Multi-Unit Risk Analysis

Research Results and Future Focus

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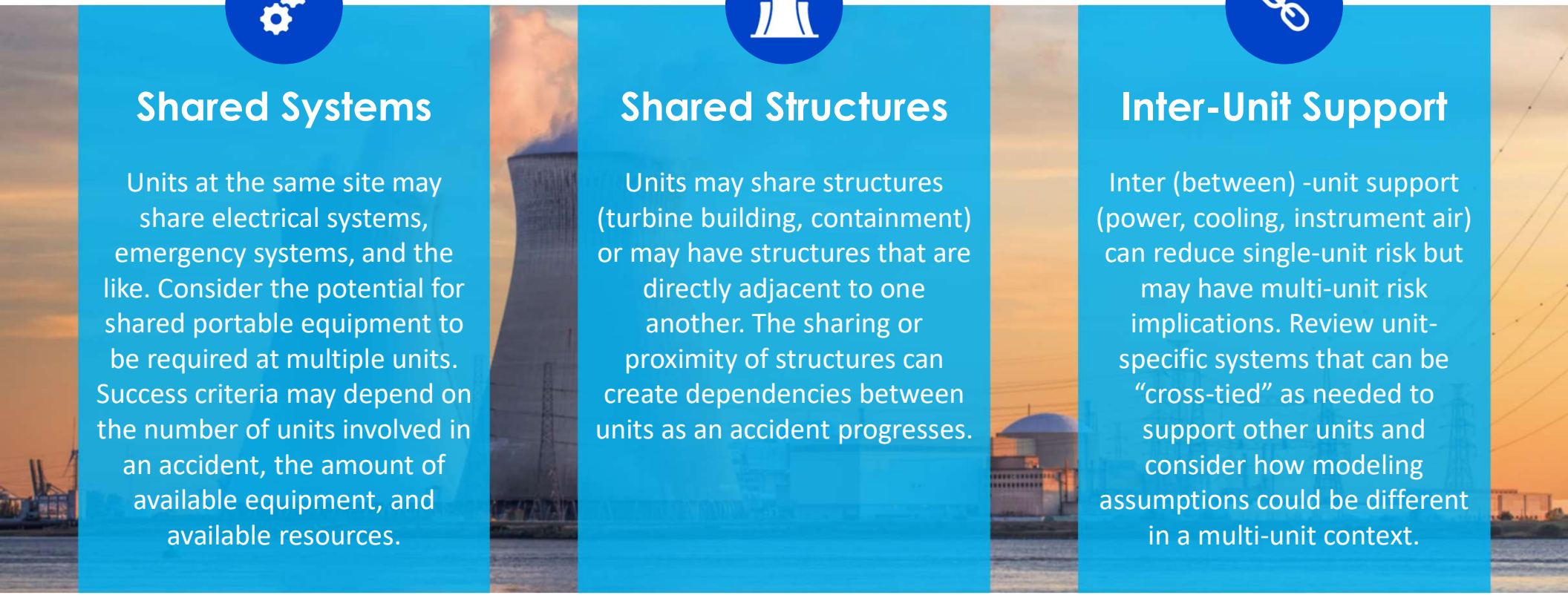
2026 NRC Regulatory Information Conference (RIC)
“Multi-Unit Risk – Are We Ready for This?”

Multi-Unit Considerations



Shared Systems

Units at the same site may share electrical systems, emergency systems, and the like. Consider the potential for shared portable equipment to be required at multiple units. Success criteria may depend on the number of units involved in an accident, the amount of available equipment, and available resources.

