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Status of New Nuclear

November 8, 2023

FLORIDA PUBLIC POWER

FMEA
FLORIDA MUNICIPAL ELECTRIC ASSOCIATION

Agenda

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- Current Operating Nuclear Fleet
- Advanced Nuclear / SMR Designs
- Nuclear Siting Announcements
- Estimated Costs
- Schedule for Deployment
- Recent and Proposed Policy Changes
- Deployment Risks
- Summary

Current Operating Nuclear Fleet

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- Ninety-three (93) operating nuclear units
  - Light Water Reactors
  - Capacity ranges from ~600MW - ~1400MW
- 12 operating nuclear units prematurely shutdown since 2012
  - Most reactor shutdowns due to market pressures
  - Some states have provided financial support to prevent other shutdowns - Illinois, California, New York, Connecticut and New Jersey
  - Michigan approved funding to support potential restart of Palisades Nuclear Plant
- Capacity Factors increased significantly over the years
  - ~2/3^{rds} of reactors with > 90% capacity factors
  - Capacity factor for remaining reactors between 80% - 90%

Current Operating Nuclear Fleet

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- License Renewal
  - 60 year license - 63 of 93 units have received extended or submitted application
  - 80 year license - 9 of 93 units have received or submitted application
  - Significant additional interest in License Renewal from other reactor owners
  - 100 year license - ongoing industry evaluations

- Fleet Operating Costs
  - The current fleet of nuclear reactors have benefited from the long-term licenses and high-capacity factors
  - Distinct increase caused by Fukushima, 9/11 and uprates

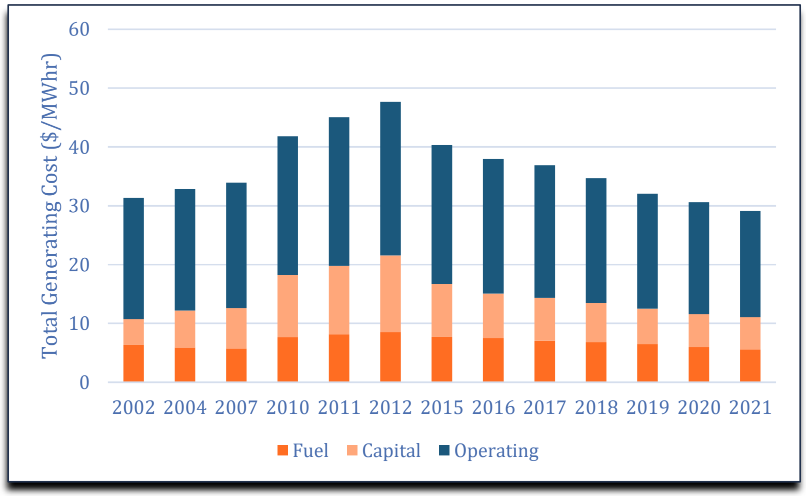
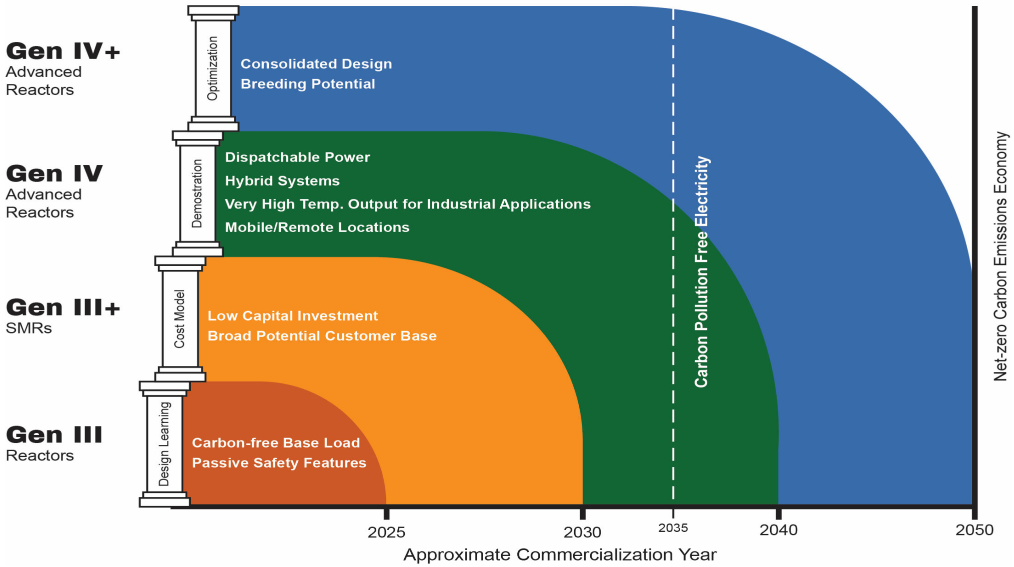


