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A Digest of Nonproliferation Literature

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A Digest of Nonproliferation Literature

Developing a Roadmap for US/Russia Collaborative Nonproliferation Technology Research and Development

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Abstract

In preparation for the 2005 US/Russian Weapons Laboratories Directors Meeting, the six laboratories participating in the meeting endeavored to develop a strategy for nonproliferation technology research and development. A literature review was conducted to identify possible areas of technical collaboration and technology opportunities associated with improving nonproliferation associated with the civilian nuclear fuel cycle. The issue of multinationalization of the nuclear fuel cycle was also researched. This digest is the compilation of one-page summaries used by management of the three US nuclear weapons laboratories in preparation for strategy development. Where possible, the Web site address of the complete paper is referenced.

Acknowledgements

The author wishes to thank Jessica Ruyle, Nancy Orlando-Gay, and Barbara Dry for their research assistance and contributions.

Contents

Acronyms

ANL	Argonne National Laboratory
DOE	Department of Energy (US)
HEU	highly enriched uranium
IAEA	International Atomic Energy Agency
INFCE	International Nuclear Fuel Cycle Evaluation
INPRO	International Project on Innovative Nuclear Reactors and Fuel Cycles
INS	innovative nuclear energy systems
LANL	Los Alamos National Laboratory
LEU	low-enriched uranium
LLC	Limited Liability Company
LLNL	Lawrence Livermore National Laboratory
LWR	light water reactor
MIT	Massachusetts Institute of Technology
MOX	mixed oxide
NEI	Nuclear Energy Institute
NPT	Nuclear Nonproliferation Treaty
NSG	Nuclear Suppliers Group
PSI	Proliferation Security Initiative
Pu	plutonium
PUREX	plutonium-uranium reduction extraction
R&D	research and development
RFCC	Regional Nuclear Fuel Cycle Centre
SNL	Sandia National Laboratories
TOPS	Technological Opportunities to Increase Proliferation Resistance of Global Civilian Nuclear Power Systems
UC	University of California

Background

In preparation for the 2005 US/Russian Weapons Laboratories Directors Meeting, the six laboratories participating in the meeting endeavored to develop a strategy for nonproliferation technology research and development. A literature review was conducted to identify possible areas of technical collaboration and technology opportunities associated with improving nonproliferation associated with the civilian nuclear fuel cycle. The issue of multinationalization of the nuclear fuel cycle was also researched.

One-page summaries of each article were prepared. This digest is the compilation of those summaries used by management of the three US nuclear weapons laboratories in preparation for strategy development. Where possible, the Web site address of the complete paper is referenced.

The digest does not necessarily express the opinion of Ruth Duggan or the view of Sandia National Laboratories.

Multi- or Internationalization of the Nuclear Fuel Cycle: Revisiting the Issue

Summer 2004
Marius Stein - Canberra Aquila Inc. Albuquerque, NM
Gotthard Stein and Bernd Richter - Forschungszentrum, Juelich, Germany
Caroline Jorant - Areva, France
http://www.iaea.org/NewsCenter/Focus/FuelCycle/stein.pdf
6 pages

This article summarizes the institutional measures recommended in a report written by the International Nuclear Fuel Cycle Evaluation (INFCE) in the early 1980s and comments on their applicability to today's situation. The article suggests changes to Article IV of the Nuclear Nonproliferation Treaty (NPT) to reflect the alterations the international community has undergone since the treaty was signed in 1968.

Many of the articles written today about the internationalization of parts of the nuclear fuel cycle are apparently restating ideas already devised by the INFCE report. The report advocates multi- or international cooperation in uranium enrichment, spent fuel reprocessing, plutonium(Pu) storage, and the transport and storage of spent fuel.

A stated problem with international cooperation in uranium enrichment and spent fuel reprocessing has been the spread of sensitive technology associated with these processes. Other roadblocks to international cooperation have been the lack of privatization in energy markets and the globalization of business.

The authors note some general trends that could lead to increased transparency and nonproliferation efforts: sustainable development, liberalization of energy markets and globalization in the private sector, transfer of sensitive nuclear technology, multinational facilities, and effectiveness of safeguards. The Generation IV International Forum and the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) have researched how to assure the sustainability of nuclear energy. The liberalization of markets on a global scale will further enhance the process of multinationalization within the private sector. Since the proliferation of sensitive technologies is difficult to inhibit, strict application of export controls, international safeguards, and the Additional Protocol will prevent the construction of clandestine facilities. Every shareholder in a multinational facility has a vested interest in preventing and uncovering possible diversion efforts, because such activities might endanger their fuel-cycle-related services.

The authors believe that Article IV of the NPT needs to be reinterpreted: "Rather than fostering the transfer of sensitive technologies and materials, the international community should encourage shared comprehensive solutions that allow all signatories to the treaty to sustain reliable nuclear fuel cycles."

A Technology Roadmap for Generation IV Nuclear Energy Systems

December 2002

Issued by the US DOE Nuclear Energy Research Advisory Committee and the Generation IV International Forum

http://gif.inel.gov/roadmap/pdfs/002_a_technology_roadmap_for_gen_iv_nuclear_energy_systems.pdf

97 pages

The paper identifies six reactor technologies that should be pursued: gas-cooled fast reactor system, lead-cooled fast reactor system, molten salt reactor system, sodium-cooled fast reactor system, supercritical-water-cooled reactor system, and the very-high-temperature reactor system. These technologies are all determined to be proliferation resistant and acceptable in physical protection.

A section entitled "Crosscutting Proliferation Resistance and Physical Protection R&D" describes three research and development (R&D) areas that should be pursued and that would address five security threats in a reactor. These five security threats were defined as: state-driven diversion or undeclared production of fissile materials, theft of fissile materials, theft of nuclear material for radiation dispersal devices, sabotage of nuclear facilities, and sabotage of nuclear materials in transport.

