

Defining a Role for Advanced Nuclear Generation in the 21st Century

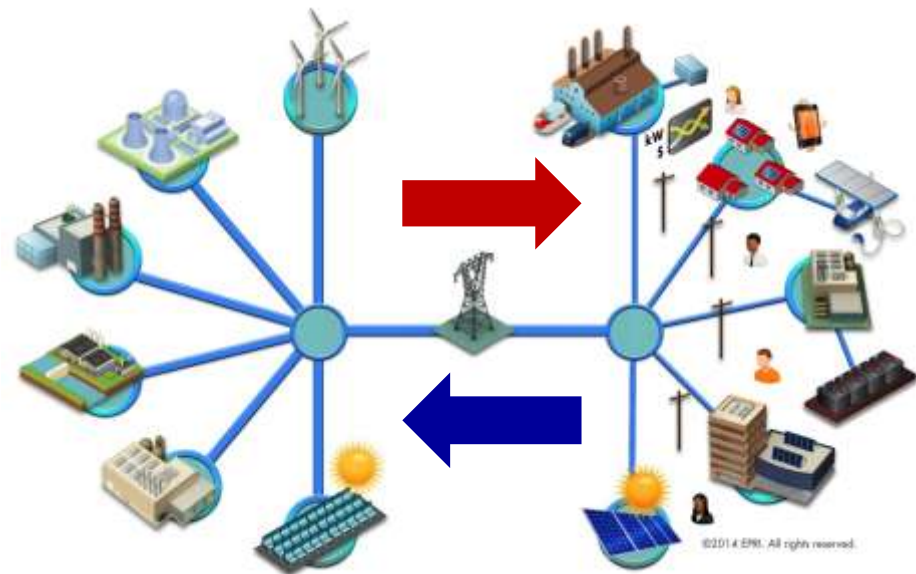
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Nuclear Infrastructure Council
Advanced Reactor Summit III
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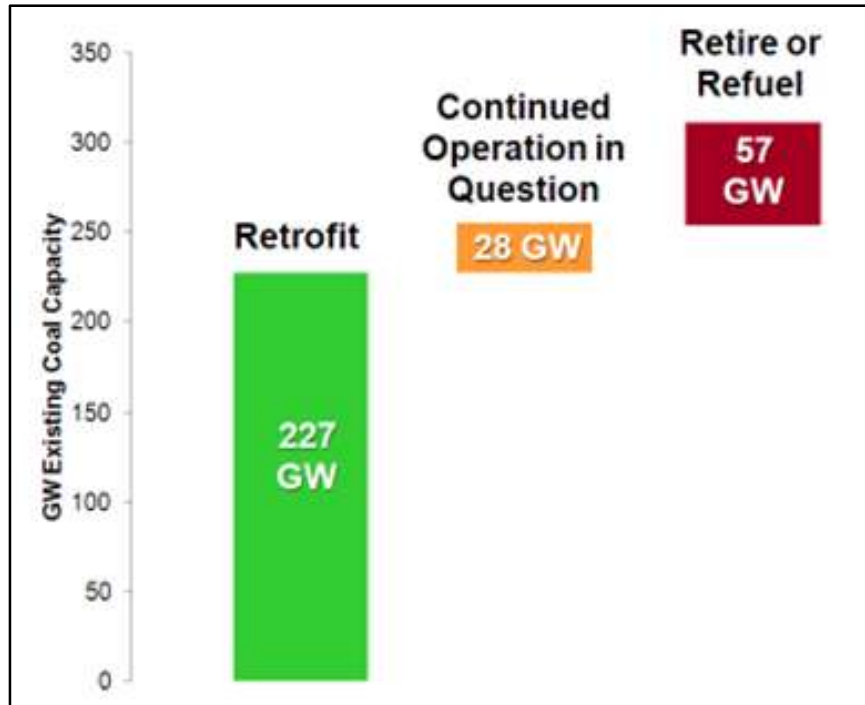
The Commercial Environment for Nuclear is Changing

- Developed energy markets must adapt large, aging infrastructures to maintain adequate energy and capacity
- Developing energy markets face challenge and opportunity of “clean slates” and new choices
- New paradigms to support future energy infrastructure:
 - flexibility
 - resilience
 - connectivity
- Uncertainty is only certainty:
 - price of natural gas?
 - price of carbon emissions?
 - new technology (or lack thereof)?



