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March 19, 2025

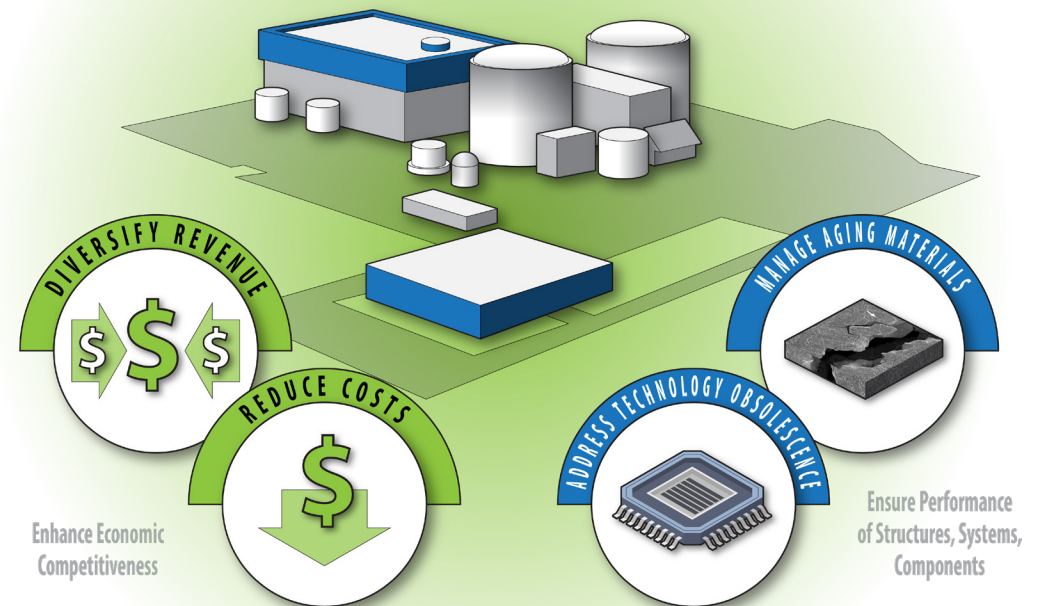
Generic Risk Assessment and Siting Guidance



Meeting Purpose and Objectives

Purpose: Industry update on Industrial Process-NPP hazards analysis and separation distance research findings

- Related to research conducted by the Flexible Plant Operations and Generation Pathway (FPOG) on nuclear integrated hydrogen production.
- To inform future FPOG high temperature electrolysis (HTE) hydrogen integration research and to support LWRS and NRC collaboration.
- To inform future FPOG industrial process integration research and to support LWRS and NRC collaboration.