The first research and development area discussed is "R&D Supporting the Safeguards and Physical Protection Strategy":

1) Determine the type, amount, and location of nuclear materials suitable for weapons use, other nuclear material from which such material could be created, and hazardous radioactive material
2) Identify potential vulnerabilities for all materials in the fuel cycle for each of the five security threats: For each vulnerability identified, research and development should be carried out to decrease the attractiveness of the material.
3) Determine means to protect key reactor or fuel cycle facility technology that could be used for proliferation against intended use and related systems, equipment, and materials that could be used against unauthorized replication
4) Identify and increase the intrinsic and extrinsic protection afforded against each material's diversion, theft, or dispersal
5) For solution processing systems involving partial decontamination, identify potential means to extract material suitable for weapons use through the misuse of normal plant equipment or through the introduction of additional systems that might be concealed
6) Interaction with the International Atomic Energy Agency (IAEA) should start during the viability research and development phase
7) Using the simplified probabilistic risk assessment for the system, identify the vulnerability to sabotage that could lead to releases of radioactive material or theft resulting from breaches of containment
8) Determine the potential use of the reactor for clandestine production of plutonium or uranium-233, the impact of such use on the safe operation of the reactor, the detectability of fertile material introduced into irradiation positions, and the detectability of changes in the neutronic or thermal-hydraulic behavior of the reactor
9) For each step in the fuel cycle, define a concept for determining the amounts, locations, and characteristics of all material in real time.

The second area for research and development is "R&D of Proliferation Resistance and Physical Protection Evaluation Criteria and Metrics." Research and development is recommended to produce the set of criteria and metrics for the evaluation of the intrinsic and extrinsic barriers that address each of the five security threats.

The third area for research and development is "R&D of the Assessment Methodology." Explicit comprehensive methods for evaluating the adequacy and requirements for a safeguards and physical protection system are needed to assess the protection and response capabilities it provides.

Safeguards for Generation IV Reactors: Is There a Technical Fix?

2001

American Nuclear Society Meeting June 17-21, 2001, Milwaukee, Wisconsin

Andrew C. Kadak, MIT

3 pages (review of hard copy)

This author argues that nuclear weapons proliferation, referring only to state proliferation, has nothing to do with nuclear power proliferation. He states that nuclear proliferation is a political problem and fundamentally cannot be fixed by technology.

The author argues that some of the US and NPT policies toward nuclear energy have exacerbated the problem instead of helping it. He uses an example of the United States denying a country access to nuclear power and the said country merely going to another source to receive the knowledge and equipment. This action leaves the United States out of the loop on safety and nonproliferation requirements such as restricting enrichment knowledge.

The author is essentially arguing that, although technical approaches are a good idea to prevent proliferation, we should not become obsessed with them since "they will not deter a nation from building such a weapon if the national need or will is there to do so."

"The true safeguards regime is one in which the desire to build a nuclear bomb does not exist. We should look at those fundamental drivers before we make nuclear energy plant systems so complex or conclude that it is not a technology that should be deployed on a worldwide basis."

Can the Proliferation Risks of Nuclear Power Be Made Acceptable?

April 9, 2001

Edwin S. Lyman, Nuclear Control Institute

http://www.nci.org/conf/lyman/

11 pages

This author ultimately argues against the expansion of nuclear power. The US Department of Energy (DOE) has invested large amounts of money in the research of grandiose proliferation-resistant systems. However, he notes, electric utilities, in general, are not interested in these systems.

The self-protections in spent fuel will eventually fade and this material will have to be protected again. If buried, the fuel would be sufficiently safe from theft.

The IAEA's safeguards budget has not increased in real terms in more than a decade. Funding will be a pinnacle step to the safety of nuclear energy. "Does the world really need energy systems that are considered to be so threatening that they have to be maintained so as to be as dangerous as possible?" Some nuclear specialists tend to get caught up in using the natural protection of spent fuel and try to maintain the radioactivity of fuel to prevent theft.

"The costs of maintaining the security programs necessary to pass an Operational Safeguards Response Evaluation are considered burdensome by US nuclear plant operators, who have been actively seeking reductions in physical protection requirements." If nuclear power plants are already complaining about protection requirements, are they really going to be willing to submit to further regulations?

Proliferation Aspects of Plutonium Recycling

Fall 2002
Bruno Pellaud
IAEA - Former Deputy Director General of the IAEA and Head of the Department of Safeguards
European Commission - Advisor to the European Commission on Euratom Security Matters
Swiss Association for Atomic Energy - President
http://www.inmm.org/topics/contents/fall02issue/pellaud.pdf
9 pages

Bruno Pellaud argues that policymakers live under the delusion that all plutonium is a proliferation risk as the result of an experiment conducted by the United States in the 1970's in which a bomb was created and set off using reactor grade plutonium. The author clarifies this experiment, stating that the classification has since changed and that the plutonium that was used was really fuel grade not reactor grade, still a grade that he believes is dangerous.

The author of the article wants further classification of plutonium, arguing that the lower grades of plutonium are for all practical purposes unusable in a nuclear weapon. He also argues that with less protection needed for the lower grades of plutonium, the higher grades can receive more protection, which he believes to be needed.

"Indeed the recycling of plutonium eliminates - for all practical purposes - the proliferation risks associated with plutonium. The plutonium contained in, or separated from, mixed oxide (MOX) spent fuel incorporates so much of the undesirable isotopes Pu-238 and Pu-240 that the material becomes useless for a weapon and even for an explosive device."

Pu-238 and Pu-240 cause high heat and radiation levels, rendering handling of them very dangerous. Therefore, he argues that all of the higher grades of plutonium should be converted into MOX grade thus eliminating all proliferation risks.

In another argument the author concludes that if a terrorist organization were able to obtain reactor grade plutonium they would *only* possess the technology to create a 1kT bomb with limited reliability. He seems to think that this is an acceptable risk.

The author's new categories of plutonium are high-grade, low-grade, and depleted-grade. High-grade would contain weapons-grade and fuel-grade plutonium, which contains less than 17 percent Pu-240. Low-grade would contain plutonium with 17-30 percent Pu-240. This classification would contain the most plutonium, because it would correspond to medium-high burnup of light water reactor (LWR) fuel. Nuclear engineers are trying to increase the burnup of the fuel that is used in reactors. The higher the burnup is, the higher the efficiency and power production capabilities of the fuel. Depleted-grade fuel would have greater than 30 percent Pu-240. This would be mostly plutonium in irradiated LWR MOX.

Economics of Reprocessing vs. Direct Disposal of Spent Nuclear Fuel

December 2003
Harvard University Project on Managing the Atom
Matthew Bunn, Steve Fetter, John P. Holdren, Bob van der Zwaan
http://bcsia.ksg.harvard.edu/BCSIA_content/documents/repro-report.pdf
127 pages

Bunn performed an extensive economic analysis of the entire fuel process and concluded that the once-through fuel cycle was still significantly cheaper than reprocessing. He also concluded that it will be at least a "few decades, if then" before the cost of uranium would make reprocessing more cost-effective than direct disposal.

