

Latin American Section of ANS Meeting

A stylized graphic of an atomic symbol, consisting of several intersecting curved lines and two circular nodes, rendered in a light blue color against the dark blue background.

American Nuclear Society

ANS Initiatives

- Navigating Nuclear project with Discovery Education
- Increase value of ANS to all members
- “Connecting” all parts of ANS
- Grand Challenges
- Incorporation in Illinois
- Supporting U.S. Nuclear Policy Review
- Developing the future leaders in Nuclear Energy
- Special Committee on Advanced Reactors



Perspectives on the Future of Nuclear Power in the United States of America

Latin American Section Annual Meeting
Rio de Janeiro, Brazil

John E. Kelly
President
American Nuclear Society
August 28, 2018

Nuclear Energy A Presidential Priority



ANS



“Begin a complete review of U.S. nuclear energy policy to secure domestic energy independence and to revive and expand the U.S. nuclear energy sector by preserving the nuclear fleet, paving the way for deployment of advanced nuclear designs, and stimulating exports abroad”

Make Nuclear Cool Again



"If you really care about this environment that we live in... then you need to be a supporter of this [nuclear energy] amazingly clean, resilient, safe, reliable source of energy."

Secretary Rick Perry at Press conference, May 10, 2017

Near Term Challenges for Nuclear Power in the U.S.



- Keep current fleet operating
- Resolve cost and schedule for new builds
- Investment/finance for new builds
- Grid of the future
- Waste management
- Achieving national security objectives thru the supply chain
- Advanced SMR deployment
- Gen IV development and demonstration

Decarbonization of Electricity Production by 2050



<u>Source</u>	<u>2010</u>		<u>2035</u>			<u>2050</u>
	Elect (TWhr)	CO ₂ (Gton)	Elect (TWhr)	CO ₂ (Gton)		Elect (TWhr)
Natural Gas	1000	0.44	1520	0.51	~0	
Coal	1730	1.58	1600	1.66	~0	
Fossil (CCS)	0	0	?	0		1600
Nuclear (Large)	790	0	870	0		900
Nuclear (SMR)	0	0	?	0		700
Hydro	325	0	300	0		300
Renewable	200	0	440	0		2100
Petroleum/Other	50	0.04	40	0.03	~0	
TOTAL	4095	2.05	4970	2.2	~0	5600

