EPRI Reactor Technology Assessment Guide

For GAIN-State of Kentucky Workshop

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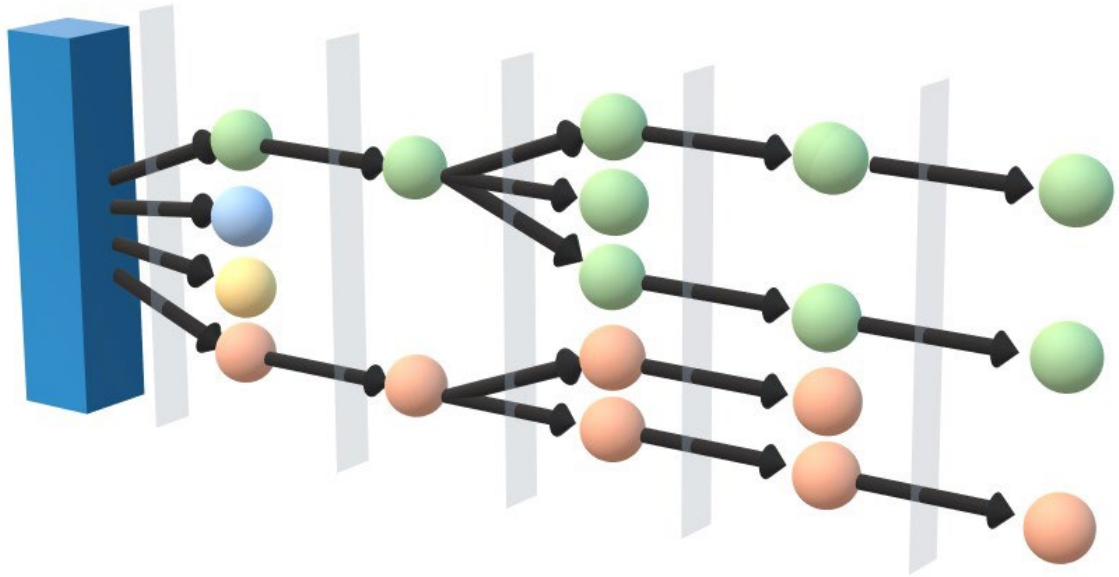
Agenda

- Overview
  - What is the Reactor Technology Assessment Guide?
  - Key Definitions
  - Primary Process Steps
- Details
  - Analytical Processes
  - Risk Management
  - Mission and Business Object
  - Assessment Criteria



KEY ASPECTS

Nonprofit

Chartered to serve the public benefit, with guidance from an independent advisory council.

Thought Leadership

Systematically and imaginatively looking ahead to identify issues, technology gaps, and broader needs that can be addressed by the electricity sector.

Independent

Objective, scientific research leading to progress in reliability, efficiency, affordability, health, safety, and the environment.

Scientific and Industry Expertise

Provide expertise in technical disciplines that bring answers and solutions to electricity generation, transmission, distribution, and end use.