Technological Opportunities to Increase Proliferation Resistance of Global Civilian Nuclear Power Systems (TOPS)

January 2001
John J. Taylor – Chair, EPRI
Schock and Strauch (LLNL), Arthur and Tape (LANL), Ahearne (Duke University), Bengelsdorf (Bengelsdorf, McGoldrick and Associates, LLC), Bunn (Harvard University), Cochran (Natural Resources Defense Council), Golay (MIT), Hill (ANL), Matsui (Institute of Applied Energy, Japan), Nigon (COGEMA, France), Panofsky (Stanford University), Peterson (UC-Berkeley)
http://nuclear.gov/nerac/finaltopsrpt.pdf
19 pages

This report provides suggestions for several technologies for which more research and development money and effort should be spent to increase proliferation resistance of nuclear power systems. The recommended areas of importance are:

1. To develop improved methodologies for assessing proliferation resistance
2. To develop technology to strengthen the application of extrinsic (institutional) barriers against proliferation
3. To develop new technologies to enhance the intrinsic barriers against proliferation, thereby reducing the burdens on the extrinsic system

This report recommends developing a methodology to quantify and evaluate the proliferation resistance of a nuclear system design using intrinsic and extrinsic characteristics and to identify areas of weakness.

Appendix 3 lists the recommended research and development to strengthen the extrinsic barriers to proliferation. General areas include Information technology, systems studies, improved material accounting and facility monitoring, wide-area environmental monitoring, application of probabilistic risk assessment methodology, enhanced material-tagging safeguards measures, improved cost surveillance and international/regional safeguards interaction, measures to improve national material protection, control, and accounting systems, and the importance of aggregating spent fuel.

The report also includes the necessary intermediate and long-term research and development needed for intrinsic barriers. (Refer to pages 15-17.)

Intermediate	Long-Term
• Light Water Reactors and their fuel cycles • High Temperature Gas-Cooled Reactors • Fast Spectrum Reactors • Small Modular Reactor Systems • Research Reactors • Transmutation Technology	• Advanced Light Water Reactors • Liquid Metal Reactors • Liquid Fuel Reactors • Gas-Cooled Reactors • Reactors that don't require refueling for 10-15 years • Reprocessing that doesn't require the separation of plutonium

Summary and Overview: A Report of the Technical Coordinating Committee to the Final INFCE Plenary Conference

February 25, 1980
International Nuclear Fuel Cycle Evaluation
53 pages (review of hard copy)

INFCE was to be a technical and analytical study whose results were to be transmitted to governments for their consideration in developing their nuclear energy policies and in international discussions concerning nuclear energy cooperation and related controls and safeguards.

Eight working groups were formed:

- Fuel and Heavy Water Availability
- Enrichment Availability
- Assurances of Long-Term Supply of Technology, Fuel, and Heavy Water and Services in the Interest of National Needs Consistent with Nonproliferation
- Reprocessing, Plutonium Handling, Recycling
- Fast Breeders
- Spent Fuel Management
- Waste Management and Disposal
- Advanced Fuel Cycle and Reactor Concepts

Results suggest that nuclear energy will grow to meet global energy demands. Nuclear energy should be made widely available to meeting the world's energy requirements. Twenty-two reactor types and their fuel cycles were studied and five were selected for further study – once-through LWR fuel cycles and heavy water reactor fuel cycles, large-scale introduction of fast breeder reactors, LWRs with recycle of self-generated plutonium, and heavy water reactors with recycle of self-generated plutonium or uranium/thorium fuel recycle.

The uranium, thorium, and heavy water availability demand was explored and it was concluded that regional imbalances of uranium supply and demand cause concern about assurances of supply for the consumer and about assurances of markets for the producer. Fuel cycle services were analyzed and the group determined that regardless of the spent fuel management concept, growth in the accumulation of spent fuel is expected to exceed storage capacity unless early action for provisions is taken.

It was also concluded that reprocessing, MOX fuel fabrication, plutonium handling, and recycling can all be carried out in conformity with International Commission on Radiological Protection recommendations. The radioactivity of the enrichment plant inventory is extremely low, and the main environmental concerns focus on chemical effluents, energy consumption, and heat removal. Environmental considerations must also include socioecological environmental concerns.

The risks of diversion identified by the working groups were fresh fuel containing enriched uranium or plutonium; uranium enrichment; reactors; spent fuels storage; reprocessing, including plutonium storage and MOX fuel fabrication, and spent fuel or waste disposal. Transportation was also considered as a target for theft. Use of commercial-grade plutonium is unattractive compared with weapons-grade plutonium produced by a dedicated program.

Long-term assurance of commercial nuclear energy is dependent on international cooperation and a climate that is politically, economically, technically, and commercially conducive to the development of a healthy nuclear industry and efficient functioning of market forces. Government intervention will be required for this to succeed.

Four categories of technical options were considered: measures to reduce the presence of weapon-usable materials in separated form in the fuel cycle, measures to use radioactivity to protect those materials from diversion, measures to protect them by the use of physical barriers, and the use of lower enrichment for research reactor fuels.

A network of bilateral and multilateral agreements by which states undertake to accept international safeguards on some or all of their nuclear activities is an essential component of the regime. Special needs of and conditions in developing countries were also considered, and a list of criteria was developed for their participation in nuclear energy programs.

Securing the Bomb: An Agenda for Action

May 2004
Matthew Bunn and Anthony Wier - Project on Managing the Atom, Harvard University
http://bcsia.ksg.harvard.edu/BCSIA_content/documents/securing_the_bomb.pdf
130 pages

This report discusses the continuing global danger from a terrorist attack using a stolen or improvised nuclear bomb. A number of myths are debunked and the global threat is also examined.

A review of the key developments and progress in the last year is also included as well as a budget review from 2002 through 2004. FY05 proposed funding for controlling nuclear warheads, materials, and expertise is discussed in terms of:

- Securing nuclear warheads and materials
- Interdicting nuclear smuggling
- Stabilizing employment for nuclear personnel
- Monitoring stockpiles and reductions
- Ending further production
- Reducing excess stockpiles

A “Security First” agenda is proposed to reduce, consolidate, and secure existing nuclear materials with recommended actions by the US president and Congress, the Russian president, and the leaders of the Group of Eight and other key states.