2013 U.S Electricity Consumption and CO₂ Emissions. EIA **CE=32%**

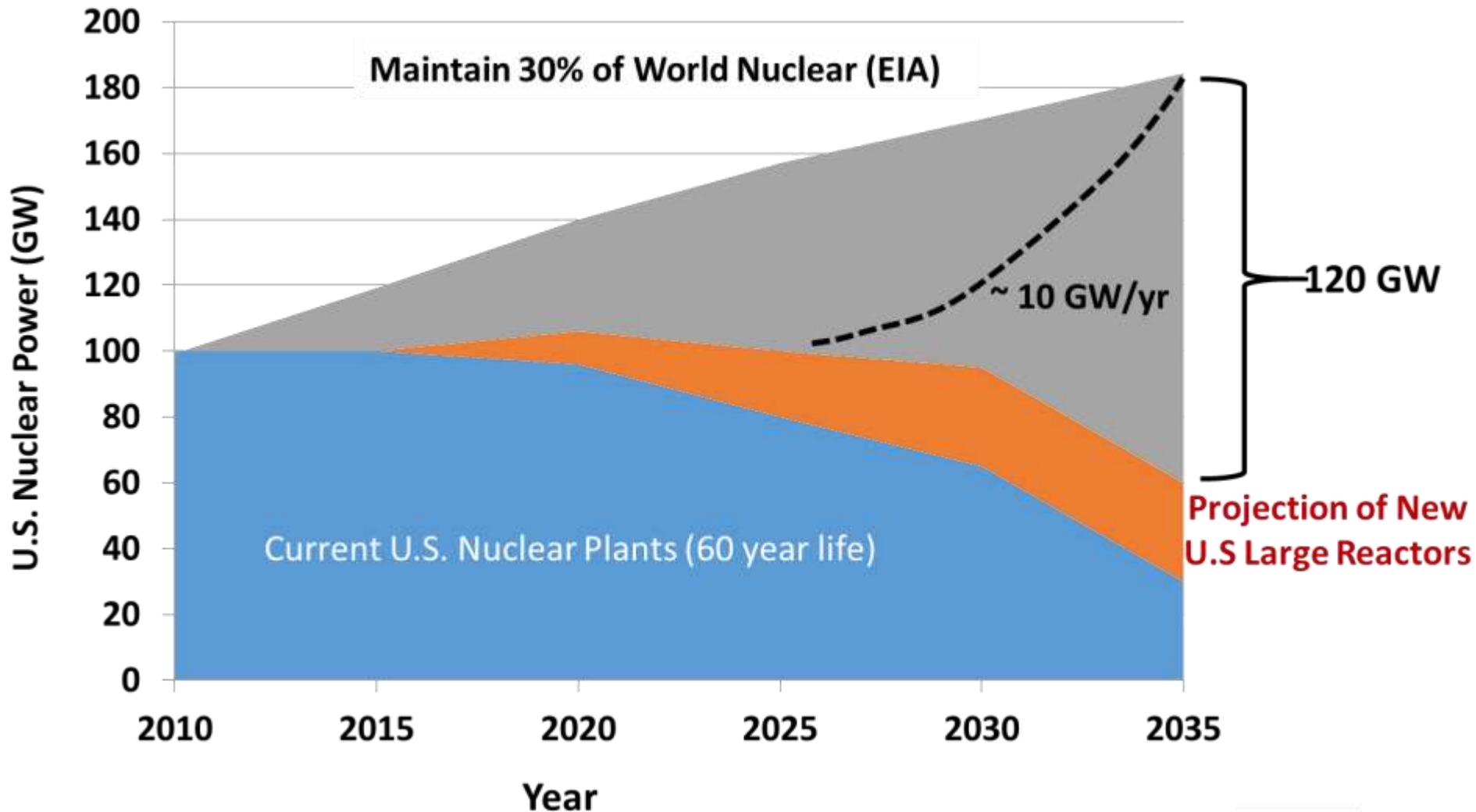
Projections to 2050
CE= 100%

Source: EIA, Annual Energy Outlook 2013

Global Leadership in Nuclear Power



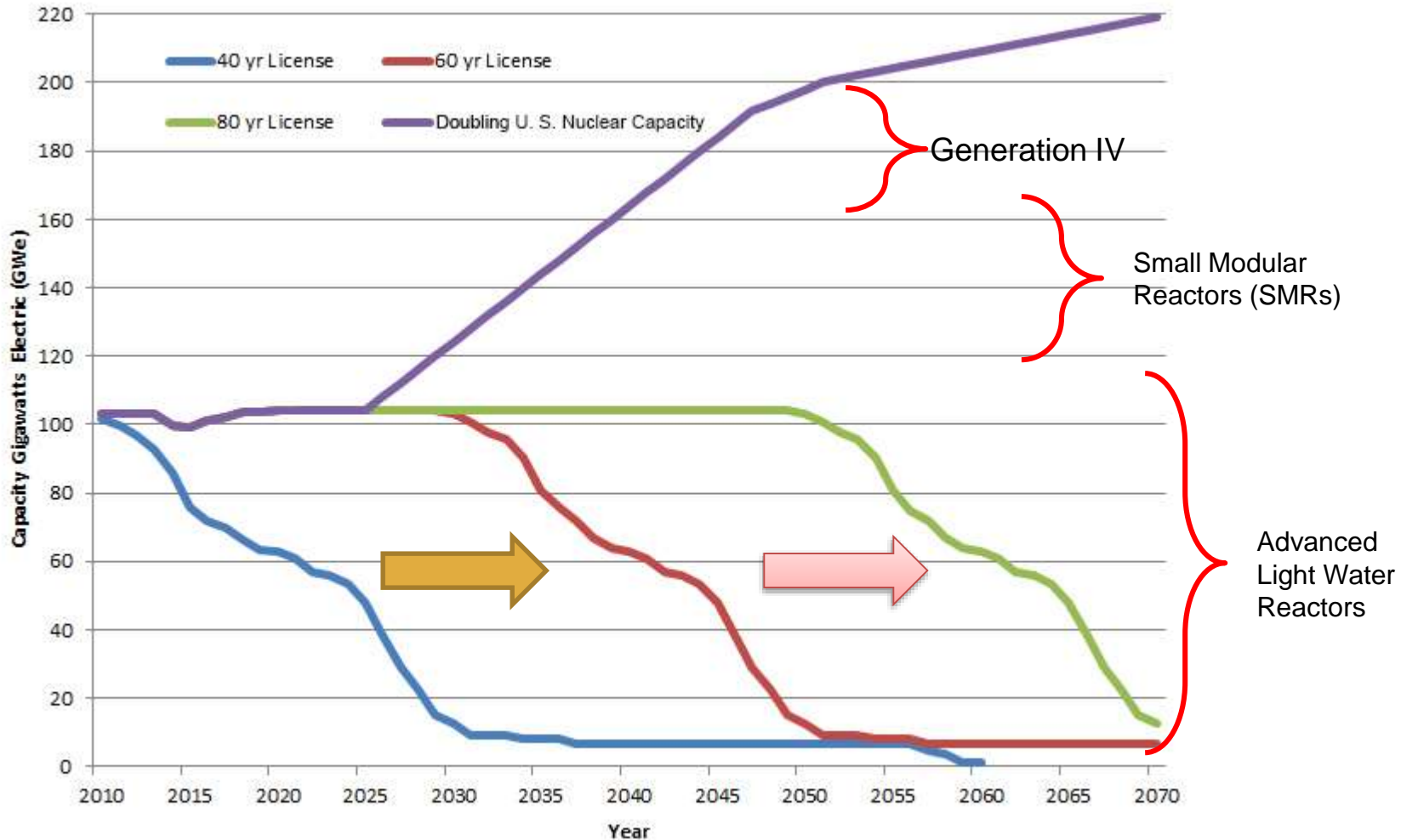
ANS



Nuclear Power Capacity Needed to Meet Future Electricity Demand



ANS



Keeping the Current Fleet Operating



ANS

- **Future of US nuclear industry is very dependent on keeping the current fleet operating**
 - Revenues
 - Sustainability of supply chain
 - Workforce development
- **Complex Situation**
 - Reform market policies and structure
 - Utilities seeking near term support from States
 - Reduce operating costs
 - Subsequent License Renewal



Nine Mile Point ~ Courtesy Exelon

Enhanced Accident Tolerant Fuel



ANS

Develop a new fuel/clad system that would be more tolerant to accident conditions