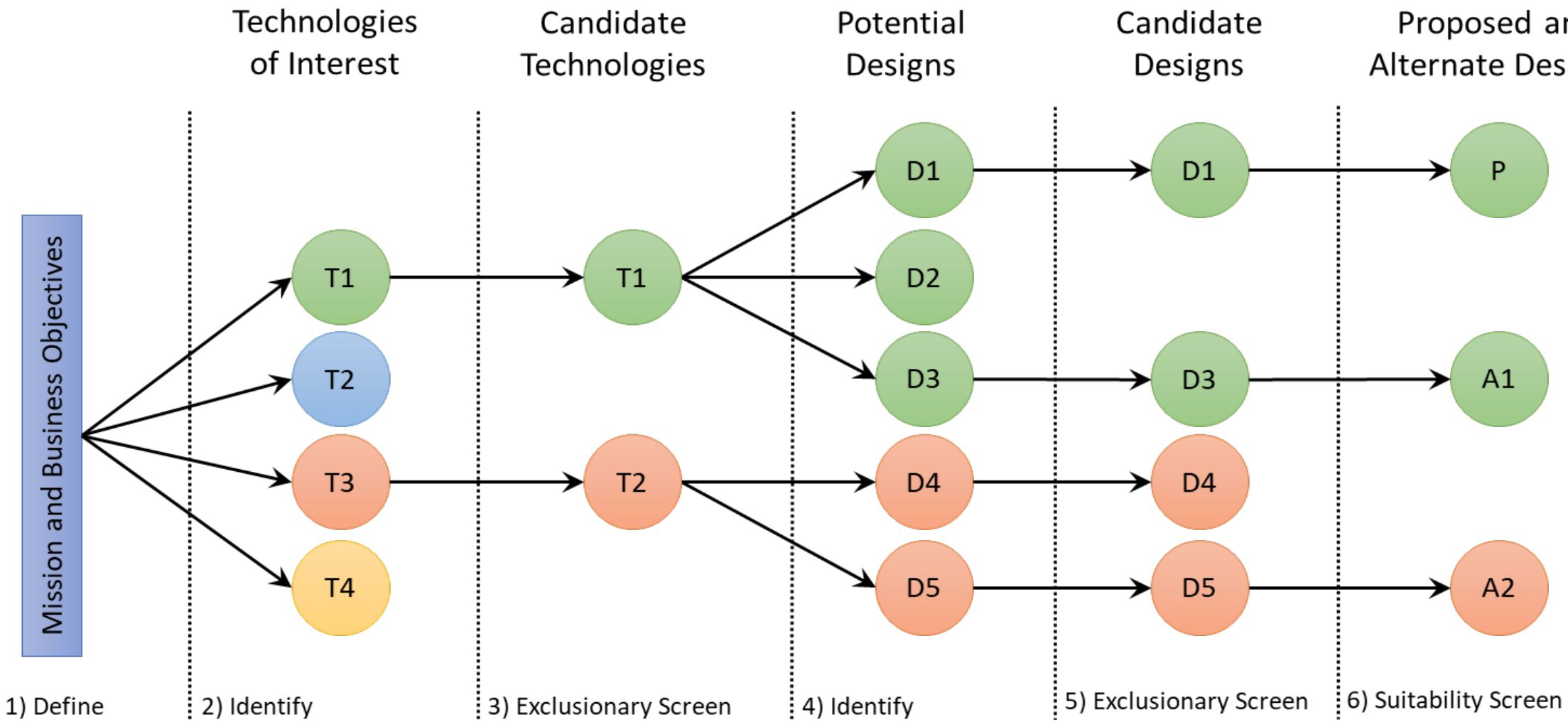
Collaborative Value

Bring together our members and diverse scientific and technical sectors to shape and drive research and development in the electricity sector.

What is the Reactor Technology Assessment Guide?

- Provides an owner-operator, or potential owner-operator, with a straightforward decision-making framework including an uncomplicated and repeatable process that helps the organization:
  - Define and understand their business objectives
  - Evaluate general technologies and specific designs against those objectives
  - Develop a defendable justification for a primary selection and alternatives
  - Understand the inherent risk of technology and design selection and provide tools to help manage that risk
- Intended to cover all sizes and types of reactors, be regulatory neutral, and of value to all EPRI's global stakeholders

Primary Process Steps



Analytical Processes

- **Mission and Business Objective**—Guidance for the owner-operator on how to develop their mission and business objectives.
- **Assessment Criteria**—represent, facility design, safety, siting, operations, and maintenance requirements.
- **Criteria/Importance Weighting**—Development of weighting factors that reflect the relative importance of individual criteria.
- **Criterion Scoring**—Development of utility functions that quantify the relative suitability of a design with respect to a single criterion.

Evaluation of proposed and alternate designs requires all four processes

Risk Management

- **Selection Risk** – the risk inherent in the process of selecting the 'best' technology and design
  - Rigorous Use of this Process
  - Well-developed Mission and Business Objectives
  - Proper Weighting Factors
- **Pre-Deployment Risk** – the risk that a chosen technology or design will be available, licensable, technically capable, and have a supporting supply chain, for deployment on schedule
  - Avoidance Factors
  - Suitability Scoring
- **Deployment Risk** – the risk of the actual plant deployment (i.e., construction and operations)
  - Cost and commercial related factors (financial risk model)

