhanced safety and security
- Lower capital cost capacity additions
- More flexibility to meet electricity demand; more distributed and more incremental
- More operational flexibility; load-following and continued operation during loss of off-site power
- Smaller footprint and reduced emergency planning zone lead to more siting options; opportunity to repower coal plants

Option for reliable and carbon-free electricity generation in affordable increments!

Challenges to an Advanced Reactor Build Decision



- New design features
- **Testing and code validation**
- Regulatory policy
- **NRC licensing**
- **Fuel design and supply**
- **Supply chain readiness**
- Capital costs
- **Operating costs**
- **Deployment schedule**
- **Project management**
- **Economics/Business Case**
- Sustainable policy support
- **Financing and contracting**



Economic Considerations

- Traditional Large Light Water Reactors
  - Average for 2 AP 1000 reactors (Vogtle/Summer) Wikipedia
    - ~ $12B - $14B for 2250 MW
    - ~ 2013: nuclear construction start, 2019 - 2020: forecast completion
- NuScale – current vendor estimate
    - ~ $3B for 570 MW
    - ~ 3 years to construct
- SMR Value Considerations
  - Modular construction
  - Reduced construction period
  - Reduced financing costs
  - Potential for reduced transmission interconnect costs

Conclusions

- Submitted Early Site Permit Application (ESPA) to the NRC on May 12, 2016
- Develop an SMR option for TVA and the USA to meet broader nuclear deployment needs in the 2030's
- Take a leadership role in addressing SMR deployment risks in partnership with DOE via potential full-scale demonstration at Clinch River in the mid-2020's
- As long as the option continues to have value to TVA, TVA will make incremental investments commensurate with SMR vendor progress, continued DOE partnership and expectation of an acceptable business case

Acknowledgement and Disclaimer

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Small Modular Reactors & Advanced Nuclear Reactors

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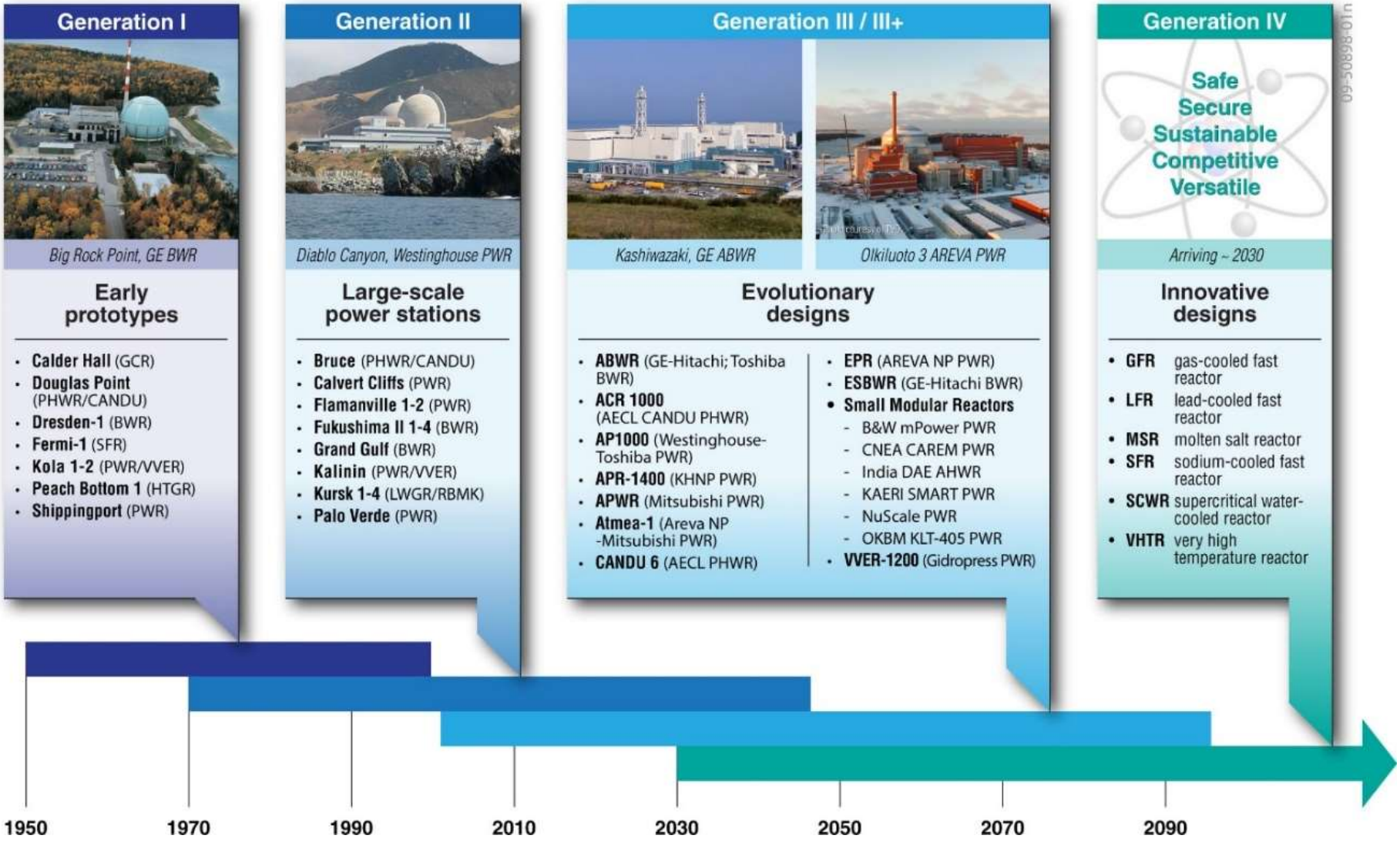
NARUC Subcommittee on Nuclear Issues

July 26, 2016

Electric Power Research Institute

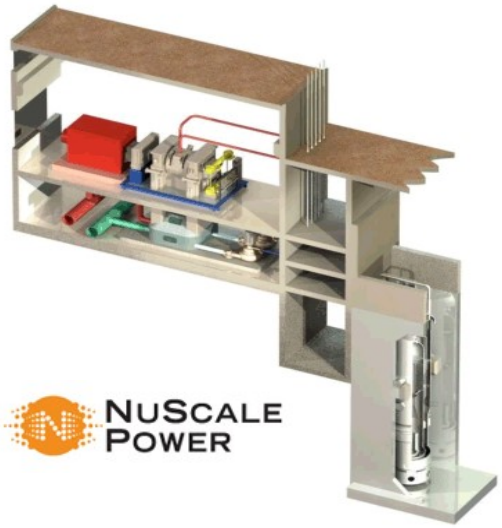
EPRI ELECTRIC POWER RESEARCH INSTITUTE

Nuclear Technology Options



Generation IV International Forum (GIF) website https://www.gen-4.org/. Accessed September 2015

Can Economy of Small be Realized for SMRs?



- Design Simplicity
- Planning, Siting
- Staffing
- Emergency Planning
- Advanced Manufacturing

Together…Shaping the Future of Electricity

For more information contact:

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