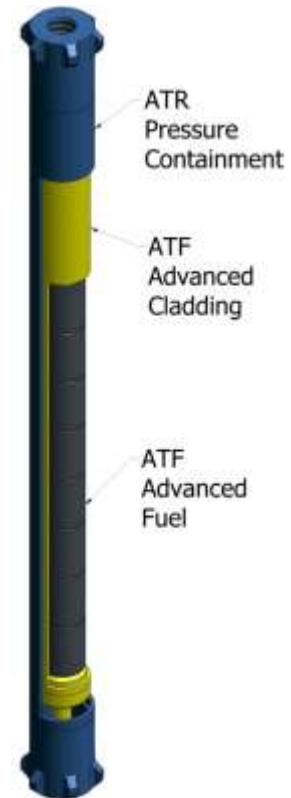
- Eliminate or reduce hydrogen production
- Withstand higher temperatures

3 vendors

- Framatome
- Westinghouse
- GE

Range of concepts

- Coatings on Zr
- New cladding material
- Higher thermal conductivity fuel
- Si-C cladding



Schematic drawing of the capsule-rodlet assembly for the new accident tolerant fuel experiment in the Advanced Test Reactor (6.2 inches long, 0.4 inches in diameter).

New Builds in U.S.

Will these be sufficient to overcome existing plant retirements?



■ First new reactors being built in U.S. in 30 years

- Facing first-of-a kind challenges

■ Nuclear construction

- Vogtle
- V.C. Summer?

■ Challenges for nuclear deployment

- High capital cost
- Lower electricity demand
- Low natural gas prices
- Market structure issues



*Vogtle Unit 3
Courtesy of Georgia Power*



*V.C. Summer Unit 2
Courtesy of SCANA*

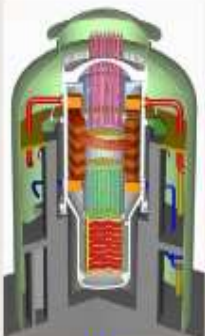
Small Modular Reactors



Light Water Cooled SMRs



CAREM-25
Argentina



IMR
Japan



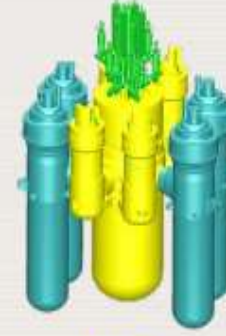
SMART
Korea, Republic of



VBER-300
Russia



WWER-300
Russia



KLT-40s
Russia



mPower
USA



NuScale
USA



Westinghouse
SMR - USA



CNP-300
China, Peoples Republic of



ABV-6
Russia

IAEA definition:
< 300 MWe

Potential Benefits:

- Factory fabrication
- Reduced onsite construction
- More flexible siting
- Modular expansion
- Faster return on investment

Why the Interest in SMR Technologies?

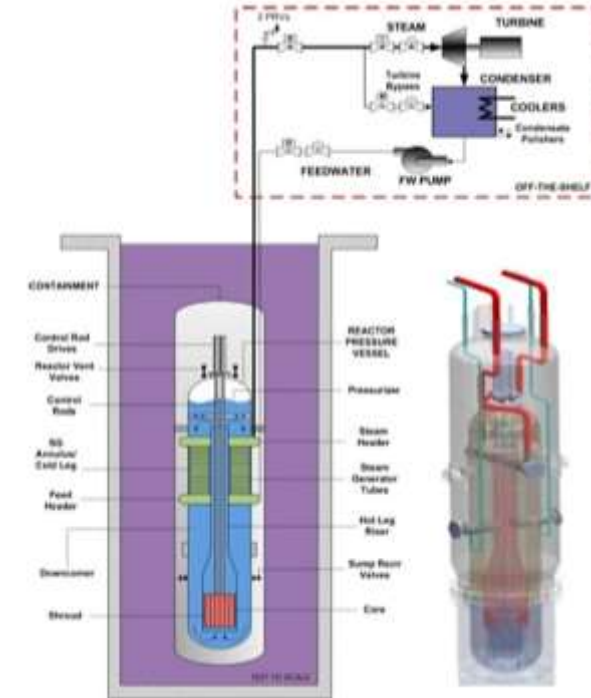


Potential Benefits

- Enhanced safety and security
- Reduced capital cost makes nuclear power feasible for more utilities
- Shorter construction schedules due to modular construction
- Improved quality due to replication in factory-setting
- Meets electric demand growth incrementally
- Domestic job creation potential very high

Potential Markets

- Domestic and international utility markets
- Non-electrical (process heat/desalination) customers



Current Status of SMRs in the US

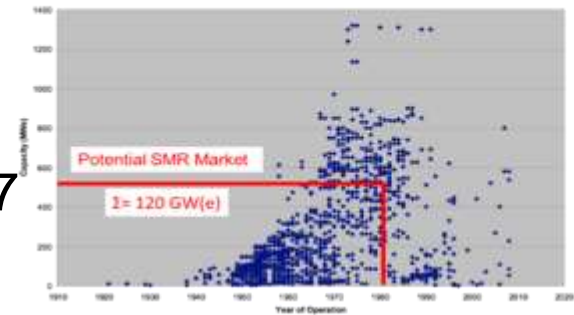


ANS

NuScale

- Design Certification Application (DCA) submitted to the NRC in January 2017
 - NRC accepted and docketed March 2017
 - DCA review and approval expected in 2021

Clean Energy Option



U.S. Coal Plant Capacity vs. Age

NuScale/UAMPS Siting

- Site use agreement for a site on the INL
 - Preferred site identified in August 2016