This agenda focuses on three elements:

- Removing the nuclear material entirely from the world’s most vulnerable sites
- Accelerating and strengthening the effort in Russia
- Building a fast-paced global coalition to improve security for nuclear stockpiles around the world

Guidance for the Evaluation of Innovative Nuclear Reactors and Fuel Cycles

June 2003
INPRO Phase 1A Report, IAEA
http://nucleartimes.jrc.nl/Doc/tecdoc-1362.pdf
152 pages

This report examines the issues of the nuclear fuel cycle by examining innovative and proliferation-resistant nuclear technology. It focuses on:

- Prospects and potentials of nuclear power within the next fifty years
- User requirements for innovative nuclear energy systems (INS) in the areas of economics, sustainability and environment, safety, waste management, proliferation resistance, and crosscutting issues
- Methodology for assessment of INS

Nuclear power could ultimately supply fifty percent or more of the world's primary energy, depending on innovation and continuous development of nuclear technologies leading to INS that will be superior to existing plants. These systems include electricity-generating plants, plants of various size and capacity for high-temperature heat production, district heating, and seawater desalination, to be deployed in developed regions as well as in developing countries and countries in transition.

INPRO has defined a set of *Basic Principles, User Requirements*, *and Criteria* (consisting of an indicator and an acceptance limit) for each area. Users encompass a range of groups, including investors, designers, plant operators, regulatory bodies, local organizations and authorities, national governments, NGOs and the media, and the end users of energy (e.g., the public and industry).

Four selected economic scenarios from the *Special Report on Emission Scenarios* study have been analyzed, covering a variety of possible future developments that are characterized by differing levels of globalization and regionalization and by differing views of economic growth versus environmental constraints. For nuclear technology to gain and grow market share, it must be competitive with competing energy technologies.

INPRO has set out two basic principles related to sustainability, one dealing with the acceptability of environmental effects caused by nuclear energy and the second dealing with the capability of INS to deliver energy in a sustainable manner in the future.

The safety principles and requirements developed within INPRO are based on extrapolation of current trends and seek to encompass the potential interests of developing countries and countries in transition. For nuclear reactors, the fundamental safety functions are to control reactivity, to remove heat from the core, to confine radioactive materials, and to shield radiation. For fuel-cycle installations, the safety functions are to control subcriticality and chemistry, to remove decay heat from radionuclides, to confine radioactivity, and to shield radiation.

The already existing nine principles defined by the IAEA for the management of radioactive waste have been adopted by INPRO without modification.

INPRO has produced basic principles that require the minimization of the possibilities of misusing nuclear material in INS; a balanced and optimized combination of intrinsic features and extrinsic measures; the development and implementation of intrinsic features; and a clear, documented, and transparent method of assessing proliferation resistance. Compliance with these basic principles requires the application of the concept of defense-in-depth by, e.g., incorporating redundant and complementary measures; an early consideration of proliferation resistance in the development and design of INS; and the utilization of intrinsic features to increase the efficiency of extrinsic measures. Research and development is needed to develop a process to assess the proliferation resistance of a defined INS.

Globalization brings with it the opportunity to draw on a broader pool of resources. International cooperation in science and development can assist with optimizing the deployment of scarce manpower and the construction and operation of large-scale research and engineering test facilities.

INPRO has also developed a methodology for evaluating INS. The INS methodology comprises the INPRO *Basic Principles, User Requirements, and Criteria* and a set of tables and guidance on their use that can be used to evaluate a given innovative energy system or a component of such a system on a national, regional, and/or global basis.

Universal Compliance: A Strategy for Nuclear Security

June 2004
George Perkovich, Joseph Cirincione, Rose Gottemoeller, Jon B. Wolfsthal, Jessica T. Mathews
Carnegie Endowment for International Peace
http://wmd.ceip.matrixgroup.net/UniversalCompliance.pdf
94 pages

This draft strategy report provides a blueprint for rethinking the international nuclear nonproliferation regime. The report details the core principles and policies for a new nuclear security strategy as well as technical and political elements, such as restructuring the nuclear fuel cycle, a global threat assessment, and pathways to resolve regional proliferation crises.

Universal Compliance is proposed to mean all sectors (nuclear weapons states, non-nuclear weapons states, NPT states, and Non-NPT states, corporations, and individuals) must comply with treaties and declarations of intent through demonstrated performance. This paper proposes the following:

- No new nuclear weapon states
- Secure all nuclear materials
- Stop illegal transfers
- Devalue the political and military currency of nuclear weapons
- Commit to conflict resolution, including an initiative to persuade India, Pakistan, and Israel to commit to nonproliferation obligations

The elements of an enforceable regime include:

- A global threat assessment, to include nuclear terrorism and transfers, regional proliferation and conflict, and a breakdown of the nonproliferation regime
- Strengthening enforcement through new, stronger international laws; a revived security council to exercise tough diplomacy; inspections that work; and the use of force for counterproliferation and preemption
- Blocking supply by securing the global nuclear complex through universally securing weapon-usable nuclear materials, stopping production of weapon-usable fissile materials, ending the use of weapon-usable material, and eliminating existing stocks; global threat reduction; and stopping transfers (through export controls and interdiction)
- Abating demand by locking in successes (reducing the political value associated with nuclear weapons), providing conflict resolution and regional security mechanisms, revising US nuclear policy and the nuclear reduction agreements, and disarmament
- Applying the strategy for regional crises to areas such as South Asia, Iran, the Middle East, North Korea, and Northeast Asia, with a targeted move toward establishing weapons of mass destruction-free zones in these areas

Carnegie Nonproliferation Report Recommends Suspension of Enrichment

July 5, 2004
Nuclear Energy Overview
2 pages (review of hard copy)

The Nuclear Energy Institute (NEI) supports the nonproliferation recommendations in the Carnegie Nonproliferation Report, with emphasis on securing and controlling weapons-grade fissile material as an international priority. However, NEI opposes a pause in commercial uranium enrichment and the assumption that reprocessing used nuclear fuel is a major proliferation threat. NEI believes that rather than propose a cessation of enrichment activities, commercial market principles might be utilized as disincentives to national enrichment programs. This pause would also jeopardize the down-blend of Russian high-enriched uranium.

Proliferation and the Future of Nuclear Power

March 2004
The Atlantic Council
http://www.acus.org/docs/0403-Proliferation_Future_Nuclear_Power.pdf
10 pages

Los Alamos National Laboratory sponsored a seminar in March 2004 that concluded that, with proper institutional support and appropriate nuclear energy technologies, nuclear power can play a significant role in meeting energy demands within the framework of a reinforced nonproliferation regime.

