An Analysis of Nuclear Proliferation Resistance: Country Specifics

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Introduction

- **Before Early 1970s**

  - IAEA safeguards manage the proliferation risks

  - Indian nuclear explosion of 1974

  - Reappraisal of the US nonproliferation policy

- **After Early 1970s**

  - Carter's nonproliferation policy of 1977

  - Commencement of studies of alternative fuel cycles to reduce proliferation vulnerabilities of civil nuclear energy systems

  - Studies on proliferation resistance: NASAP (1976-80), INFCE (1977-80), Plutonium disposition (1994-2000), TOPS (1999-2001), INPRO (since 2000), GIF (since 2001)

NASAP

- **What NASAP**

  - NASAP (Nonproliferation Alternative System Assessment Program) begun by US DOE between 1976-1980

  - Recommendations for development of nuclear power systems and institutions that are more proliferation resistant

- **Proliferation Resistance**

  - Capability of a nuclear energy system to inhibit, impede, or prevent the diversion of associated fuel-cycle materials or facilities from civilian to military uses

  - Achieved through a combination of *technical* and *institutional* features of the system, to the detriment of would-be national or subnational proliferators

NASAP (cont)

- **Measures Improving Proliferation Resistance**

  - Use of diversion-resistant form of materials and technologies

  - Avoid of unnecessary sensitive materials and facilities

  - An effective export control system

  - Joint or international control of the necessary sensitive materials and facilities

  - Full-scope safeguards and a timely international system of warning and response

- **Institutional and Technical Barriers**

  - Institutional mechanisms are perhaps effective in dealing with national proliferation, while technical barriers appear to deal adequately with most subnational threats.

NASAP (cont)

Measure	Proliferation resistance using unsafeguarded facilities or materials	Proliferation resistance using safeguarded facilities or materials	Effect on IAEA safeguards	Proliferation resistance to subnational threat
Coconversion	Little or no change	Increased	Little or none	Increased
Coprocessing	Increased [a]	Increased [a]	Little or none	Increased
Preirradiation	Increased [b]	Increased [b]	Little or none	Increased
Spiking	Increased [b]	Increased [b]	Degraded	Increased
Partial processing	Increased [a]	Increased [a]	Degraded	Increased
Passive measures and physical barriers	Little or no change	Increased	Enhanced	Increased
Active use-denial	Not applicable	Increased	Little or none	Increased
Fuel-service centers (including collocation)	Little or no change	Increased	Enhanced	Increased
Fuel management and transport control (including storage/ transport as mixed oxide or mixed-oxide assemblies)	Increased [b]	Increased [b]	Little or none	Increased

[a] Depends on how easily the facility can be modified to produce pure plutonium stream.
[b] May not be very effective where reprocessing plant is deployed.

INFCE

- **What INFCE**

  - INFCE (International Fuel Cycle Evaluation) between 1977-1980

  - Examination proliferation resistance ensuring that benefits of nuclear power do not to be denied

- **Measures Improving Proliferation Resistance**

  - Bolstering of safeguarding capabilities

  - Colocation of reprocessing and mixed-oxide fuel fabrication plants and coconversion of mixed-oxide from mixed plutonium and uranium solution

  - Physical barriers to protect special nuclear material

INFCE (cont)

- **About Technical Barriers**

  - Technical measures could significantly reduce risk of theft or diversion by subnational proliferators, but would not constitute significant deterrents to determined national proliferators.

Plutonium Disposition

- **CISAC Studies on Plutonium Disposition**

  - Studies on plutonium disposition by CISAC (Committee on International Security and Arms Control) of National Academy of Science between 1994-2000

  - CISAC used “spent fuel standard” as a proliferation resistant criterion for disposition of excess U.S. and Russian weapons-grade plutonium, recovered from dismantled U.S and Russian nuclear weapons

- **Spent Fuel Standard**

  - Makes plutonium roughly as inaccessible for weapons use as the much larger and growing stock of plutonium in civilian spent fuel

  - Describes proliferation resistance attributes in terms of intrinsic barriers to acquisition of plutonium from its storage site, to separation of plutonium from spent fuel, and to use of separated plutonium in nuclear weapons

Plutonium Disposition (cont)

Barrier	Importance of barrier against the threat		
	Host-nation breakout	**Theft for a proliferant state**	**Theft for a sub-national group**
Barriers to acquisition of the Pu from its storage site			
Mass and bulk of item	Zero to low	Moderate	Moderate
(low) concentration of Pu in item	Zero to low	High	High
Radiation hazard to acquires	Low	Moderate	Moderate
Technical difficulty of partly separating Pu from bulk components of item on site	Zero to low	High	High
Thermal, chemical, and nuclear signatures aiding detection	Zero to moderate	Moderate to high	Moderate to high
Barriers to separation of the Pu from diluents and fission products			
Technical difficulty of disassembly	Low	Low to moderate	Moderate
Technical difficulty of dissolution and separation	Low	Moderate to high	High
Quantity of material to be processed	Low to moderate	Moderate to high	High
Hazards to separators	Low	Moderate	Moderate
Signatures aiding detection	Zero to moderate	Moderate to high	High
Barriers to use of the separated Pu in nuclear weapons			
Deviation of isotopic composition from weapons-grade	Moderate	Moderate	Low

TOPS

- **What TOPS**

  - Task Force on Technical Opportunities for Increasing the Proliferation Resistance of Global Civilian Nuclear Power System (TOPS) by US DOE between 1999-2001

  - Identify areas in which technical contributions could be useful to increase proliferation resistance of civilian nuclear energy systems.