Microgrids



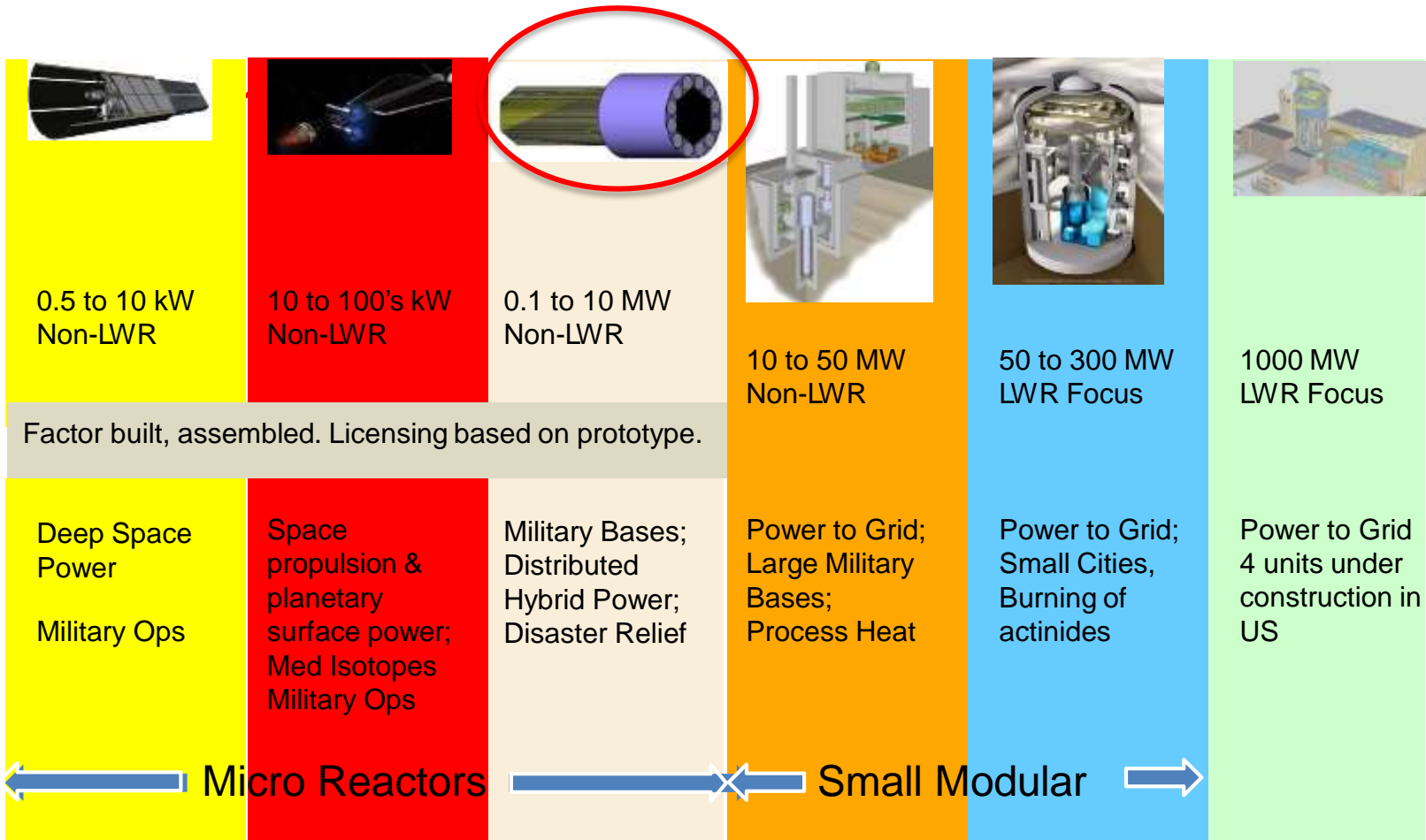
TVA Siting

- Submitted Early Site Permit Application to NRC
 - Review commenced January 2017, completed in approximately 30 months