Mission and Business Objectives

- **Technology and Design Assessment Envelope** – Define the overall bounds (i.e., Systems, Structures, and Components, SSCs) for which the assessment process will be performed.
- **End-Product** – Define the desired end-product, or mix of end products, desired for the project.
- **Required Output** – Identify and describe required product output of the plant, based on its mission (ex: MWe, MWt, kg of hydrogen/day)
- **Target Location of Plant (or Plants)** – Identify the target location of the future facility, or facilities.
- **Service Requirements** – items such as the need and priorities for flexible or firm generation, reliability, weather resiliency, and black start capabilities.
- **Operating Life** – the minimum, as well as the desired, operating life of the plant.
- **Need Dates and Time Frames** – the need date (if there is one), or perhaps more general time frames, for not only the in-service date, but also preceding milestones.
- **Target Budgets** – Costs the owner-operator is willing to take on for the project:
  - Exploration, Engagement with Potential Suppliers, Facility Licensing, Construction, Operations
- **Owner-Operator's Long-Term Goals** – for example, a single plant, building out a fleet, supporting demonstration, or other goals

Development of the mission and business objectives is a foundational activity

Assessment Criteria Categories

3.1 Basic Operations

Criteria used early in the process to primarily differentiate technology and designs.

3.2 Site Selection and Characterization

How to use site characterization as the criteria when a site has been selected.

3.3 Maturity and Remaining Effort

Criteria to identify the technology readiness level and amount of time and effort required to achieve commercialization.

3.4 Technology Capabilities

The technology specific criteria related to the SSCs of the design.

3.5 Cost and Commercial Related Factors

Financially related criteria.

Assessment Criteria – Typical Screening Activity (example)

Table 2-3: Technology Assessment Criteria and Typical Screening Activity

Section	Criteria	Candidate Technologies Screening	Candidate Designs Screening	Proposed/ Alternative Designs Screening
3.1	Basic Operations			
3.1.1	Plant Energy Output	Yes	Yes	Yes
3.1.2	General Operations & Maintenance	No	No	Yes
3.1.3	Fuel and Used Fuel Management			
3.1.3.1	Fuel Selection	Yes	Yes	No (see note)
3.1.3.2	Used Fuel Storage and Disposal	Limited	Yes	No (see note)
3.1.4	Good Neighbor	No	No	Yes
3.2	Site Selection and Characterization			
3.2.1	Site Evaluation	Limited	Yes	Yes
3.3	Maturity and Remining Effort			
3.3.1	Design Maturity and Remining Effort			
3.3.1.1	Design Completion	Limited	Limited	Yes