Nuclear power should be encouraged to help meet anticipated long-term global energy needs, but it must be economically competitive, must benefit the environment, and must continue to be operated very safely and with high capacity factors. Greater public support of the nuclear option will also be required.

The paper also references the six-lab agreement with the goals of:

1) Reducing air pollution and climate change risks and improving energy security by increasing the nuclear fraction of US and world energy needs through safe and economical nuclear energy solutions
2) Reducing the threat of nuclear weapons proliferation by enhancing safeguards and security for all elements of the fuel cycle
3) Minimizing reactor waste requiring repository disposal through the investigation and development of more proliferation-resistant fuel-cycle technologies

Participants at the seminar have selected six next-generation nuclear energy systems concepts: sodium liquid metal-cooled reactor, very high temperature reactor, supercritical water-cooled reactor, lead alloy-cooled reactor, gas-cooled fast reactor, and molten salt reactor. Participants also support more research and development on advanced fuel cycles, including both open and closed fuel cycles. The article noted that the highly enriched uranium (HEU) blend-down effort now provides ten percent of the US electric supply.

Under nonproliferation, the issues of Iran and North Korea were discussed in terms of eliminating a nonindigenous full fuel-cycle capability through multilateral fuel supply and waste disposal assurances.

The Nuclear Fuel Cycle: A Challenge for Nonproliferation

March/April 2004
Lawrence Scheinman
http://www.acronym.org.uk/textonly/dd/dd76/76ls.htm
26 pages

This article reprints an essay originally published under the title "Multinational Alternatives and Nuclear Nonproliferation" in the1981 Winter edition of *International Organization*. A two-page preface explains how the threat has changed but why the discussion is still relevant today. Scheinman begins with words echoed today: "The rationale for multinational institutional arrangements for the nuclear fuel cycle is relatively straightforward. The dispersion of nationally controlled sensitive facilities now threatens to transform weapons proliferation; the adequacy of international verification safeguards for preventing this is at issue, while bilateral controls are becoming less feasible and less effective; and the international community is not ready for more comprehensive international solutions." Scheinman provides an historical account of the multinational institutional arrangements of the 1970s, which were primarily formed for commercial reasons.

Scheinman posits the following assumptions:

1. Widespread support exists for finding ways to meet energy requirements while minimizing the risks of nuclear weapons proliferation
2. Sensitive materials and the facilities that produce them create special problems for which safeguards alone may not be adequate to achieve nonproliferation
3. Additional measures reaching beyond traditional bilateral or multilateral arrangements may therefore be necessary, including mutual agreement to limit use of nuclear technology and materials

The issue of state sovereignty and the apparent discriminatory nature of additional measures reaching beyond bilateral or multilateral arrangements are discussed, as well as arguments challenging the efficacy of such agreements.

In conclusion, Scheinman suggests that for a multilateral system that includes supplier and acceptor states to succeed, there needs to be a coalescence of motives by both to assure trust and stability.

Nuclear Power and Nuclear Weapons: The Connection Is Dangerous

January 1983
James Holdren
Bulletin of the Atomic Scientists
6 pages (review of hard copy)

The motivation for acquiring nuclear weapons is political; therefore, the only practical preventive actions are political ones that reduce motivation and those must recognize the interaction of motivations and barriers to weapons acquisition. Nuclear power lowers the barriers to nuclear weapons acquisition.

A weapon program requires a sizable cadre of highly trained specialists, a source of fissionable raw material, and facilities for converting the material to a weapons-usable form. A commercial nuclear power program lowers these barriers in three ways: 1) assembles people having dual use skills and melds them into a working unit, 2) provides fissionable material, and 3) directly provides the means for converting raw fuel into weapons-usable material.

Economically, the marginal cost of adapting a nuclear power program to produce bombs as well as electricity is less than the cost of building from scratch an equivalent weapons capability in facilities totally dedicated to that purpose.

The main political barriers are: possession of nuclear weapons increases chances of being attacked with nuclear weapons; the international norm (NPT); internal dissent over nuclear weapon acquisition; and increased external sanctions and countermeasures.

A nuclear power program provides a legitimating cover for nuclear activities that would otherwise be unambiguously weapons oriented. Certain components of a nuclear power program (enrichment plants, reprocessing plants, stockpiles of separated plutonium) constitute a temptation to produce nuclear weapons under provocation insufficient to motivate the undertaking of a weapons program from scratch.

Countries can drift toward a military capability without any intention of arriving at it. Changes in government and regional stability can change motivations.

Countries on most lists of potential proliferators – Pakistan, Argentina, Iraq, Libya, Taiwan, South Korea, Brazil – all have achieved this threatening status with the help of technology transferred to promote civilian nuclear power. Civilian nuclear power has spread the technological base of nuclear weaponry.

Six approaches are suggested:

- Work to strengthen gradually the NPT and associated safeguards administered by the IAEA
- Strengthen superpower guarantees against nuclear threats to the security of non-weapons states
- Internationalization of regional enrichment and reprocessing facilities
- Develop and promote more proliferation-resistant fuel cycles for nuclear power generation
- Take unilateral or multilateral action with other nuclear technology suppliers to restrict access to proliferation-prone technologies and to punish proliferative action by withholding assistance and by other economic and political sanctions
- Develop and encourage the worldwide use of a variety of nonnuclear energy options

The race is between the growth of nuclear war probability as a function of the number of countries having the means for it and the reduction of the probability through increased rationality in world politics.

Nuclear Power and Nuclear Weapons: The Connection is Tenuous

1983
Bernard Spinrad
Bulletin of the Atomic Scientists
6 pages (review of hard copy)

Five main arguments are presented for the tenuous connection between nuclear power and nuclear weapons:

- No technical barrier to making nuclear weapons exists.
- Nuclear power presents more discouraging factors than encouraging ones as a route to proliferation, because weapons made by diverting materials from nuclear fuel cycle operations, although possible, are inferior to those specially produced from dedicated weapons facilities.
- The only effective barriers to nonproliferation that have worked and continue to work are institutional.
- Nuclear power decreases world tension over energy supplies thus reducing that issue as a motivator for war.
- For over 25 years, nuclear power has been instituted in many countries as a trade-off against nuclear weapons.

As far as cost and strategic attractiveness are concerned, production reactors and high-enrichment isotope separation plants are simpler, cheaper, and easier to hide than are nuclear power plants.