Figure adapted from NEI Nuclear Cost in Context Report

SMR Designs

- Gen III+: Light Water Reactors (LWRs) Selected Vendors
    - GE-H BWRX-300 – 300 MW_e
    - Westinghouse AP300 – 300 MW_e
    - Holtec SMR-160+ – 160 MW_e
    - NuScale VOYGR (50 MW_e (licensed) →77 MW_e)
  - Advantages
    - Passive safety systems
    - Significant operating experience with LWRs
    - Standard low enriched fuel
  - Steam temperature for Gen III+ designs lower temperature for some industrial applications
    - Electrical superheat required



Advanced Reactor Designs

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- Advanced Reactor Designs (Gen IV) Designs / Selected Vendors
  - High Temperature Gas Cooled – X-Energy: XE-100 (ARDP Project) – 80 MWe
  - Sodium Cooled – Terrapower: Natrium (ARDP Project) -345 MWe
  - Molten Salt - Kairos Power – Hermes Test Reactor (in Oak Ridge, TN) – 35 MWth
  - Advantages
    - High steam temperatures for industrial applications, including hydrogen production
    - Energy storage or ramp rate to accommodate intermittent renewable generation
    - Sodium cooled reactors can be used for recycling spent nuclear fuel and minimizing waste volume
    - TRISO fuel provides additional barrier for fission biproducts
  - Limited operating and licensing experience when compared to LWRs
  - Limited capacity for HALEU fuel enrichment – federal support to increase enrichment capacity

Industrial Temperatures →

Hydrogen and Ammonia Production

>700°C
Natural Gas Reforming

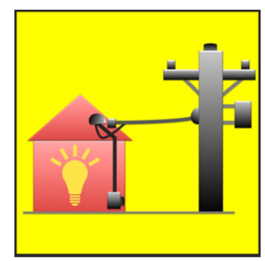
>400°C
Haber-Basch

Industrial Temperatures →

Chemical and Load Following Applications

>300°C
Methanol production

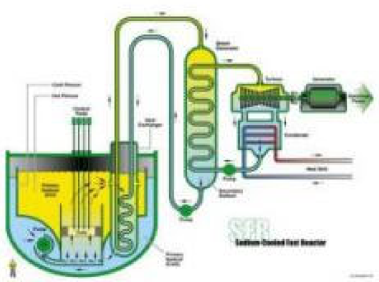
>370°C & < 590 °C
Petroleum Refining



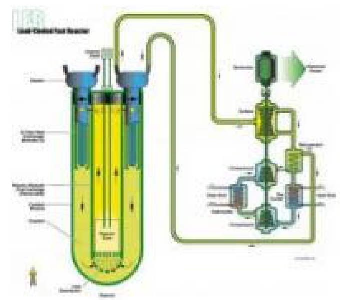
8%/minute
Ramp rate

Advanced Nuclear/SMR Designs

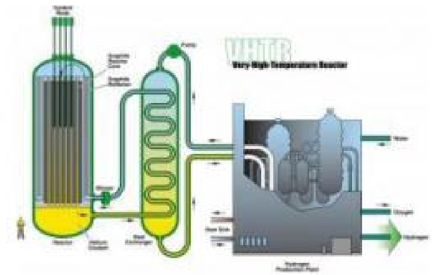
Gen IV - 6 Focus “Reactor Design Families” of the Gen IV Forum