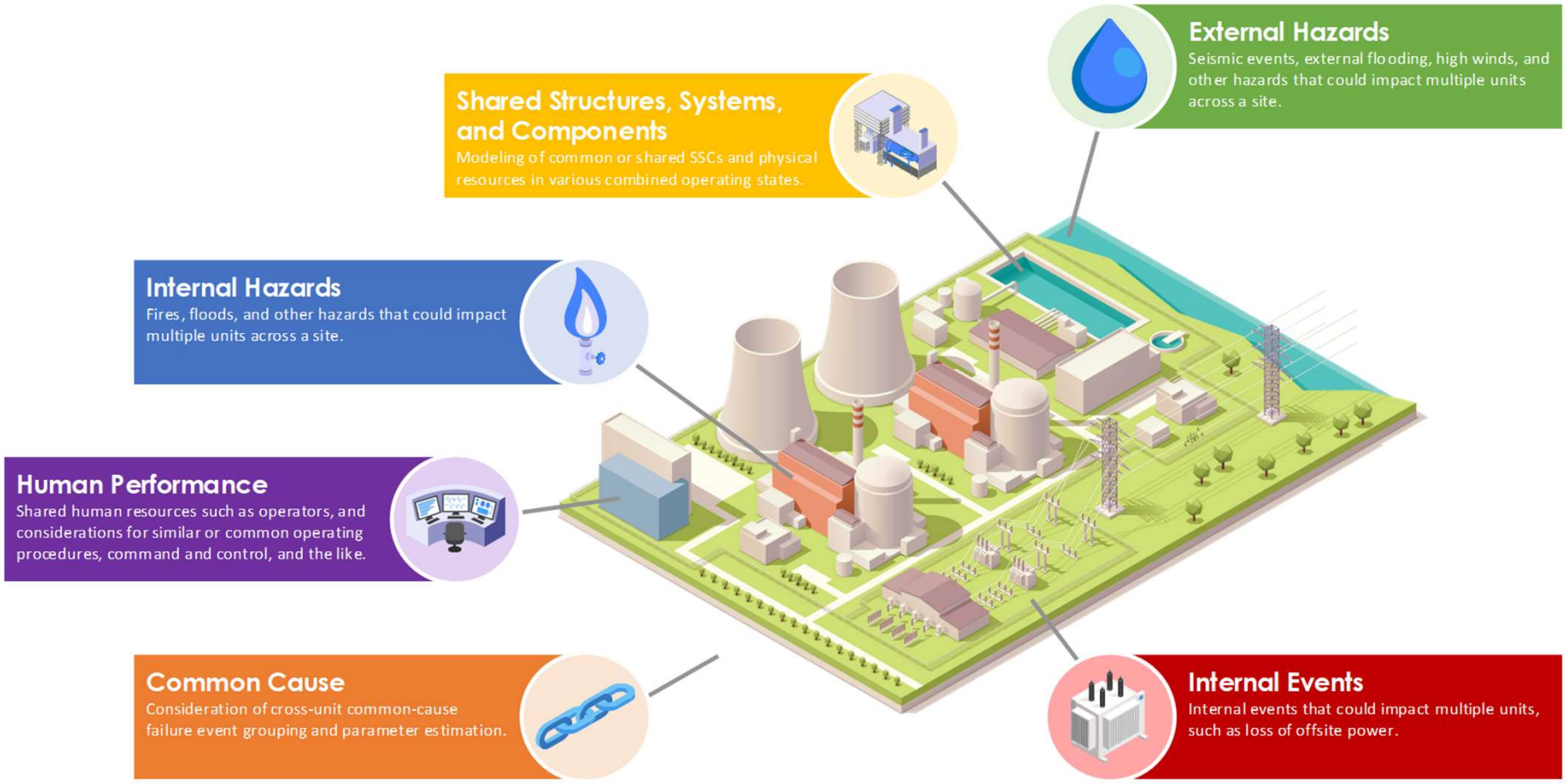
Shared Structures

Units may share structures (turbine building, containment) or may have structures that are directly adjacent to one another. The sharing or proximity of structures can create dependencies between units as an accident progresses.

Inter-Unit Support

Inter (between) -unit support (power, cooling, instrument air) can reduce single-unit risk but may have multi-unit risk implications. Review unit-specific systems that can be "cross-tied" as needed to support other units and consider how modeling assumptions could be different in a multi-unit context.

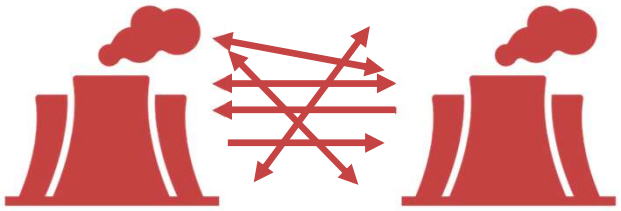
The Potential Scope of a Multi-Unit Risk Assessment