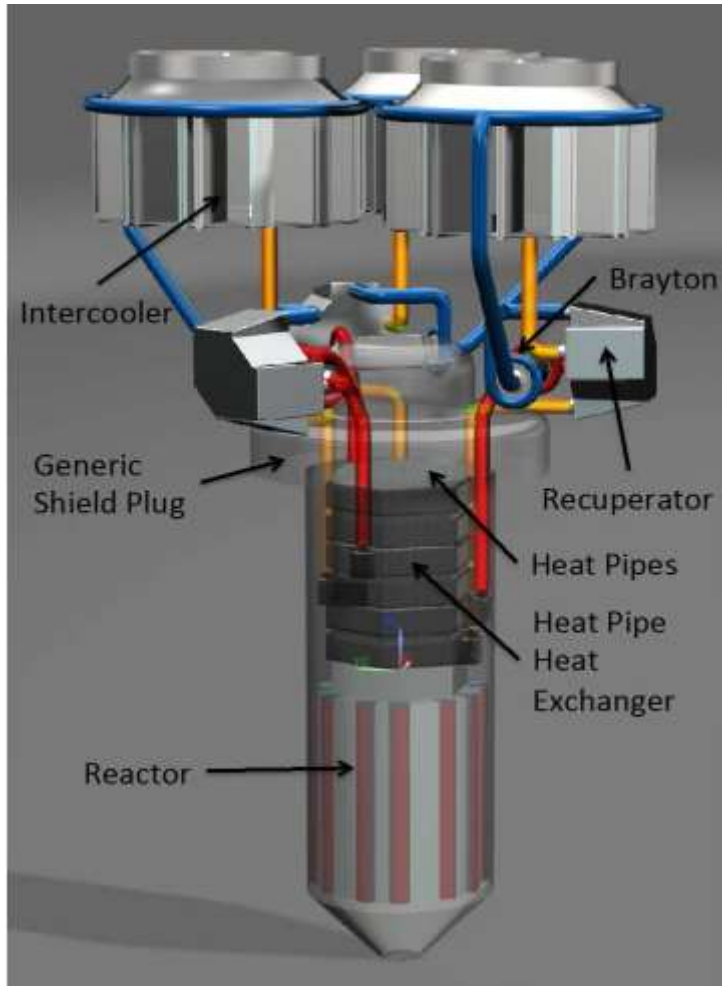
Factory Fabrication



Growing interest in Micro Reactors

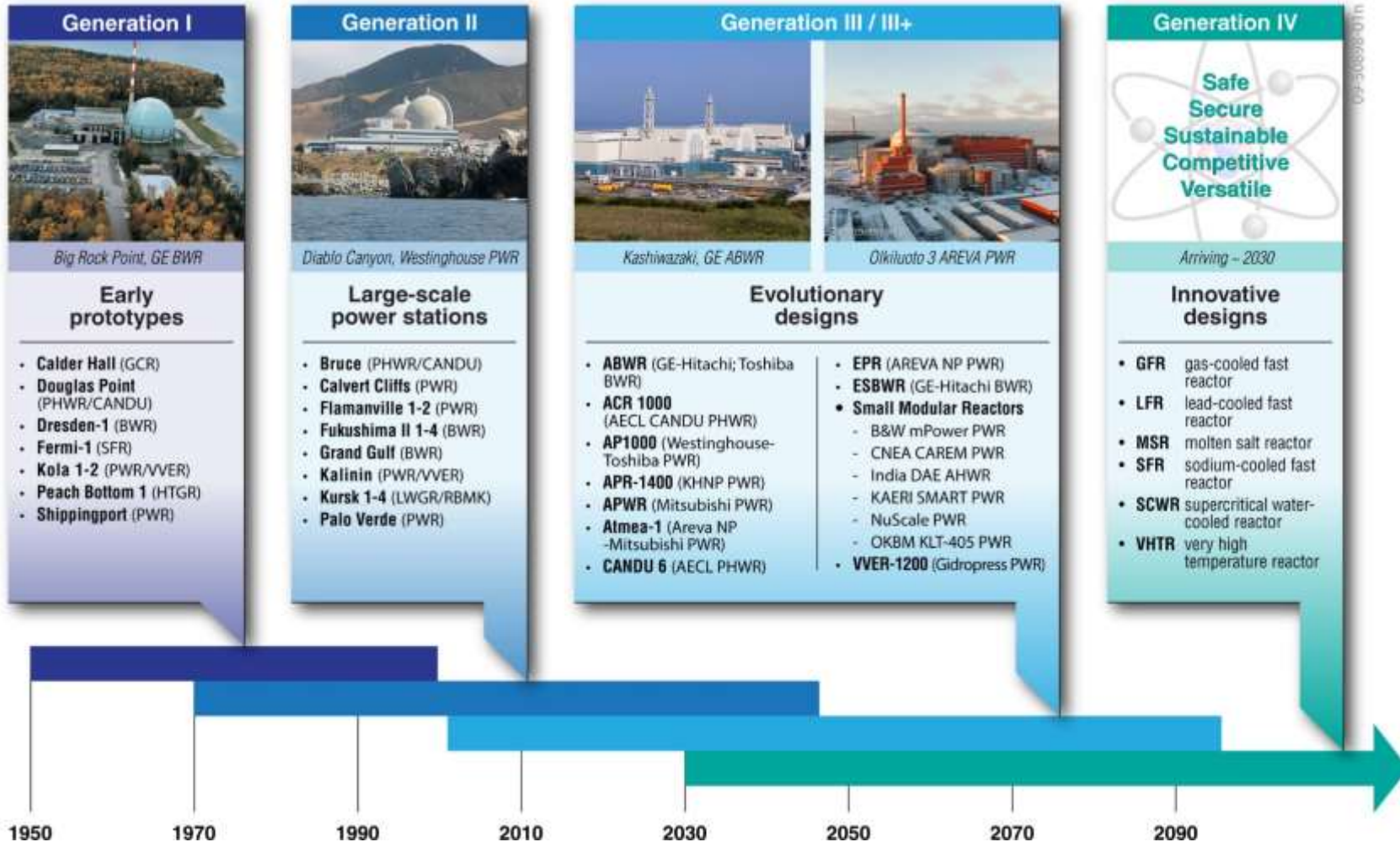


LANL MegaPower Reactor Design



- 0.5-5 MW electric (DoD Base)
- No moving parts or high pressure
- Heat pipe cooled (no water)
- Encapsulated in armored transport cask
- LE-UO₂ fuel (16-19% enriched)
- Different Power Conversions Systems





Generation I



Big Rock Point, GE BWR

Early prototypes

- **Calder Hall** (GCR)
- **Douglas Point** (PHWR/CANDU)
- **Dresden-1** (BWR)
- **Fermi-1** (SFR)
- **Kola 1-2** (PWR/VVER)
- **Peach Bottom 1** (HTGR)
- **Shippingport** (PWR)