Deterministic Hazards Assessments of Industrial Customers

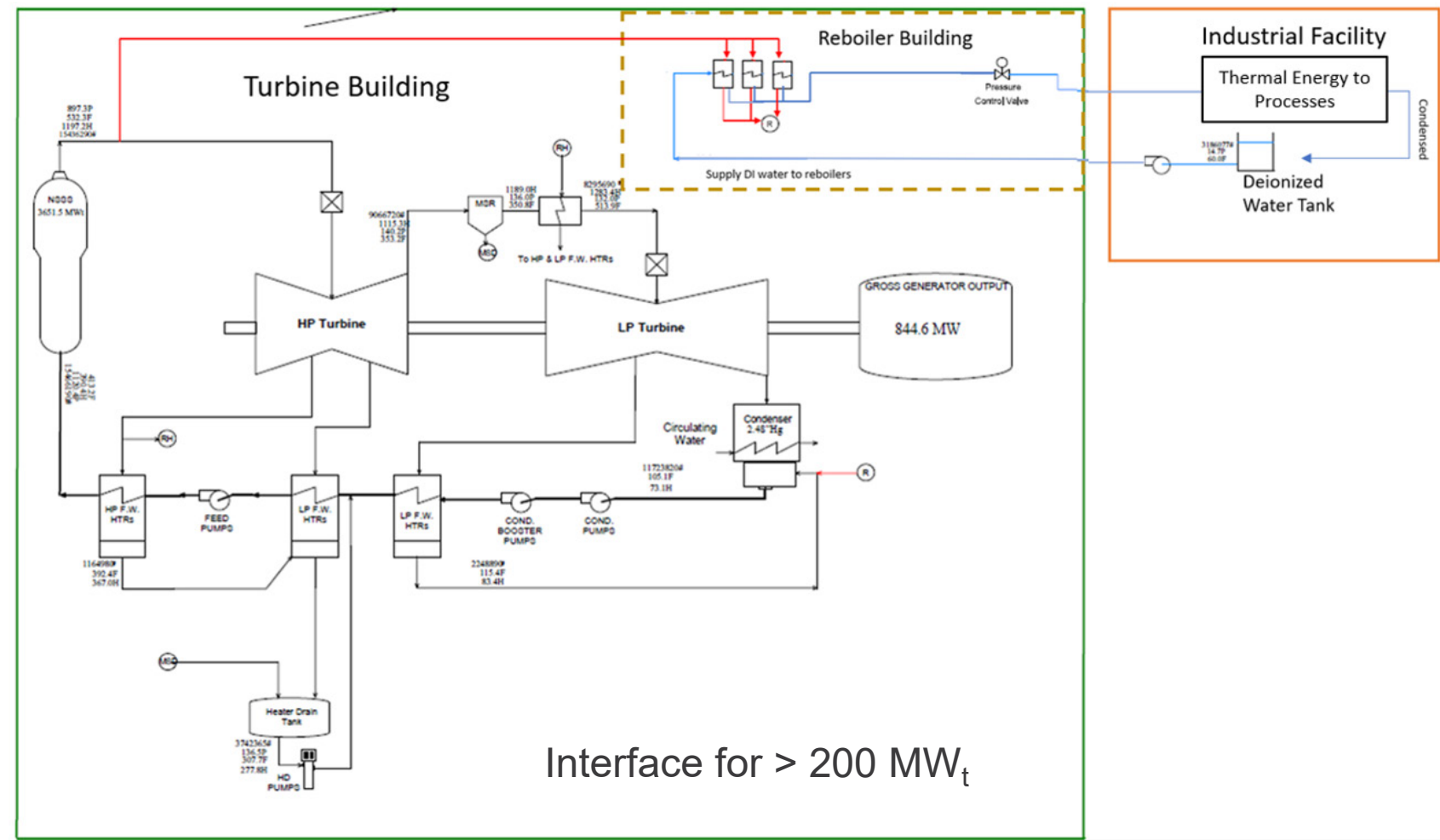
- Report INL/RPT-24-80742 performed hazards assessments on representative industrial customers offsite of an LWR.
 - Oil or chemical refinery
 - Methanol plant
 - Wood pulp and paper mill
- Hazards assessments included:
 - Accidentology – **what has gone wrong**
 - Hazards Identification – **what can go wrong**
 - System level failure modes and effects analysis (FMEA)
 - Akin to a HazOps and HazID
 - Toolbox of existing assessment methodologies

Nuclear Integrated Industrial Facilities Risk Results

- PRA
 - Initiating event (IE) frequency increases of **internal** events based on plant modifications are minimal
 - IE frequency of **external** events from the industrial customer facility must be limited by one or both:
 - Safe separation distance through siting
 - Engineered barriers

LWR Modifications for Customer Steam Delivery (PRA)

- Thermal Extraction Safety
 - Internal IE frequency increases of internal events
 - Steam line break (MSLB)
 - Can tap steam off of cold reheat for $<200 \text{ MW}_t$
 - Insignificant increases in IE MSLB @ 7.7% max of all the cases we studied.



