Metrics and Methodologies for Assessment of Proliferation Risk

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Proliferation Risk Questions and Issues That Technical Assessments Can Inform

- Relative nonproliferation advantages of alternative nuclear energy systems for: energy generation, material production, waste treatment, research
- System architecture (e.g. once through vs. closed fuel cycles)
- International arrangements vs. national programs
- Broader Energy-Environment-Economics-Nonproliferation-Security-Safety Trade-offs

➢ Many stakeholders…information needs to be presented in an understandable way to each specific user

Issues for Assessment of Proliferation Risk

- How to characterize and measure it
- How to evaluate it
- How to ***use*** it (for fuel cycle systems)
  - Absolute vs. relative assessments
  - System risk reduction and management
  - Informing design alternatives (e.g., safeguards by design)
  - Global nuclear architecture construction
- How to communicate it (to various audiences)
  - Program policy makers
  - Designers
  - Other stakeholders

Evaluations should consider…

- Country Context
  - Objectives
  - Capabilities
  - Strategies
- System design features relevant to risk
- Safeguards and Security Contexts
- Policy considerations

Note: 3 Stages for Evaluation: Acquisition, Processing, Weaponization

Some Assessment Methodologies

- Generation IV International Forum (GIF) Proliferation Resistance and Physical Protection (PR&PP) Evaluation Methodology
- IAEA INPRO Methodology
- MAU variants
- SAPRA
- Adaptations from Reactor Safety Arena
- Older approaches:
  - NASAP/INFCE
  - TOPS

GIF Goals and Objectives for PR&PP

Technology Goal for PR&PP:

Generation IV nuclear energy systems will increase the assurance that they are a very unattractive and the least desirable route for diversion or theft of weapons-usable materials, and provide increased physical protection against acts of terrorism.

Specific Objectives:

- Facilitate introduction of PR&PP features into the design process at the earliest possible stage of concept development

- Assure that PR&PP results are an aid to informing decisions by policy makers in areas involving safety, economics, sustainability, and related institutional and legal issues

U.S. participation in PR&PP co-sponsored by DOE/NNSA and DOE/NE

PR&PP
Important Distinction
…sometimes the distinction get blurred

Proliferation resistance is that characteristic of a nuclear energy system that impedes the diversion or undeclared production of nuclear material or misuse of technology by the *Host State* seeking to acquire nuclear weapons or other nuclear explosive devices.

Physical protection (robustness) is that characteristic of a nuclear energy system that impedes the theft of materials suitable for nuclear explosives or radiation dispersal devices and the sabotage of facilities and transportation by *sub-national entities* and/or *non-Host States*.