Nuclear power and nuclear weapons both rely on the neutron-induced fission of specific types of heavy atoms to produce energy. In power reactors, fissile material is used in a fuel mixture. For weapons production, the required fuels are highly enriched fissile materials in the form of pure metals. Additionally, reactors are designed for recovery of fuels and fission products, while the reverse is true of nuclear weapons production.

The only truly effective barrier to proliferation of nuclear weapons is consensus, enforced by international agreements and national education, that proliferation is extremely dangerous to the world's security and will not be tolerated.

Causes of energy uncertainty can best be reduced by decreasing the world's dependence on oil.

Global Cleanout: An Emerging Approach to the Civil Nuclear Material Threat

September 2004
Philipp C. Bleek, Belfer Center for Science and International Affairs, Harvard University
http://bcsia.ksg.harvard.edu/BCSIA_content/documents/bleekglobalcleanout.pdf
28 pages

Obtaining fissile material, either HEU or plutonium, remains the single greatest obstacle to acquiring a nuclear weapon. The United States has conducted five operations over the past decade to clean out specific vulnerable civil nuclear material stockpiles supplied by the Soviet Union:

- Project Sapphire for HEU in Kazakhstan moved HEU to Oak Ridge, Tennessee, for reprocessing into low-enriched uranium (LEU)
- Operation Auburn Endeavor for HEU in Georgia moved HEU to the UK for blend-down
- Project Vinca for HEU in Belgrade at an institute under IAEA safeguards moved HEU to Russia
- The Romania Operation for US-origin spent fuel and Russian-origin fresh HEU fuel in which the Russian-origin fresh HEU Fuel was shipped back to Russia, the United States purchased LEU fuel for the US-origin reactor, and spent fuel will eventually be repatriated
- The Bulgaria Operation for HEU from a closed reactor moved the HEU to Russia for blend-down and reconstructed the reactor for LEU fuel

Efforts to date have been characterized by a consistent pattern of passivity in site identification, incoherence in site selection, sluggish implementation due to ad hoc operations, the absence of clear lines of responsibility, and insufficient empowerment of implementing offices; allowing Russia to effectively stymie progress; and failure to effectively engage third parties, including countries and perhaps nonstate actors.

The author proposes the following key ingredients of a viable global cleanout approach:

- Comprehensive, global threat assessment
- Prioritized, global implementation plan based on materials, security, and location
- Coherent US government program requiring the designation of a single legally, financially, and politically empowered implementation office with adequate resources to get the job done
- Flexible approach to providing incentives targeted to the needs of each facility and state
- Vigorous engagement with Russia to induce Russia to play a more constructive role than it has in the past
- Diplomacy to engage other countries and perhaps nonstate actors, such as third-party countries, purely commercial organizations, and nonprofit organizations

Efforts announced by the US government in Spring 2004 offer potential for the kind of comprehensive, prioritized, and accelerated effort that is urgently needed. Speed and sustained high-level engagement informed by the lessons of past efforts is essential.

Options for Strengthening the Global Nuclear Nonproliferation Regime

May 2004
Bengelsdorf, McGoldrick and Associates for DOE
115 pages (review of hard copy)

DOE requested this report to evaluate a range of options for strengthening the nonproliferation regime, with a view to reducing the risks associated with the spread of enrichment, reprocessing, and nuclear materials. For those countries that foreswear enrichment and reprocessing facilities the United States could:

- Share proliferation-resistant, advanced fuel cycle research and development to appropriate and interested countries pledging to forgo enrichment and reprocessing facilities
- Pledge to forgo PUREX reprocessing in the United States and use only proliferation-resistant reprocessing technology when it is economically justified
- Press for adoption of the proposal by which suppliers would agree to seek ways to ensure the reliable supply of nuclear fuel at reasonable cost when normal commercial markets' mechanisms fail to meet those states' needs
- Adopt principles of supply such that supplier states will enhance the security of supply to importing states and will not interfere with their supply arrangements if they are also in full compliance with their nonproliferation obligations (Some sample principles are listed on page 7.)
- Offer most favored nation treatment as an incentive
- Establish an emergency or last resort stockpile or international fuel bank as a source of guaranteed supply in such a way that does not destabilize the market
- Establish a commercial consortium with the leading suppliers of fuel-cycle services
- Develop a more proactive program of international cooperation and assistance in the management of US spent fuel and nuclear waste
- Offer more substantial and more structured programs of technical cooperation in nonsensitive areas of nuclear technology

Multinational approaches to enrichment and reprocessing must consider three factors: no single solution works for all technologies and all partners; multinational arrangements are not stand-alone nonproliferation operations and could have a counterproductive effect; institutional arrangements can only be as strong as the political, economic, and commercial foundations upon which they are built. The establishment of international or regional spent-fuel storage/disposal facilities might help discourage the emergence of national reprocessing facilities. An international custodial regime for separated plutonium under which states would deposit their excess plutonium with the IAEA for an interim period until the plutonium can be used in a civil nuclear activity or otherwise appropriately disposed. More rigorous sanctions must be developed and employed to preserve the credibility of the nonproliferation regime. All NPT parties should be brought into compliance with the obligation to conclude safeguards agreements and Additional Protocol agreements. The full potential of comprehensive and strengthened safeguards depends on universal adherence and implementation.

The Nuclear Fuel Cycle and The Bush Nonproliferation Initiative

April 1, 2004
Thomas L. Neff, Center for International Studies, MIT
http://www.iaea.org/NewsCenter/Focus/FuelCycle/neff.pdf
7 pages

The author reviews the three groups of measures proposed by the Bush Administration to prevent the proliferation of nuclear weapons: improving the existing regime, expanding effort to keep weapons byproducts from falling into the wrong hands, imposing new controls on nuclear fuel cycle technology and materials.

A historical review of proposed controls on nuclear fuel cycles produces the following:

- *Acheson-Lilienthal* (1946) – Nuclear weapons and nuclear energy are intertwined, and control largely depends on the national will and good faith of nations to not pursue weapons; no prospect of security against atomic warfare exists in a system of international agreements to outlaw weapons controlled only by a system that relies on inspection; and systems of inspection cannot by themselves be made effective safeguards to protect complying states against the hazards of violation and evasions.

- *Truman Approach* – Creation of the Atomic Energy Commission resulted in a course of national secrecy and control rather than multilateral oversight. Baruch scuttled the idea of international ownership of the means of production of nuclear materials in favor of free enterprise.