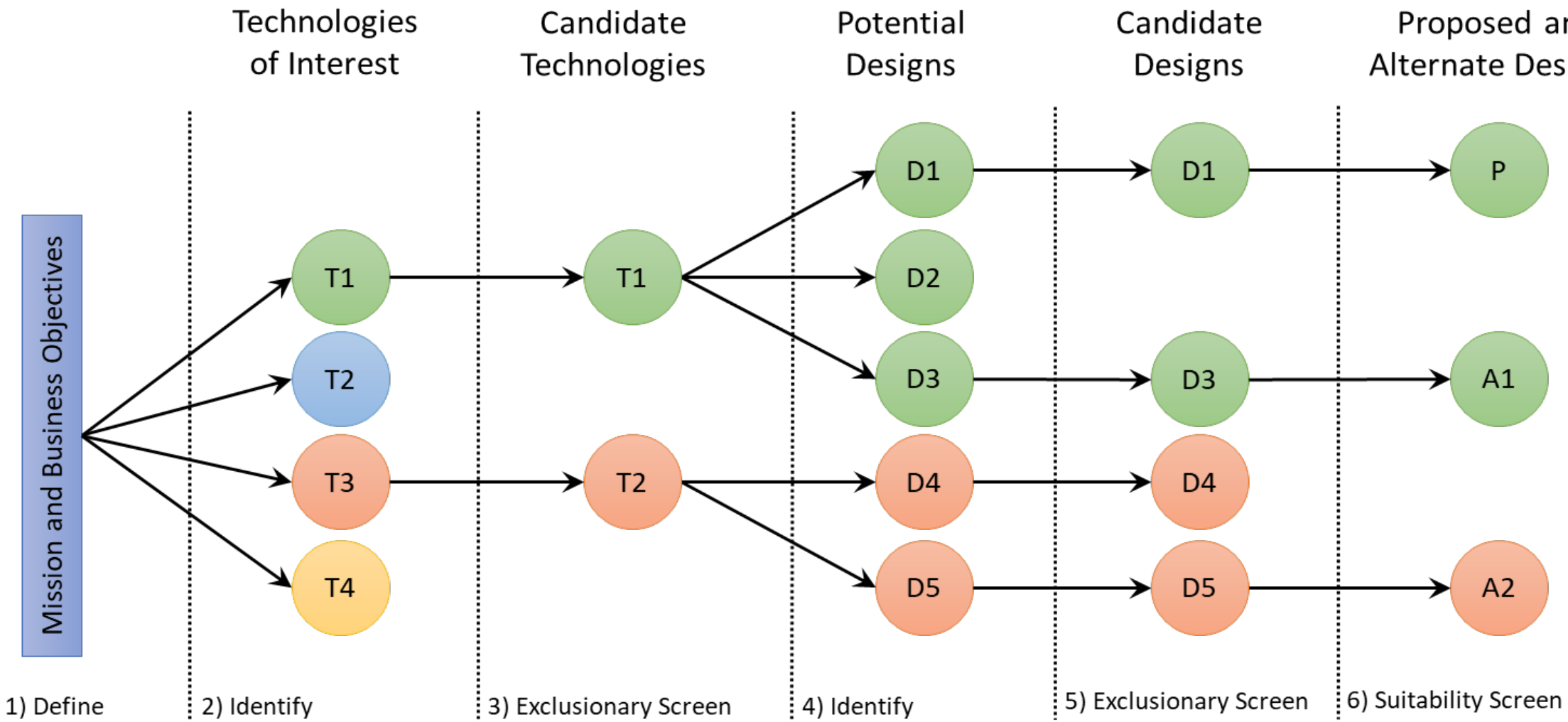
5 Categories

30 Criteria

Each with several sub-criteria

Each major criteria consists of a set of sub-criteria that is intended to be evaluated in aggregate

Questions?

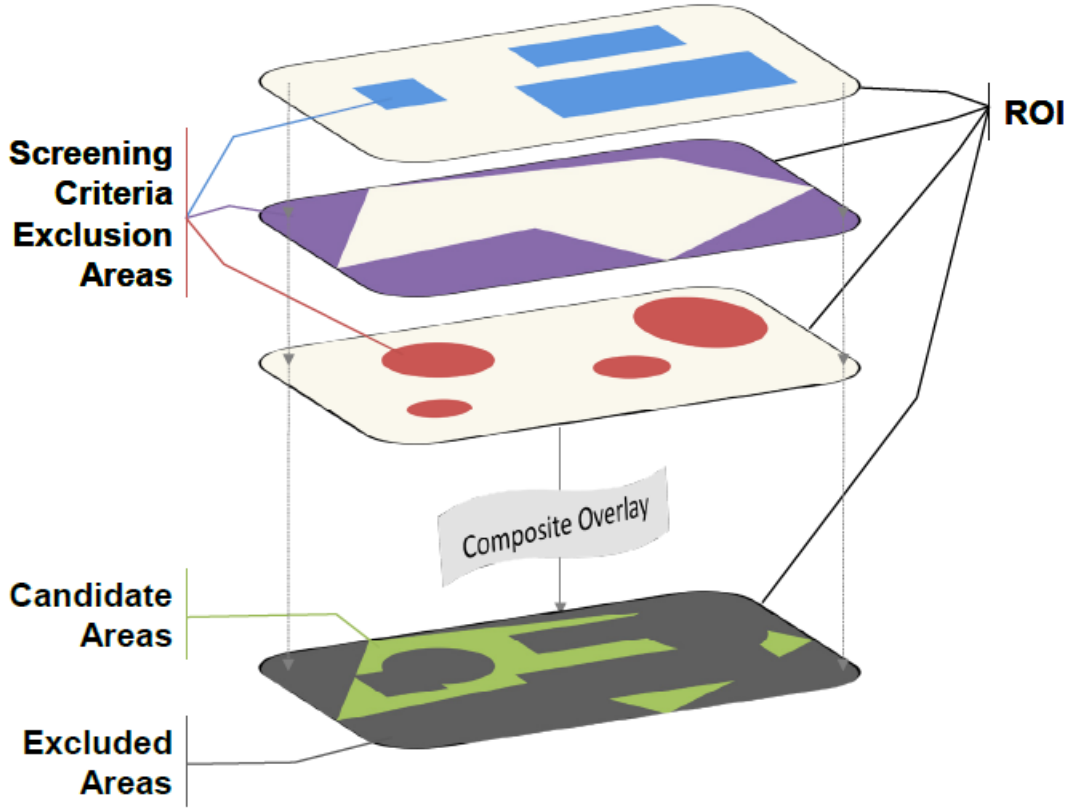


What is the EPRI Siting Guide?