The PR&PP Methodology

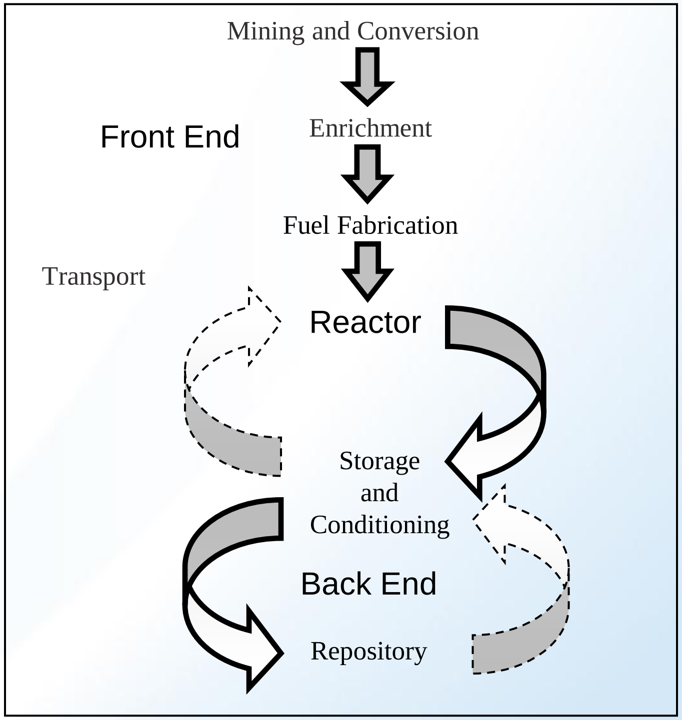
CHALLENGES → SYSTEM RESPONSE → OUTCOMES

Threats	*PR & PP*		*Assessment*
PR • Diversion • Misuse • Breakout • Clandestine Facility **PP** • Theft • Sabotage	**Intrinsic** Physical & technical design features	**Extrinsic** Institutional arrangements	**Measures** • Material Type • Detection Probability • Technical Difficulty • Proliferation Time • Proliferation Cost • Safeguards Cost • Adversary Success Probability & Consequence • Security Cost

Methodology Report approved for unlimited public distribution by the Generation IV International Forum: http://www.gen-4.org/Technology/horizontal/PRPPEM.pdf

Evaluating a Fuel Cycle System

- Decompose nuclear system into system elements to permit pathways analysis
  - Materials, facilities, processes, fuel cycle facilities, reactors, storage for fresh and spent fuel, nuclear research facilities, transportation links, etc.
- Consider the location of operations and materials, their accessibility and characteristics, and elements such as
  - Material Balance Areas (MBAs),
  - Key Measurement Points (KMPs),
  - Safeguards and physical protection systems.
- Identify interfaces with other (clandestine nuclear) systems that are not part of the system being evaluated.



When detailed design information is not available, assumptions are documented and become a part of the system design bases

Insights from Gen IV and Other Studies

- System studies can be performed on a comparative basis, e.g.
  - Study of Reprocessing Alternatives to PUREX
  - Study of Advanced Reactor Alternatives to ALWR
- Multiple pathways highlights fact there are no simple answers:
  - Results sensitive to underlying assumptions about existing capabilities and objectives of adversaries
  - Validates decision not to roll up analysis into a single figure of merit
  - Interface of extrinsic and intrinsic measures—<u>safeguardability</u> is a key consideration

Observations from Evaluation Process

- Even a qualitative analysis is useful for informing decision-makers on “big picture”

  — e.g., for which threat scenarios do particular process characteristics make a difference, and how, and where do they not.

- Useful framework for integrating key findings and insights from multiple, more narrowly focused, technical studies

The Policy-Technology Nexus

- Policy informs the statement of the questions to be addressed
- Technical evaluations are performed to provide clear statements of alternatives (indicating and displaying degrees of differentiation)
- Policy is then used again to help choose among the alternatives defined in the results

Do not infuse technical evaluation portion with subjective notions from policy

Do not misuse technical assessment to drive policy

Knowledge Gaps

- Scenario Completeness
  - Need to explore more fully
  - Threats are stylized
  - Likelihood of threats
- Human Performance
- Rolling up elements of an evaluation
- Harmonizing Design Understanding with Potential Safeguards/Protection Possibilities
- Conveying and Displaying Results:

→ ***In particular, what we know about what we do not know***

What we learned from Reactor Safety

- WASH-1400 provided risk perspective, departing from and adding to deterministic, prescriptive perspective
- It helped to set safety goals when requested by Congress in the aftermath of TMI-2 accident
- It highlighted the gaps in risk analysis:
  - Human Factors
  - Core melt and containment response
  - Data Needs

→ Lesson for Proliferation Risk Assessment?

→ Can we risk-inform this area as we do Safety?

Final Notes

- *It is the insight gained from the disciplined process of performing the evaluation that is of value, and not just the bottom line results.*
- *Seek benefits of evaluations early in the design of nuclear energy systems*
- *The evaluation process is not a one-stop check-list exercise…it is a journey (throughout the full life-cycle)*