- *Eisenhower and Atoms for Peace* – The Uranium Bank concept, multinational control of fissionable material, was abandoned as was national competition to supply the work with the benefits of civil nuclear power; the United States set up bilateral agreements instead of waiting for the IAEA. The author states that "the IAEA was forced to play catch-up with nationally backed nuclear sales…the NPT was less an instrument of control over nuclear activities than a partial codification of the international status quo."

- *The Carter Policy* – Based on a policy of cutoff of enriched uranium fuel to supplier nations that refused to join in meeting basic nonproliferation objects, this policy actually drove even allies to larger commitments to plutonium fuels.

- *The Bush Fuel Cycle Proposals* – As long as states renounce enrichment and reprocessing, reasonable cost nuclear fuel will be guaranteed. The Nuclear Suppliers Group (NSG) should refuse to sell enrichment and reprocessing equipment and technologies to any state that does not already possess full-scale, functioning enrichment and reprocessing plants. The author asserts that the proposed limitation on choices of supply are more likely, not less likely, to induce countries to make new commitment to enrichment or reprocessing facilities or give credence to claims from countries such as Iran or Brazil that can be an alternative supplier to other nations.

The author suggests that it is too late for a restrictive fuel cycle approach and focus should be on the regional conflicts that cause nations to choose nuclear weapons, with respect for the interests of those nations and their neighbors.

There Is No Absolute Right To Nuclear Energy

September 22, 2004
Michael Levi, Financial Times
http://www.iranfocus.com/modules/news/article.php?storyid=331
2 pages

"No "right" to nuclear power should be fundamental; access to peaceful nuclear energy is a privilege.…States pursuing nuclear technology should be responsible for proving that the technology will not be used to acquire nuclear arms."

Nuclear technology might be restricted to responsible states, with responsibility defined in terms of transparency and nonaggressive government. Infractions should require greater transparency by these states to submit to stringent inspections of the nuclear facilities using the IAEA intrusive Additional Protocol inspections. States that disregard their responsibilities would lose their rights to the technologies.

International Cooperation in the Supply of Nuclear Fuel Cycle Services

1977
C. Allday, BNFL
Salzburg Conference 1977
http://www.iaea.org/NewsCenter/Focus/FuelCycle/allday.pdf
9 pages

The two main areas of the fuel-cycle business in which collaborative agreements have been successfully established are reprocessing and enrichment. Uranium supply has also generated international collaboration. Fuel fabrication and uranium hexafluoride conversion have not generated international collaboration.

The long-term well-being of mankind is strongly linked to the widespread adoption of nuclear power to meet growing demands for energy and requires a moral obligation to work together to ensure that a responsible approach is made so that short-term nationalistic policies do not jeopardize the long-term energy requirements of the world.

To establish and operate multinational organizations smoothly and efficiently raises many problems. Effective mechanisms for speedy consultation and decision making will need to be established. Individual parties must ensure a high degree of coordination with this body. Objectives must be clearly identified and the market well-defined. Difficulties arising from increased membership using several languages must be mitigated.

The prevention of nuclear weapons proliferation requires that both supplier and customer nations work together to develop realistic and acceptable policies.

Regional Nuclear Fuel Cycle Centres

1977
V. Meckoni, R.J. Catlin, L.L. Bennett
IAEA Study Project
http://www.iaea.org/NewsCenter/Focus/FuelCycle/meckoni.pdf
23 pages

Need is increasing for detailed planning of the entire nuclear fuel cycle. The IAEA initiated a study project on Regional Nuclear Fuel Cycle Centres (RFCCs) in 1975 to examine the economic, safety, safeguards, and security aspects of a multinational approach to planning and establishing nuclear fuel cycle facilities as contracted to a wholly national approach and to developing a methodology to evaluate alternative strategies.

The RFCC concept envisions several countries joining together to plan, build, and operate facilities necessary to service the back end of the nuclear fuel cycle, covering spent fuel from the time it leaves the power reactor through radioactive waste management and recycling. Note that within this concept, multinational participants would be motivated by mutual needs and interests and would not necessarily be limited by geographical considerations. The schedule and operation of an RFCC would begin with the spent-fuel receiving and storage facilities followed by the reprocessing plant and other facilities.

Some conclusions:

- Spent-fuel transport cost as a function of shipping distances would not be very significant in relation to the total fuel-cycle cost.
- Existing and planned spent-fuel reprocessing capacity in the world will not be adequate during the next decade to process the irradiated fuel from the nuclear power reactors in operation during that period.
- Unless some other approach appears possible, a number of countries will have to seriously plan for establishing essential fuel-cycle services on a national basis.
- When individual countries perceive incentives to join an RFCC, then they have less incentive for establishing national facilities, thus reducing the spread of reprocessing capability around the world.
- Not reprocessing spent fuel raises problems: storage until final disposal and the plutonium content, because small reprocessing plants can be constructed and operated with data available in the open literature.
- Approximately seventy percent of the total capital cost of waste management is attributable to the solidification plant for the high-level liquid waste and the cost of disposal in a geological formation.
- Major economic and operational advantages arise from locating the RFCC at the geological disposal site.
- Unit costs of fuel reprocessing, MOX fuel fabrication, and waste management are sharply reduced with the development of larger-capacity facilities. Financing a share of an RFCC would be lower by a factor of two to three than if a state were to establish smaller national fuel-cycle facilities.

The intergovernmental agreements needed for the RFCC would enhance the controls on the transfer and use of nuclear materials and restricted technologies, would provide for the physical protection requirements for the facilities, would provide for the adequate siting of reprocessing and fuel fabrication facilities, and would define limitation on certain activities of the participants that might otherwise be detrimental to the nonproliferation objectives of the RFCC. The RFCC includes the application of full IAEA safeguards to its activities.

Multilateral Approaches to the Nuclear Fuel Cycle

June 2004
Preliminary Views of the IAEA Secretariat for the Proposed Study (Non-Paper)
http://www.iaea.org/NewsCenter/Focus/FuelCycle/preliminaryviews.pdf
8 pages

The issues discussed include:

- Controlling access to nuclear material, equipment, and information that may be relevant for the development of a nuclear-weapon program has grown increasingly difficult.
- The front end of the nuclear fuel cycle is of most immediate concern followed by a resurgent recognition of the need to address the accumulation, storage, and disposal of separated plutonium, spent nuclear fuel, and nuclear waste.