- Created as part of the Early Site Permit (ESP) Demonstration Program in early 1990s **to provide a generalized, regulatory neutral site selection process for new nuclear plants**
- Current version* (2015) incorporates experience and lessons learned from first "nuclear renaissance" and emergence of SMRs
- Provides a framework that supports development of an individualized site selection process that can withstand regulatory review
- Desired outcome is a site selection process that:
  - satisfies business objectives
  - meets regulatory requirements
  - adequately reflects consideration of alternative sites

Nuclear siting in 5 basic steps

1. Identify the region of interest
2. Screen to candidate areas
3. Identify potential sites
4. Screen to candidate sites
5. Identify proposed and alternative sites



Region of Interest (ROI) Screening Process

*2015 EPRI Siting Guide – Report no. 3002005435 available at: https://www.epri.com/#/pages/product/000000003002005435/?lang=en-US

Can the Siting Guide Be Used for Site Reuse?

- Current version addresses brownfields and reuse of fossil plant sites for new nuclear – but to a limited degree

- Revision expands and clarifies site reuse considerations with respect to:
  - level of potential site industrialization
  - degree of site characterization
  - plant mission and business objectives

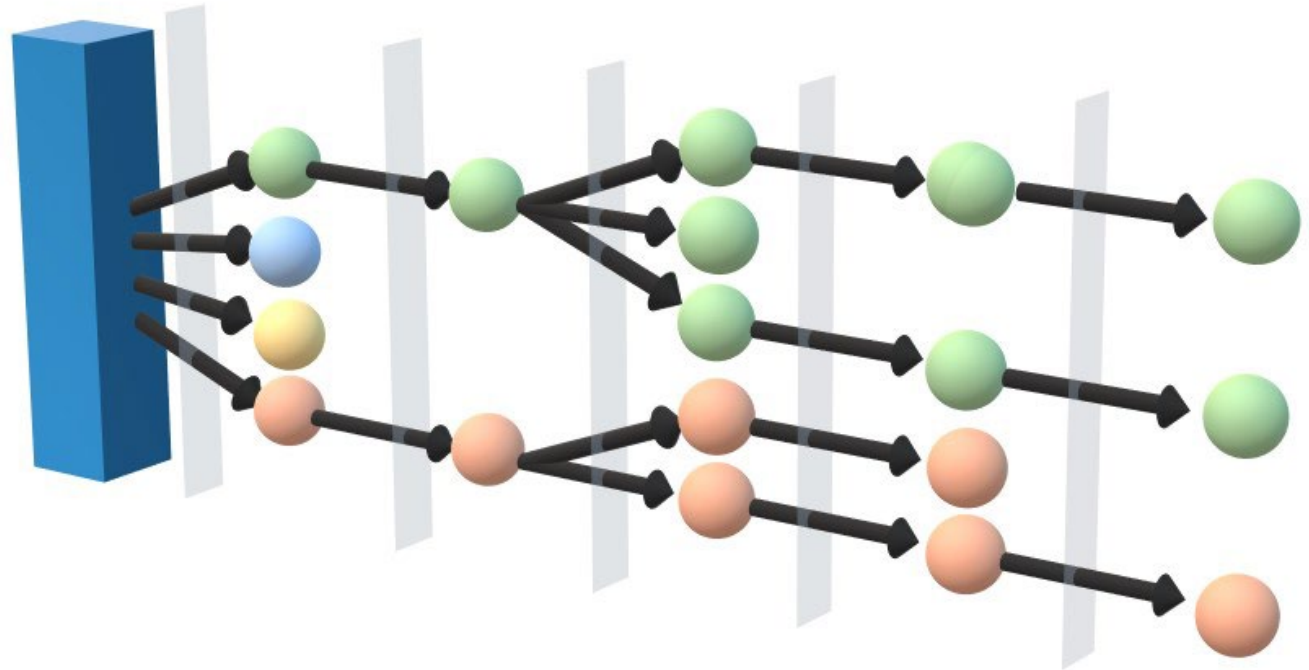
Levels of Industrialization	
Greenfield	Undeveloped
	Restored
Brownfield	Decommissioned
	Industrial
	Non-Nuclear Generation
	Contiguous to Nuclear Generation
	Existing Nuclear Generation
	Exiting Nuclear Non-Generation