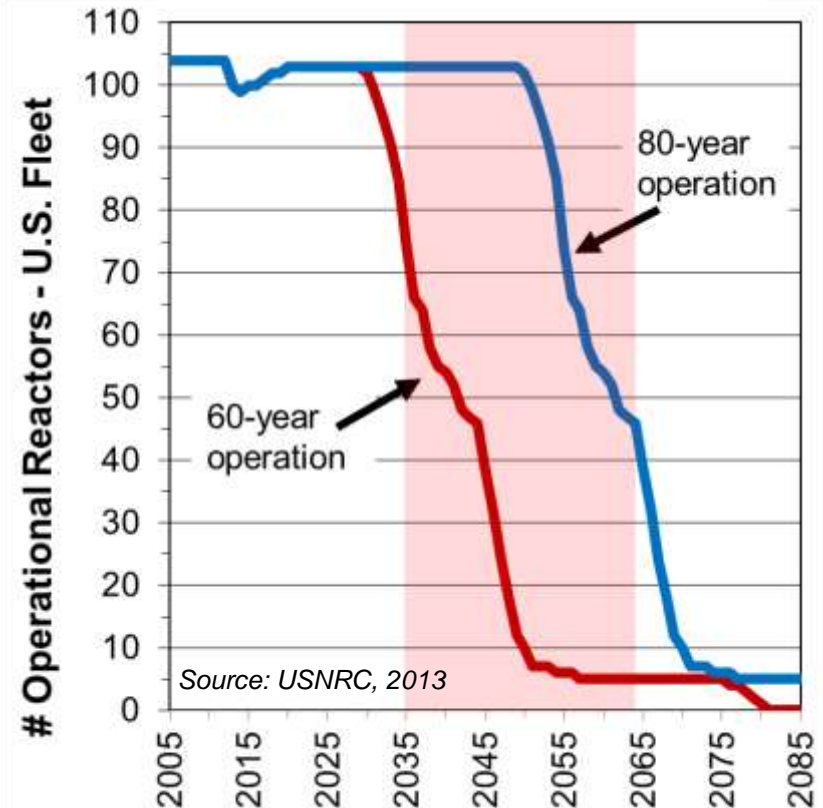
Uncertainty and Opportunity: Drivers for New Nuclear?

Coal Capacity at Risk:
Reference Case for 2020



Source: EPRI (2102) 1026743. PRISM 2.0: The Value of Innovation in Environmental Controls - Summary Report.