Generation II



Diablo Canyon, Westinghouse PWR

Large-scale power stations

- **Bruce** (PHWR/CANDU)
- **Calvert Cliffs** (PWR)
- **Fliamanville 1-2** (PWR)
- **Fukushima II 1-4** (BWR)
- **Grand Gulf** (BWR)
- **Kalinin** (PWR/VVER)
- **Kursk 1-4** (LWGR/RBMK)
- **Palo Verde** (PWR)

Generation III / III+



Kashiwazaki, GE ABWR



Olkiluoto 3 AREVA PWR

Evolutionary designs

- **ABWR** (GE-Hitachi; Toshiba BWR)
- **ACR 1000** (AECL CANDU PHWR)
- **AP1000** (Westinghouse-Toshiba PWR)
- **APR-1400** (KHNP PWR)
- **APWR** (Mitsubishi PWR)
- **Atmea-1** (Areva NP -Mitsubishi PWR)
- **CANDU 6** (AECL PHWR)
- **EPR** (AREVA NP PWR)
- **ESBWR** (GE-Hitachi BWR)
- **Small Modular Reactors**
 - B&W mPower PWR
 - CNEA CAREM PWR
 - India DAE AHWR
 - KAERI SMART PWR
 - NuScale PWR
 - OKBM KLT-405 PWR
- **VVER-1200** (Gidropress PWR)

Generation IV



Arriving ~ 2030

Innovative designs

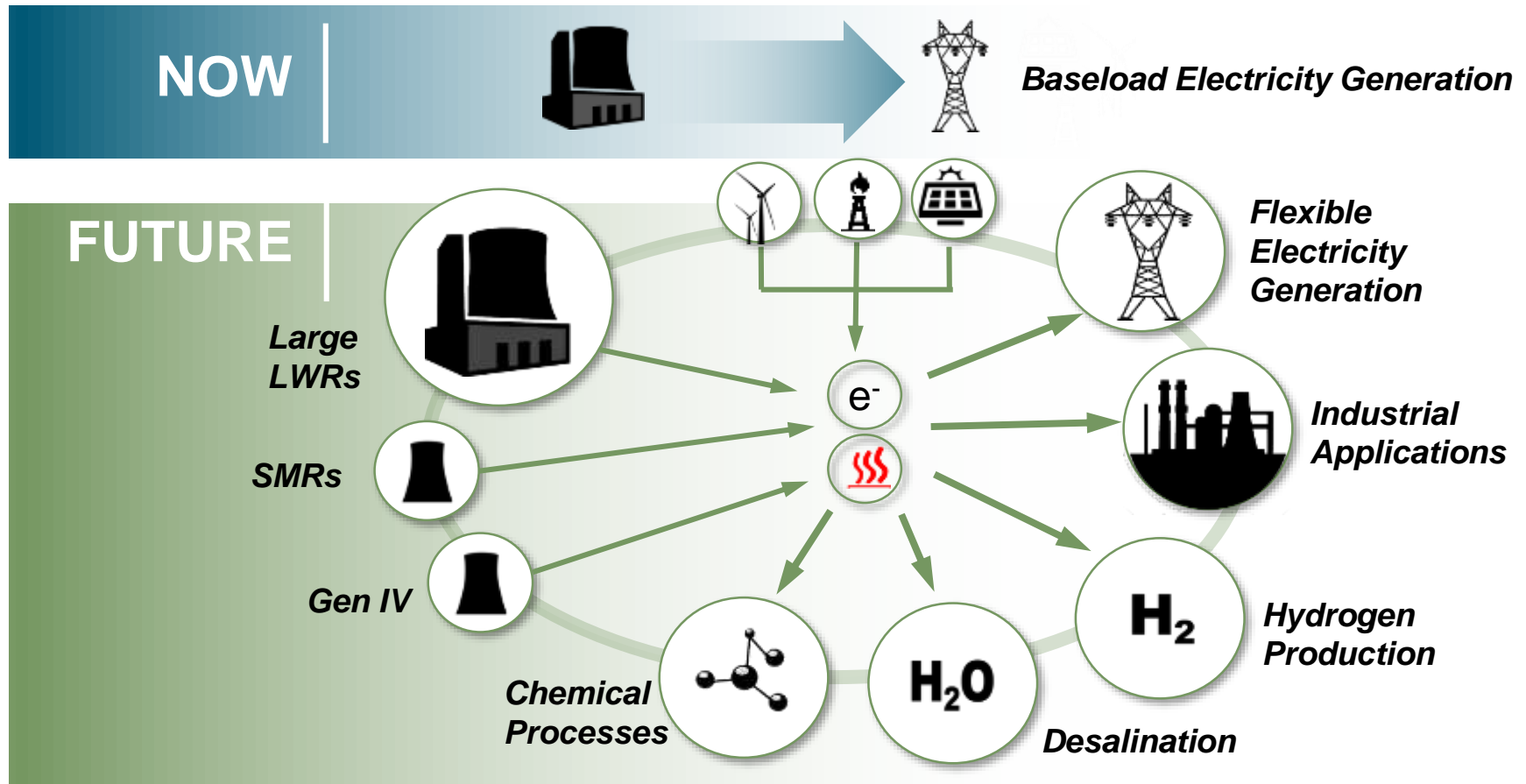
- **GFR** gas-cooled fast reactor
- **LFR** lead-cooled fast reactor
- **MSR** molten salt reactor
- **SFR** sodium-cooled fast reactor
- **SCWR** supercritical water-cooled reactor
- **VHTR** very high temperature reactor