External Event Hazards to LWR from Customer Facilities (Deterministic)

- Overpressure
 - Detonation *
 - Deflagration *
 - Vapor Cloud Explosion
 - Boiling Liquid Expanding Vapor Explosion (BLEVE)
- Heat Flux
 - Jet Fire *
 - Pool Fire
 - Fire Ball
- Toxicity
 - Chemical Effects
 - Asphyxiant
- Non-Toxic Pollutants
 - e.g., Spillage that fouls shared water source intakes
- The hazards are well-defined by customers
 - Each industry has accepted methodologies for evaluation and mitigation
- All must be resolved within the NRC's accepted methodologies and mitigations

* Applicable to Hydrogen Production

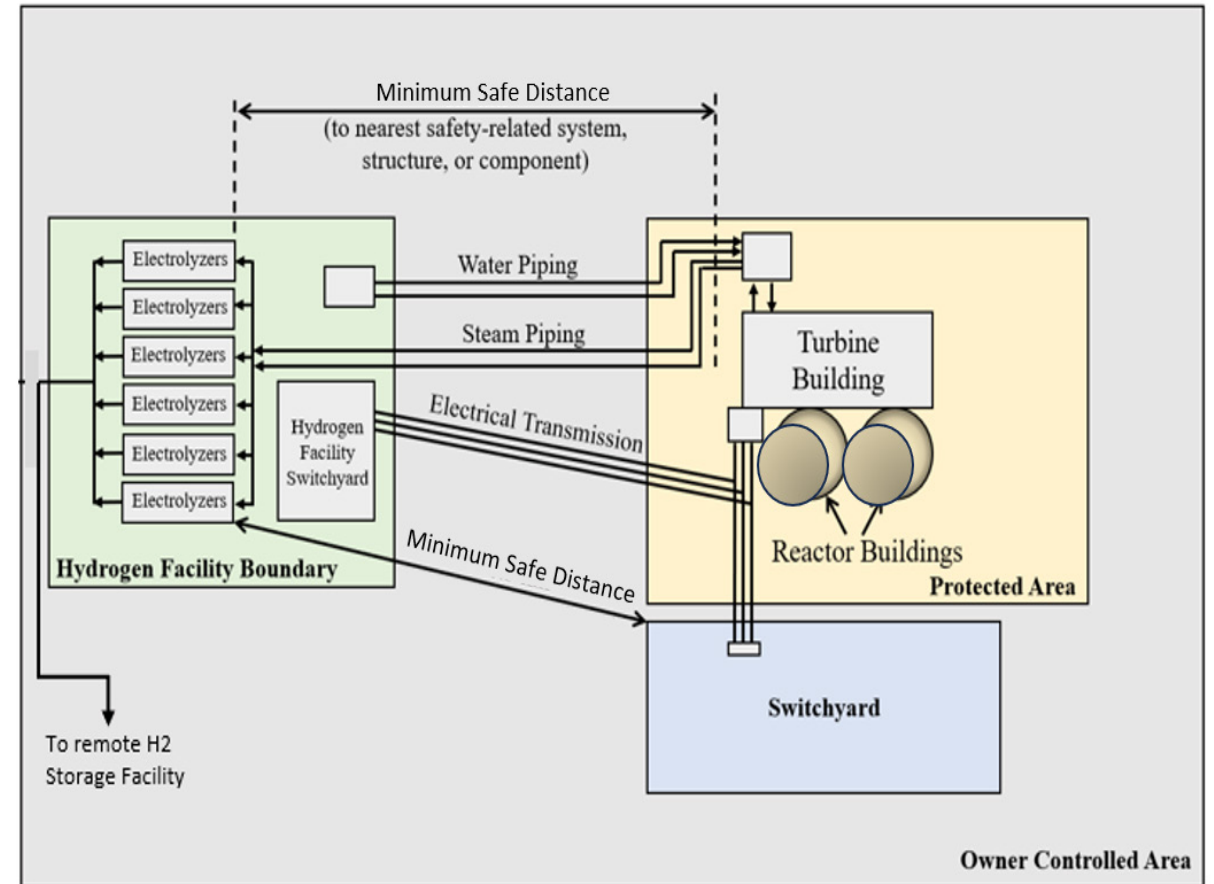
Generic Nuclear Integrated Hydrogen Plant Layout

Reference Nuclear Plant

- Westinghouse 4-loop PWR
 - 1200MW_e / 3,700MW_{th} / SWYD: 345kV
 - Typical for 1/3 of operating US NPP Units
- New Hydrogen Steam/Water Supply
- New Behind the Meter Electric