Site Characterization
None
Limited
Characterized
Existing

Mission and Business Objectives	
Electricity Generation	Firm
	Flexible
Process Heat	District Heating
	Industrial Processes
Cogeneration	Electricity + Heat
Product Generation	Hydrogen
	Desalination
Isotope Production	Commercial Isotopes

Key Definitions

- **Technology** – Both the general technology (ex: pressurized water reactor, PWR, gas cooled reactor, GCR), or a vendor specific design (Company X's Model N-100). This is important because the process defined herein uses both instances, to settle on a general technology in the initial stages, and then refine selection to a specific procurable design.
- **Design** – A procurable (or at least advertised) vendor specific reactor developed and marketed by an Original Equipment Manufacturer.



Key Definitions

- **Exclusionary Factors** – Criteria that can be evaluated based on requirements, and may be identified as minimums, maximums, needs, or other qualifying language that indicates compliance is mandatory.
- **Avoidance Factors** – Criteria that can be evaluated based on goals, and may be identified as wants, preferences, aims, or other qualifying language that indicates compliance is not mandatory, but so highly desired as to use an exclusionary screening to provide a binary go/no-go decision on a technology or design.
- **Suitability Factors** – Criteria examined based on suitability factors are done to find the best result, not necessarily to exclude any design. Suitability factors are evaluated using criterion weighting and scoring to obtain quantitative results from a qualitative process.
- **Proposed/ Alternative Designs Screening**– Criteria examined to find the best result, not necessarily to exclude any design. Suitability factors are evaluated using criterion weighting and scoring to obtain quantitative results from a qualitative process.

Risk Management

- **Selection Risk** – the risk inherent in the process of selecting the 'best' technology and design
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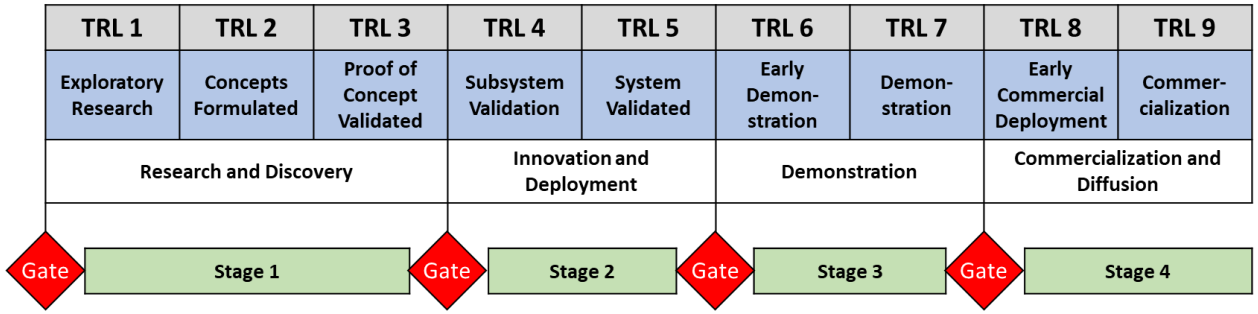
Maturity and Remaining Effort vs. Technology Capabilities

- Maturity and Remaining Effort
  - Maturity describes the current level of completeness, qualification, or suitability for adequately meeting requirements or goals (can sometimes be referred to as Technology Readiness Level, TRL)
  - Remaining effort describes the time and activities needed to meet a desired maturity level
  - When evaluating Maturity and Remaining Effort assume that the technology will be adequate for its purpose when it is available



- Technology Capabilities
  - The specific features of a nuclear plant and its design that provide for safety, reliability, flexibility, resiliency, and efficiency, for not only operations, but also construction and ongoing maintenance (i.e., what the plant is capable of)
  - For lower maturity designs, it is important that the evaluation of technology capabilities assume that the technology will meet the designer's intention upon complete development