09-00898-0111

Nuclear Energy Beyond Electricity



ANS

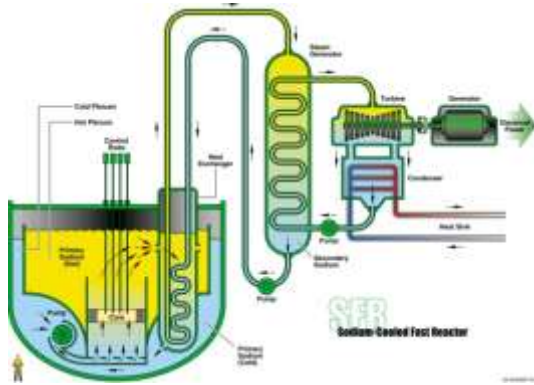


Flexible Generators ❖ Advanced Processes ❖ Revolutionary Design

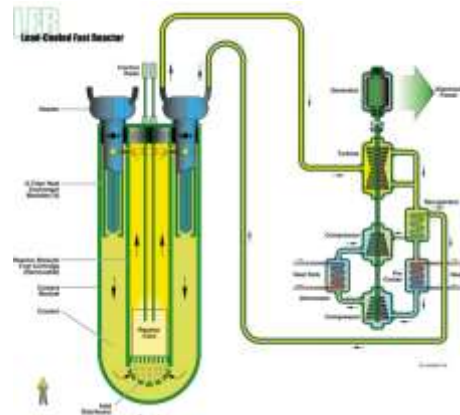


- Formed to develop education and training materials related to Generation IV systems
- Created a webinar series (monthly) to provide presentations for the general public on the Gen IV systems and cross-cutting topics
- **See www.Gen-4.org**
- Connecting with other nuclear education organizations to share information on educational opportunities and Summer Schools