- **Measures Improving Proliferation Resistance**

  - Intrinsic barriers are characterized in material barriers and technical barriers.

  - Institutional barriers is focused on existing regime such as international safeguards system by the IAEA.

  - Combination of intrinsic and institutional barriers could lead to an effective proliferation resistance.

TOPS (cont)

	Sophisticated State, Overt	Sophisticated State, Covert	Unsophisticated State, Covert	Subnational Group
Material Barriers				
Isotopic	Moderate	Low	Moderate to high	High
Chemical	Very low	Very low	Moderate to high	High
Radiological	Very low	Low	Moderate	High
Mass and Bulk	Very low	Low	Low	Moderate
Detectability	Not applicable	Moderate	Moderate	High
Technical Barriers				
Facility Unattractiveness	Moderate	Moderate	High	Very low
Facility Accessibility	Very low	Low	Low	Moderate
Available Mass	Moderate	Moderate	High	High
Diversion Detectability	Very low	Moderate	Moderate	Moderate
Skills, Expertise, and Knowledge	Low	Low	Moderate	Moderate
Time	Very low	Very low	Moderate	High

INPRO

- **What INPRO**

  - International project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) by the IAEA since 2000

  - Create an innovative nuclear power technology to further reduce nuclear proliferation risks and resolve the problem of radioactive waste in fulfilling the energy needs in the 21-th century.

- **Measures Improving Proliferation Resistance**

  - Identify four types of intrinsic features and five types of extrinsic features

  - However, current INPRO studies does not propose a specified method to develop specific technological features and institutional arrangements.

INPRO (cont)

- **Four types of Intrinsic Features**

  - Technical features of a nuclear energy system that reduce the attractiveness for nuclear weapons programs of nuclear material during production, use, transport, storage and disposal

  - Technical features of a nuclear energy system that prevent or inhibit the diversion of nuclear material

  - Technical features of a nuclear energy system that prevent or inhibit the undeclared production of direct-use material

  - Technical features of a nuclear energy system that facilitates verification

INPRO (cont)

- **Five types of Extrinsic Features**

  - States' commitments, obligations and policies with regard to nuclear nonproliferation and disarmament

  - Agreements between exporting and importing states that nuclear energy systems will be used only for agreed purposes and subject to agreed limitations

  - Commercial, legal or institutional arrangements that control access to nuclear material and nuclear energy systems

  - Application of the IAEA verification and, as appropriate, regional, bilateral and national measures, to ensure that states and facility operators comply with nonproliferation or peaceful-use undertakings

  - Legal and institutional arrangements to address violations of nuclear nonproliferation or peaceful-use undertakings

GIF

- **What GIF**

  - Generation IV International Forum (GIF) since 2001

  - Develop Gen IV nuclear energy systems for meeting challenges of safety, economics, waste and proliferation resistance

- **Measures Improving Proliferation Resistance**

  - Identify proliferation resistance and physical protection (PR&PP) of Gen IV nuclear energy systems

  - Evaluation of PR&PP are characterized by national proliferation and nuclear terrorism

  - Measuring PR&PP of Gen IV nuclear energy systems is in progress

GIF (cont)

- **Intrinsic and Extrinsic Barriers**

  - Intrinsic barriers are defined by material quality (isotopic composition, chemical separability, mass and bulk, fuel matrix radiation level, dilution and detedtability characteristics), and by technical impediments that are inherent to a nuclear system, such as facility unattractiveness and accessibility, mechanical impediments to material and vital equipment access, skill requirements.

  - Extrinsic barriers are involved with institutional controls, such as materials control and accounting (MC&A) and physical protection performed by the nation-state to prevent theft and sabotage, and the detection of diversion and misuse performed by international safeguards and by the specific agreements that a nation is signatory to.

Summary of Proliferation Resistance

- Relative importance of barriers to proliferation risk

Barrier	Would-be Proliferator	
	State	Sub-national Group
Intrinsic (material and technical barriers)	Low	High
Extrinsic (institutional barriers)	Moderate	High

Country-Specific Proliferation Risk

- **ROK vs Japan**

	ROK	Japan
Membership of NPT	Yes	Yes
Dependence on nuclear energy	High	High
Reprocessing	No	Yes
Enrichment	No	Yes
Proliferation risk	High (?)	Low (?)

Concluding Remarks

- Combined protection of intrinsic and extrinsic barriers is essential to effective proliferation resistance on the civilian nuclear energy systems, although effective proliferation resistance measures depend upon the proliferation threats.

- Due to country-specific proliferation risk imposed by NSG countries such as the US, some NPT member countries including ROK receive discrimination in peaceful use of nuclear energy and in deployment of advanced civilian nuclear energy systems.

- Concept of extrinsic barriers needs to be further developed to consider the existing discrimination of country-specific proliferation risk between NPT member countries.

- For the countries such as ROK, multinational approaches through international cooperation could add further layers of international control, increase the transparency of nuclear material management, and effectively reduce country-specific proliferation risk.