High Temp Electrolysis (HTE) Facility

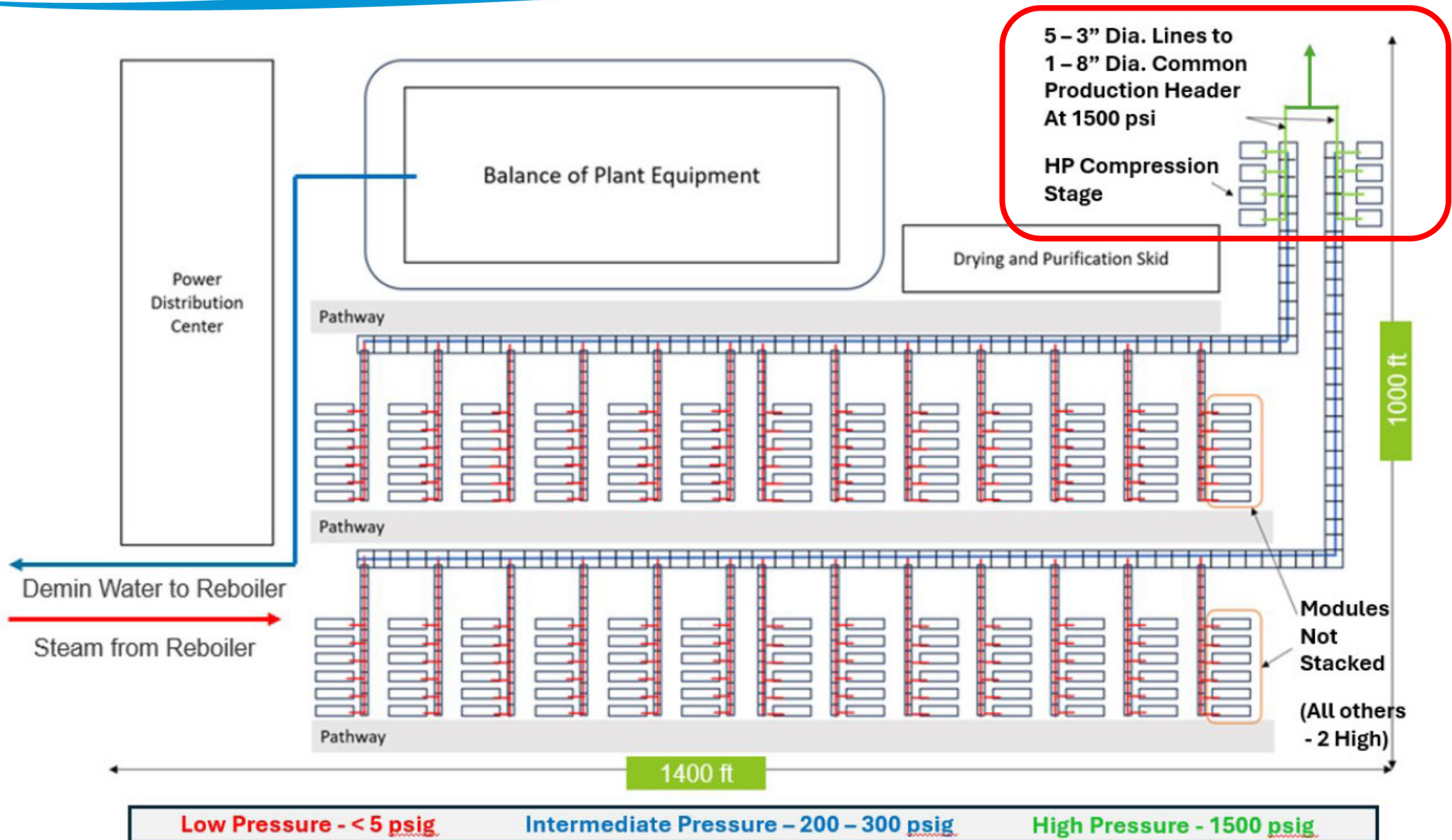
- 500MW_{DC}
- Thermal Load – 100MW_{th}
- Hydrogen Production
 - 300 tons/day @ 1500 psi