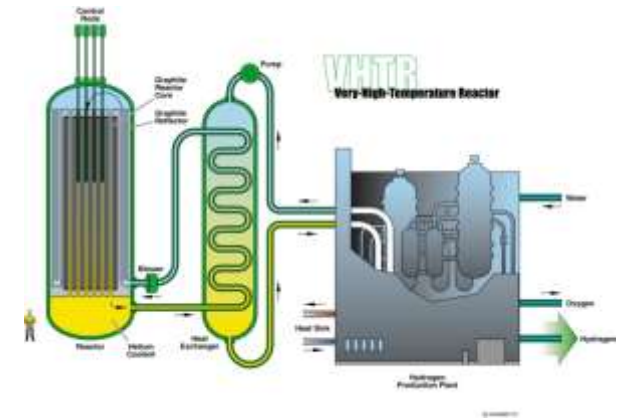
Generation IV Reactor Concepts



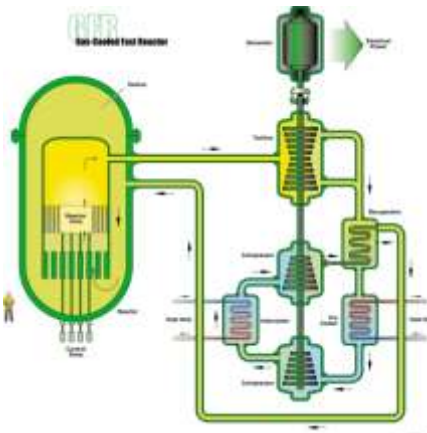
Sodium Fast Reactor



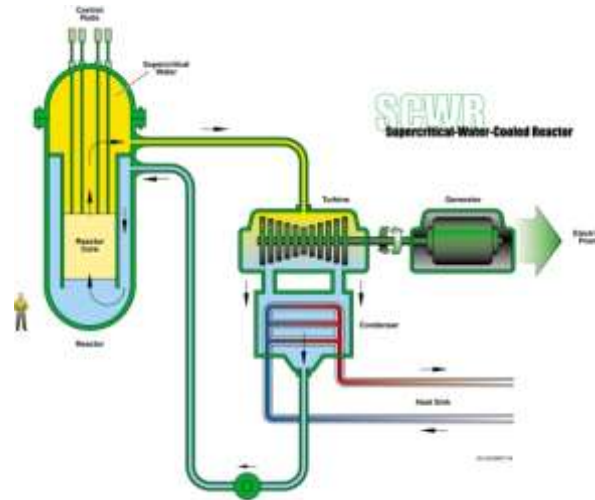
Lead Fast Reactor



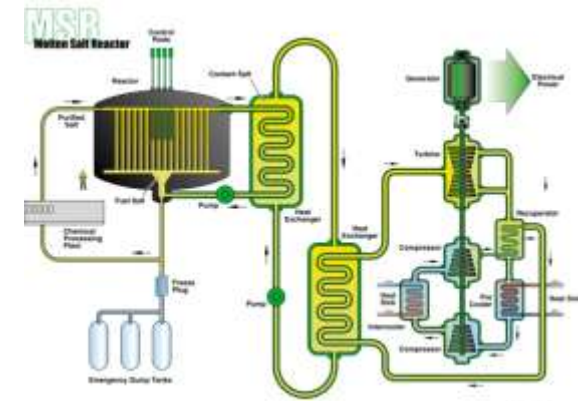
Very High Temperature Reactor



Gas Cooled Fast Reactor



Supercritical Water Cooled Reactor



Molten Salt Cooled Reactor

Over 20 Advanced Fission Reactor Designs in the United States



Sodium Fast Reactor

- TerraPower, General Electric, OKLO, etc

High Temperature Gas Reactor

- X-Energy, AREVA, TerraPower, Hybrid Energy, Ultra Safe, etc

Molten Salt Reactor

- TerraPower, Transatomic, Terrestrial, Elysium, FLIBE Energy, Kairos, etc

Lead Fast Reactor

- Westinghouse, Gen IV Energy, Lake-Chime, etc

Gas Fast Reactor

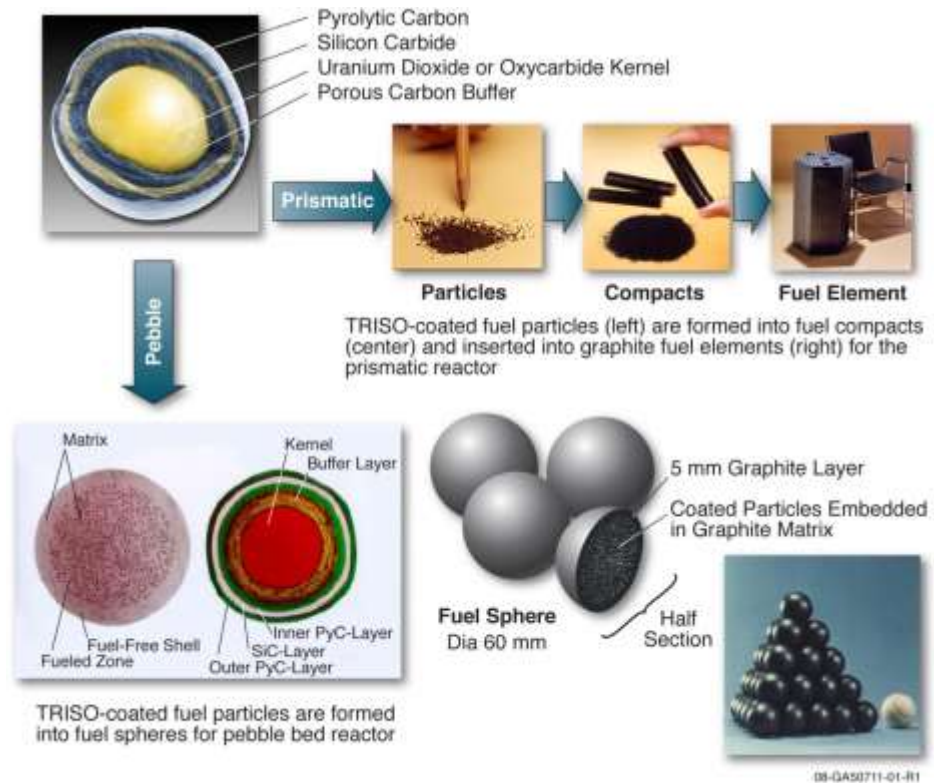
- General Atomics

High Temperature Gas Reactor TRISO Fuel



Key aspects of TRISO Fuel:

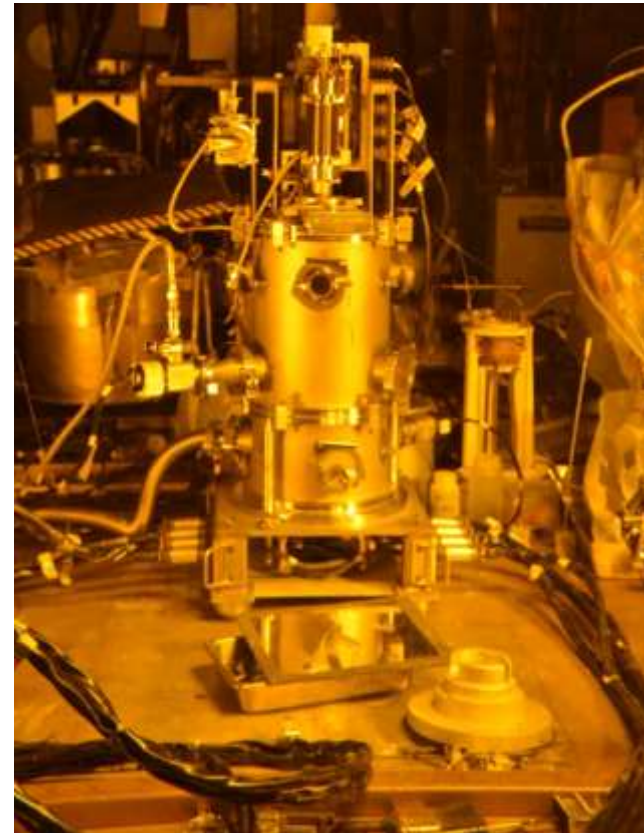
- German industrial experience demonstrated TRISO-coated particle fuel can be fabricated to achieve high-quality levels with very low defects.
- Fuel is very robust with no failures anticipated during irradiation and under accident conditions.
- Fuel form retains fission products resulting in a high degree of safety.



Fast Reactor Fuels



- Advance the scientific understanding and engineering application of fuels for use in future fast-spectrum reactors, including:
 - fuels for enhanced resource utilization (including actinide transmutation),
 - support for driver/startup fuel concepts.
- Advanced fabrication methods including remote fabrication.
- Demonstrate acceptable performance of fast reactor fuels including
 - recycled metallic fuels
 - ultra high burnup
- Support development and validation of an advanced fuel performance code.



Remote casting furnace in HFEF

Summary



- Nuclear power must be a major source of our energy production to meet global future energy needs
- Continue the safe and reliable operation of the current fleet
- Deploy SMRs in mid-2020's
- Track emerging interest in Micro Reactors
- Develop Generation IV reactor technologies for deployment in the 2030's





American Nuclear Society

ans.org