Degree of "Coupling" Between Units

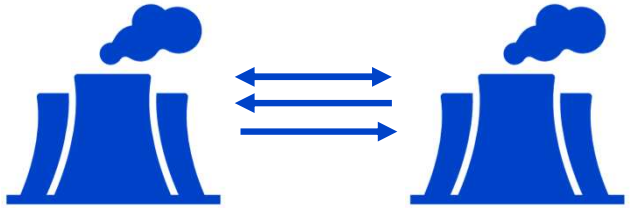
For practical purposes, ranges exist

Tightly-Coupled



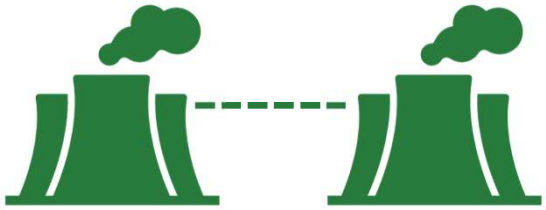
Tightly-coupled sites/units have complex dependencies between the units. Some qualitative screening may be possible. These complex interactions may require complicated risk modeling but may also provide benefit when considering mitigation pathways.

Loosely-Coupled



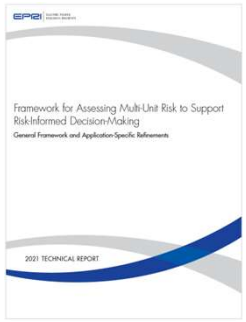
For loosely-coupled sites/units, some dependencies are expected for offsite power (grid and switchyard dependency), common component types (inter-unit common cause failure), common physical location, common cooling sources/intake, common emergency response organizations, and accident mitigation.

Uncoupled



Uncoupled sites/units present an opportunity to screen out specific multi-unit aspects. There may be some coupling due to physical proximity, such that external hazards may dominate the multi-unit risk assessment.

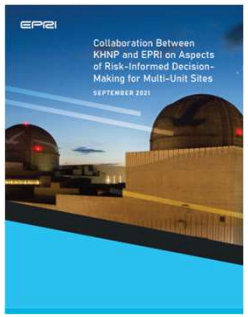
EPRI's Multi-Unit Framework and Research



3002020765 (2021)

Framework for Assessing Multi-Unit Risk to Support Risk-Informed Decision-Making: General Framework and Application-Specific Refinements

Free to the public



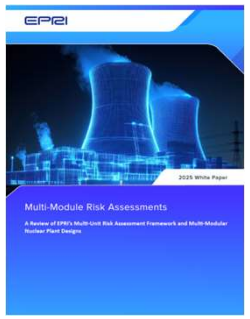
3002020756 (2021)

Collaboration Between KHNP and EPRI on Aspects of Risk-Informed Decision-Making for Multi-Unit Sites

3002029304 (2024)

Application of Multi-Unit Probabilistic Safety Assessment Strategies in Canada – Multi-Unit Risk for CANDU Nuclear Generating Stations Operating in Canada

Considerations for Next Generation Sites



3002032033 (2025)

Multi-Module Risk Assessments: A Review of EPRI's Multi-Unit Risk Assessment Framework and Multi-Modular Nuclear Plant Designs

3002032224 (2025)

Advanced Nuclear Technology: Application of EPRI Framework for Multi-Reactor Risk Analysis to Advanced Reactors

EPRI's framework supports a graded approach, building from single-unit assessments and considering the degree of coupling between units. This framework is broadly applicable to different degrees of coupling and is generally suitable for future technologies and site configurations.

Balance the Effort with the Potential for New Insights

- Consider how current single-unit PRAs/PSAs can be utilized, leveraged, and modified (as needed) to gain additional insights.
- Apply additional detail and complexity where it could identify new insights beyond the single-unit analysis.
- Consider how different levels of detail can support the development of both qualitative and quantitative insights.

"Be implementable with state of practice resources and not be overly burdensome when compared with SUPSA modelling."

IAEA Safety Report No. 110

Insights from EPRI's Research Initiatives

1 CANDU

Canadian experience with tightly coupled units generally aligns with the EPRI framework. Shared containment, common emergency systems, and central control rooms create multi-unit dependencies and the potential for cascading events.

2 Multi-Modular

When considering "multi-module" designs, EPRI's framework applies, with additional considerations for unique design elements (shared containment, common controls).

3 Advanced Reactors

New considerations regarding the reliability and consequences of failure for passive safety systems and digital control systems. Potential for new human performance considerations and additional external hazard evaluations for cogeneration facilities.

Ongoing Challenges and Potential Future Research

Unit Coupling

It's difficult to model the different degrees of coupling and dependencies between units – for example, inter-unit common cause failure, human dependencies. Also, there are limited data sets to support detailed evaluations.

Model Complexity

Large/detailed multi-unit risk assessments are pushing current software tools and computational resources to (or beyond) their limits, resulting in longer quantification times.