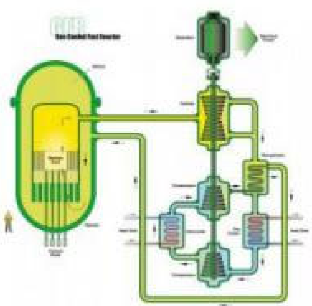
Sodium Fast Reactor



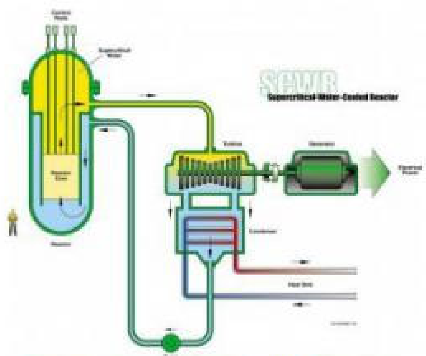
Lead Fast Reactor



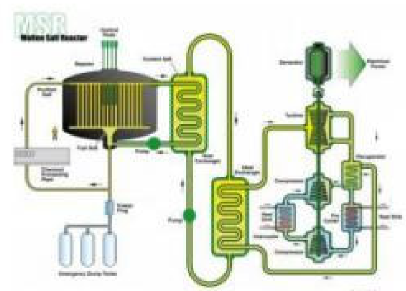
Very High Temperature Reactor



Gas Cooled Fast Reactor



Supercritical Water Cooled Reactor



Molten Salt Cooled Reactor

Advanced Nuclear/SMR Designs

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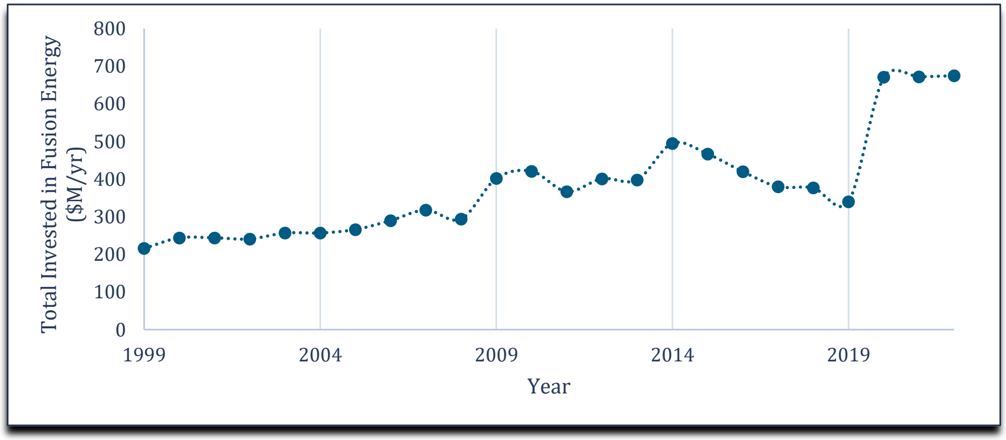
- Microreactors
  - Many companies targeting deployment by 2030
  - Focus on modularity and efficient manufacturing practices
  - Large Emphasis on transportability for some of the DOD applications (Project Pele) – BWXT

Microreactor Company	Reactor	Nameplate Capacity (MWe)
Westinghouse	eVinci	5
USNC	MMR	3.5 – 15
	Pylon	1.5 – 15
OKLO	Aurora	15
BWXT	BANR	1 – 5
Radiant	Kaleidos	1.2

- Fusion
  - 9.1 Billion in public funding invested in fusion since 1999
  - 6.2 Billion in cumulative private investment in 2023 globally
  - ~20 U.S. Fusion Developers
  - Many developers designing demonstration prototypes for operations later this decade



Nuclear Siting Announcements

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Nuclear Siting Announcements

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Estimated Costs

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- First of a Kind Advanced Reactor installation (DOE Estimate)
  - $85/MWhr - $109/MWhr (2023$, LCOE)
  - $6,200/kWe - $10,000/kWe (2023$ overnight capital cost)
- Nth of a kind Advanced Reactor installation (DOE Estimate)
  - $66/MWhr (2023$, LCOE)
  - $3,600/kWe (2023$, overnight capital cost)
- Overnight costs of ~$2,300 per kW on 7 large light water reactors built in South Korea over the last 20 years
  - ~50% overall reduction in capital costs of nuclear reactors over the period
- Nth of a kind cost plateau with 10-20 reactor installations
- Existing transmission systems at coal stations provides opportunities for reduced costs