Hazards of Hydrogen vs Other Industrial Facilities

- **Hydrogen** is relatively benign and a good candidate for placement inside the NPP owner-controlled area (OCA)
 - Fire protection NFPA codes dictate placement within the OCA under Fire Protection Engineering Evaluation
- **Hazards at other industrial facilities** are outside the OCA
 - Each industry has accepted methodologies for evaluation and mitigation
 - Chemical-specific methodologies are often used.
 - e.g., heavy hydrocarbons are not evaluated for their full TNT equivalence due to their low vapor pressure
 - Safe siting distance and/or engineered barriers are used for mitigation
- All on-site and off-site hazard assessment methodologies must be resolved within the NRC's accepted methodologies and mitigations for impacts on NPP SSCs
 - Simply, the customer's accepted practices for their safety program must meet the NRC's expectations to protect the NPP

Example 500 MW_{DC} Hydrogen Facility

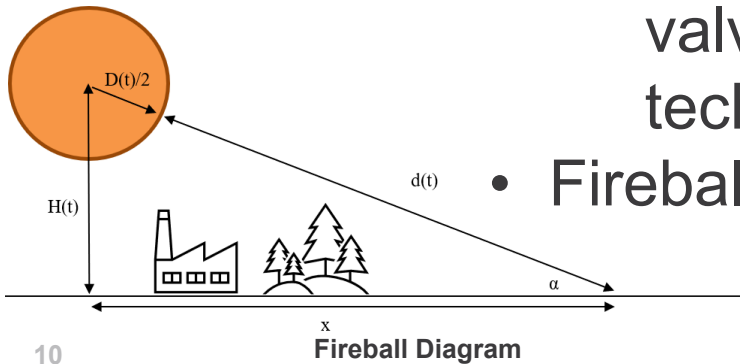


Hazards Toolbox For All Industrial Processes

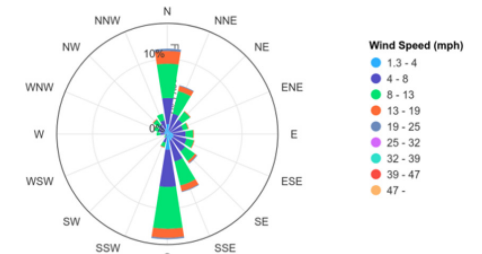


- Report INL/RPT-24-80742 explored existing methodologies for common industrial hazards
 - Vapor cloud dispersion analysis for toxic and/or explosive mixtures
 - Blast analysis other than hydrogen-specific methods
 - Blast mitigation strategies
 - Barriers, explosive isolation valves, suppression techniques
 - Fireball heat flux analysis

Suppressant is delivered via a High Rate Discharge propellant of pressurized Nitrogen



Combination Toxic Cloud and HTEF Overpressure Analysis



10-year Wind Rose for Generic River Site

Siting Considerations

- Report INL/RPT-24-80742 listed siting considerations for safety
 - Safe siting distance is a primary defense to hazards presented by the customer facility and other local hazards
- Report INL/RPT-23-74311 lists considerations other than safety
 - Adherence to environmental protections
 - Local laws, codes, and zoning
 - Economic considerations
 - Long runs of steam piping cost more to build
 - Performance considerations
 - Steam quality may be affected

Preliminary Research Conclusions

- PRA and Deterministic Risk Assessments
 - Initiating event (IE) frequency increases of internal events based on required plant modifications are minimal and support 10 CFR 50.59
 - IE frequency of external events must be limited by safe separation distance through siting distance and/or engineered barriers
 - Industry accepted hazards analysis tools from specific industries will be petitioned for use to meet codes and guidance by the NRC.
- Siting the Customer Facility
 - Siting for safety
 - Determined by customer facility hazards
 - Determined by other local hazards
 - Siting for economics
 - Local zoning, geography, laws, codes
 - Costs associated with required long runs
 - Thermal losses, construction cost increases

Future Research Potential

- Probabilistic Risk Assessments
 - Leverage generation risk assessment research for advanced reactors and apply to LWRs
 - Assesses the customer's energy supply risk based on maintenance and random events and their times to recovery
 - Can be used as an input to economic risk
- Siting
 - Leverage FY25 work in advanced reactor siting methodologies
 - EPRI and STAND methodologies with some further suggestions.



Sustaining National Nuclear Assets

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