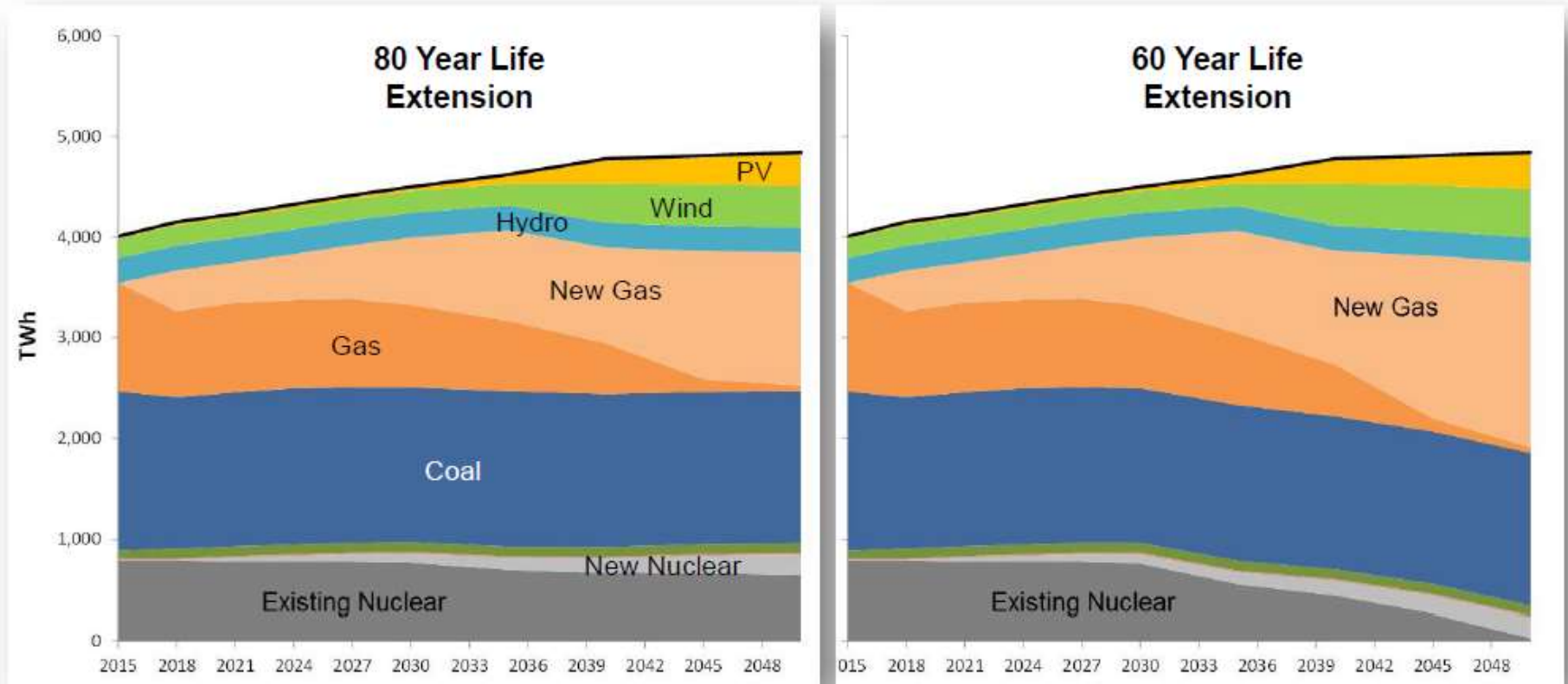
Retirement of US LWR Fleet



- Utilities will want/need options for intensive, low carbon energy
- Many plans and projections assume 80% of existing LWRs operate to 80 years

Challenge and Opportunity: \$2 trillion in coal and nuclear generation at risk in the United States alone.

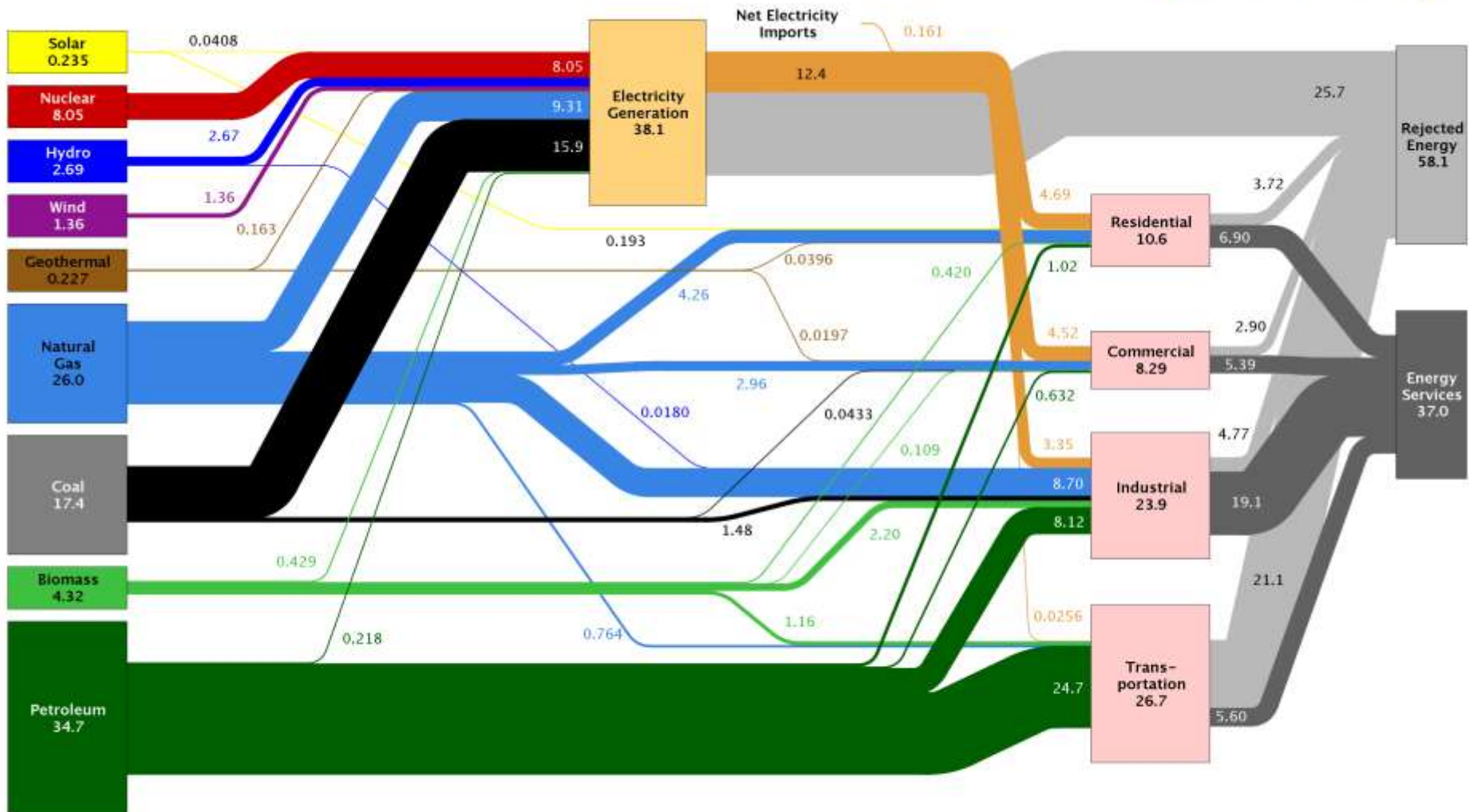
U.S. Electricity Generation without Carbon Policy