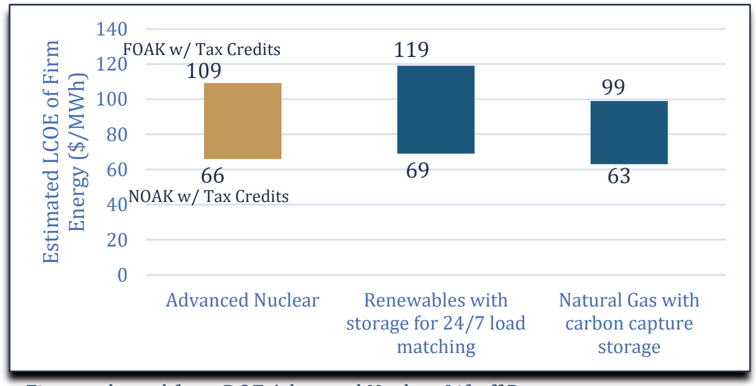

Figure adapted from DOE Advanced Nuclear Liftoff Report

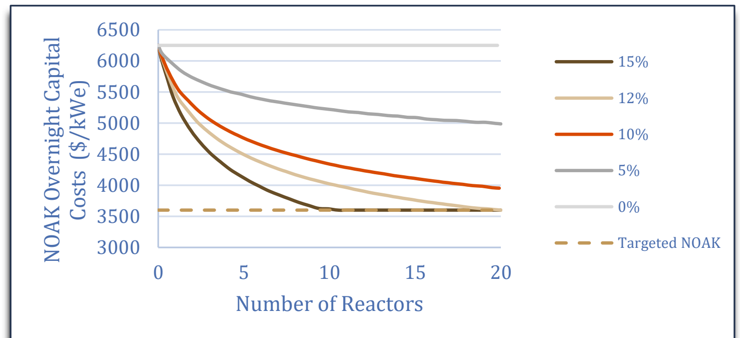

Figure adapted from DOE Advanced Nuclear Liftoff Report

Estimated Costs

- Cost advantages of Advanced reactors and SMRs
  - Passive safety systems requires fewer costly safety related systems
  - Factory manufacturing and pre-fabrication of many components and systems before installation on site
  - Reduced onsite construction period
  - Nth of kind cost efficiency reached sooner due to reduced construction period
- Potential disadvantages
  - Lower capacity to recover the capital and operating costs
  - Economic benefit realized when reached n-th unit
  - The licensing process for Advanced Reactors and SMR designs can be a lengthy and costly process

Schedule for Deployment

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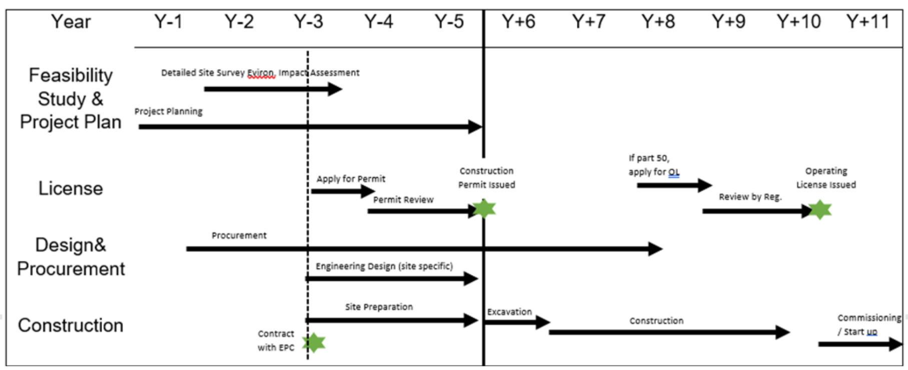
- Several deployment underway have publicly announcement deployment later this decade
  - GE-H: Ontario Power Generation (Darlington) – Construction complete end of 2028, powering the grid in 2029
  - X-Energy – Dow (Seadrift) ~2030
  - Terrapower – Kemmerer, WY – ~ 2030
- The timeline from a feasibility study to commissioning, according to DOE projections, is 11 years



Recent Nuclear Policies

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- Bipartisan support for nuclear
  - Climate Change – Greater acceptance for nuclear as part of solution to reduce carbon emissions
  - Geopolitics – Growing concern U.S. falling behind Russia and China in expanding nuclear technology around the globe
- Inflation Reduction Act (IRA) created multiple avenues of support
  - Tax credits for existing reactors up to $15/MWhr
  - New nuclear facilities can choose between $25/MWhr (for 10 years) or 30% investment tax credit for power plants coming online after 2025
    - An additional 10% for brownfield or conversion from coal to nuclear
  - Hydrogen production tax credits
  - Financial support for domestic supply for HALEU

Proposed Policy Changes

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- ADVANCE Act (Proposed Federal Legislation)
  - Proposed legislation passed in bipartisan manner by the US Senate in July 2023
  - Develop and Deploy New Nuclear Technologies
    - Create incentives to deploy the next generator of nuclear reactors
    - Require NRC to develop pathway to review licensing of nuclear facilities at brownfield locations
  - Improve NRC efficiency and reduce regulatory costs
  - Strengthen US nuclear fuel cycle and supply chain infrastructure
- Advanced Nuclear Reactor Generic Environmental Impact Statement (GEIS) – 2025
  - Generic environmental impacts will reduce effort for each site specific environmental assessment

Deployment Risks

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- First of a Kind (FOAK) construction cost – Who bears the cost for these FOAK deployments?
- Expansion of nuclear supply chain is a potential challenge
- Development of nuclear workforce
- Some states (TN and VA) funding supply chain and workforce initiatives
- Licensing the number of reactor designs and siting of numerous designs could strain the NRC reviewers leading to potential delays
  - Low end estimates, from the DOE, report that an increase of ~500 dedicated license reviewers and 350-500 SMEs might be required
- Overbudget or project schedule delays will reduce interest in follow up deployments
  - Cost efficient, NOAK deployments will require a number of initial higher cost deployments (> 10 units)

Summary

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- Advanced Reactor/SMR Designs
  - Passive safety systems – further improve safety and reduce cost of active safety systems
  - Modular design expected to reduce cost over time
  - Some Gen IV designs support industrial applications
  - Some Gen IV designs have limited operating and licensing experience
- Bi-Partisan Support for the industry
  - Financial support for advanced reactor designs
  - Support for deployment of initial reactor design
  - Incentives for coal to nuclear conversion
- Risks
  - FOAK deployment costs
  - Supply chain and work force limitations
  - NRC resource constraints