Operating States

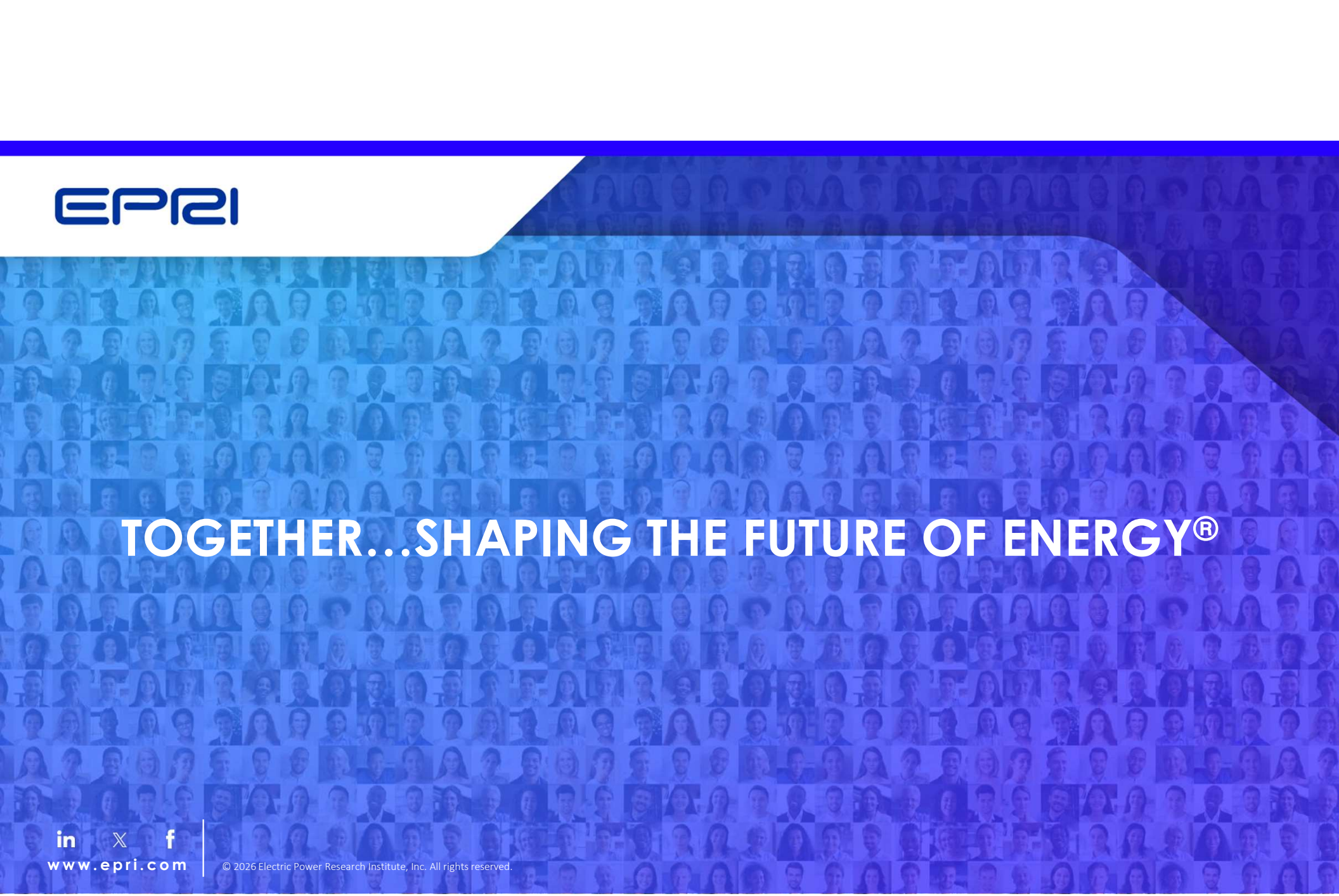
It can be difficult to account for the various combinations of plant operating states (at power or refueling), especially at sites with multiple units in different states.

Risk Aggregation

It's challenging to appropriately aggregate the results of risk models that use different levels of detail (screening vs. full scope) and that carry varying degrees of uncertainty in their risk evaluations.

The Human Element

When the same room or workstation is used to control multiple units, additional methodologies for assessing performance-shaping factors, such as stress and clarity of indications, may be needed. This includes communication and interfaces between operators across multiple units, as well as command-and-control associated with a multi-unit accident sequence.



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