Note: US-REGEN. Does not include CPP but does reflect other recent EPA regulations.

The Need and Opportunity Extend Beyond Electricity

Estimated U.S. Energy Use in 2012: ~95.1 Quads



Source: LLNL 2013. Data is based on DOE/EIA-0035(2013-05), May, 2013. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Are Storable Commodities and New Markets the Future Play for Advanced Nuclear?

- Hydrogen as the dominant energy carrier for transportation
 - displacing petroleum
 - leap frogging battery technology

- Potable water as the “oil” of the 21st century
 - 50% of world’s population within 200 km of coast
 - fresh water comprises only 2.5% of earth’s water; of this only 1% is readily accessible for use
 - trading of water as a commodity has begun

The Mirai, the world's first fuel cell vehicle for the mass market



http://www.toyota-global.com/innovation/environmental_technology/fuelcell_vehicle/

“Toyota sees great potential in hydrogen and fuel cell vehicles.”

Cogeneration is Not New to Nuclear

Diablo Canyon's Desalination Facility to Help Fight California Drought

- PG&E enters five-year agreement with county
- Desalinated water to fight wildfires; other uses under study
- Integrated nuclear and desal facilities used in Japan, India and Kazakhstan

June 18, 2015—As California suffers through its fourth straight year of drought, increasingly severe shortages of water are raising alarms. The state has issued stringent water conservation measures for cities and towns as well as in the state's vast agriculture industry.

San Luis Obispo County, on California's Central Coast, has found an innovative way to supplement its rationed supply of fresh water. The Diablo Canyon Nuclear Power Plant has an on-site desalination facility that it uses to generate fresh water from seawater, both to cool the plant and for its employees' drinking water needs.



photo: PG&E

NEI SmartBrief, June 18, 2015.



photo: Fluor

The Midland Nuclear Power Plant, abandoned at 85%, was later converted to a combined-cycle, natural-gas-fired cogen facility.

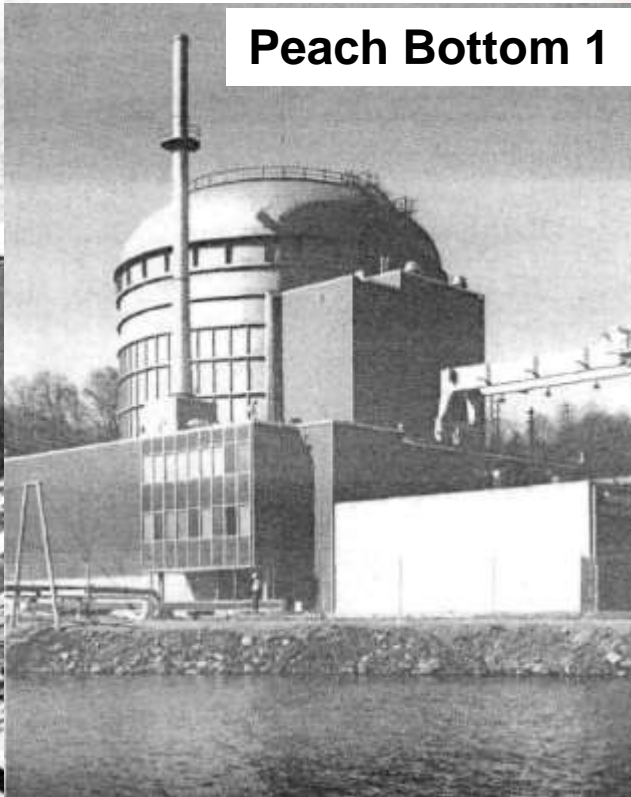
<http://www.fluor.com/projects/gas-fueled-power-plant-epc-commissioning>

Time to Reimagine the Public-Private Partnership for Bridging the Demonstration to Deployment Divide?

Fermi 1



Peach Bottom 1



Piqua



CVTR



These non-LWRs were built with >50% industry investment and operated by utilities.

Images from U.S. Atomic Energy Commission (1967)

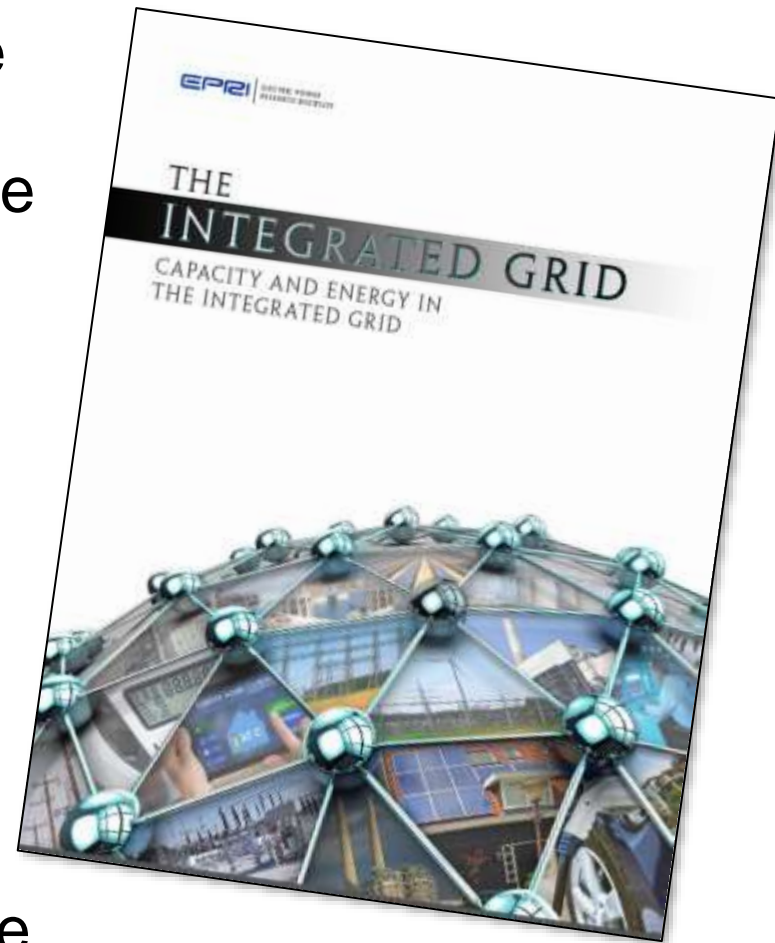
EPRI Perspective on GEN IV Role

- Maintaining nuclear role in 21st century will be challenging in terms of scale and timing for meeting:
 - generation capacity needs
 - emission targets
- GEN IV can/should complement GEN III/III+
 - no Generation IV without healthy Generation II/III/III+
 - GEN II/III will continue to provide nuclear generation backbone through 2100
- Sustained future role for nuclear energy in many countries, markets will require more compelling business case(s) derived from GEN IV technology attributes:
 - enhanced passive safety from inherent physical properties of design
 - natural resource amplification via high conversion or breeding
 - **asset flexibility: deployment, operations and products**

Compelling commercial drivers and owner/operator requirements have not been clearly articulated.

EPRI Has Established a Formal GEN IV RD&D Program

- Vision: EPRI will play a leading role to enable commercialization of advanced nuclear generation in time to make a difference
- Objective: Build foundation for advanced nuclear technology now for options later (*i.e.*, 2030 +)
- Four-year funding commitment as part of a broader EPRI strategic focus on a flexible, resilient and integrated energy infrastructure
- Successful leveraging of resources to yield outcomes comparable to the ALWR program



EPRI-led Activities Under GEN IV Program

- Scout global advanced reactor and enabling technologies
- Articulate what the technology *customer* (owner/operator) wants/needs
- Define what roles advanced nuclear can play in future power systems and broader energy infrastructures
- Identify and support viable RD&D pathways to commercialization through collaboration
- Provide independent, credible technology assessments and analyses



Together...Shaping the Future of Electricity