Three measures for study are raised, which taken together could have the potential to provide enhanced nonproliferation assurance to the international community:

- Restrict reprocessing and enrichment exclusively to facilities under multinational control
- Deploy new nuclear energy systems that by design avoid the use of materials that may be applied directly to making nuclear weapons
- Multinational approaches for the management and disposal of spent fuel and radioactive waste, because not all countries have the appropriate geological conditions for such disposal or the necessary financial and human resources

Annex I lists twenty-one key questions to be considered as a starting point for multilateral approaches.

Annex II recalls certain concepts and suggestions for multilateral approaches that were considered in previous decades, providing a brief historical context.

Considerations on Multinational Repositories

2004
J.M. Potier, S. Hossain, IAEA
http://www.iaea.org/NewsCenter/Focus/FuelCycle/tucson04.pdf
13 pages

Repository development has been carried out on a strictly national basis. In 1998, the IAEA produced a technical document outlining the important technical, institutional, economic, sociopolitical, and ethical considerations to be taken into account in the process of realizing multinational cooperation for the implementation of a nuclear repository. This report concluded:

- The multinational repository concept does not contradict ethical considerations.
- The high ratio of fixed to variable costs for a repository ensures that considerable economies of scale will apply.
- Transport of nuclear material is so safe that the transport distances required by a multinational repository will not have a significant impact on public health.

The multinational repository concept assumes that waste originating from more than one country is being disposed of in a common repository. A regional repository is applied to multinational concepts for which the host country and the partner countries are located in the same region of the world. The international repository concept implies that the waste disposal is organized under the authority of a supranational body such as the United Nations.

Three scenarios were studied: an add-on scenario whereby a host country complements its own waste by accepting wastes imported from other countries, a cooperation scenario characterized by participation of partner countries (included the host country) in developing a repository program, and an international scenario in which a higher level of control and supervision is implemented.

Findings:

- Increased level of security might result through the involvement of the international community.
- The accumulation of larger volumes of nuclear materials might attract various subversive attacks and increase the potential consequences resulting from them. Increased risks of theft or diversion of nuclear material may occur during transport.
- Developing a multinational repository is a decades-long undertaking that must survive changes in political systems.
- Lower unit costs could offer an economic advantage in a large-capacity, multinational repository over national programs.
- Technical advantages can result from collaborating on repository implementation. A technical challenge may arise from the variety of waste sources.
- While greater levels of shared knowledge of the institutional framework in partner countries could result in better relationships and changes to migrate toward more common frameworks, the operating life of a multinational repository could extend beyond the lives of the critical institutions in the participating countries and would require treaties specifically to deal with waste retrieval and waste possession.
- Public acceptance and support is necessary, and the process must be perceived as being fair and equitable in the sharing of benefits and challenges.

An important condition is to site, design, and operate multinational repositories so as to take advantage of the inherent ability of repositories to enhance the physical security and safeguards for the emplaced waste. An IAEA safeguards regime will be required. Disposal solutions must be environmentally acceptable and checked by performance assessments. Economic advantage must lie in offering a multinational repository site and an agreement to share the costs and financial risks. Participating countries should have appropriate bodies in their national organizations for interacting with the host and partners on waste transport and transboundary impacts as well as with the international community through the IAEA.

Multinational repositories can enhance global safety and security by making timely disposal options available to a wider range of countries and should continue to receive support from all countries that have an interest in a shared disposal solution. An immediate practical step could be to facilitate these concepts for spent sealed sources.

The Political Economy of Nuclear Energy in the United States

September 2004
Pietro S. Nivola, Brookings Institution Policy Brief #138
http://www.brookings.edu/dybdocroot/comm/policybriefs/pb138.pdf
8 pages

The American nuclear power industry remains the world's largest, with more than one hundred reactors currently in operation. However, nuclear power provides only one-fifth of the US demand for electricity. On average, electricity produced by operational nuclear plants tends to be cost-competitive with gas- or coal-generated power after the nuclear plants have been paid for. The capital costs associated with new builds is prohibitive, and regulatory strictures have slowed construction time and added to expenses. Only steep taxes that cover the main competitors of nuclear-generated electricity (coal and natural gas) as carbon emitters would put nuclear power back in contention.

DOE's Domestic Nuclear Security Initiatives

July 2004
Hugh E. Naylor IV and Charles D. Ferguson, Center for Nonproliferation Studies, Nuclear Threat Initiative
http://www.nti.org/e_research/e3_50b.html
7 pages

DOE's consolidation plan for its geographically dispersed weapons-usable nuclear material is in response to previously underestimated assessments of terrorist nuclear capabilities. The main barrier to assembling a crude, yet devastating, nuclear weapon is the difficulty of acquisition of sufficient quantities of bomb-usable material. By consolidating weapons-grade material to a much smaller number of sites within the nuclear weapons complex and strengthening the security at these sites, DOE would reduce the number of targets and make penetrating nuclear materials storage facilities even more challenging.

Another high priority is that all excess HEU should be down blended to a non-weapons usable form as soon as possible.

Steps Toward Cooperative Global Nuclear Security – A Report of the Five-Nation Project Conference

September 2003
Scott D Sagan, CISAC, Five-Nation Project Conference
12 pages (review of hard copy)

The participants in the Five-Nation Project Conference – a group of current and retired government officials and scholars from China, India, Pakistan, Russia, and the United States - have studied and discussed global problems of nuclear security over the past year. The nine principles of improved nuclear security resulting from the Five-Nation Project Conference held in St. Petersburg, Russia, in September 2003 are as follows:

1. We should expect a continuing terrorist interest in weapons of mass destruction, including nuclear weapons, in the future regardless of what happens to the al-Qaeda network.
2. The theft of a single nuclear weapon or a significant quantity of nuclear materials in any country poses a risk for all countries. Nuclear weapons must be protected at their storage sites, in transport, and in other facilities as the first line of defense in a multilayer concept of defense. The second line of defense is improved border monitoring programs to detect smuggling of nuclear material out of the country of origin. The third line of defense is identification, warning, and defense programs at national border points of entry.
3. Organizational best practices should be shared and discussed in the areas of personal reliability programs; Nuclear Emergency Search Team programs; design basis threat techniques, exercises, and red teams; and independent nuclear security audits.
4. Multilateral discussion of all past incidents in which theft of or attack on nuclear weapons or materials was attempted or succeeded could produce vicarious learning to improve techniques to reduce such dangers.
5. An awareness of the insider threat problem should influence policy decisions concerning design basis threats, personnel reliability programs, and guard force deployments and procedures for nuclear facilities in all countries.
6. All nuclear materials, not just nuclear weapons, need adequate levels of protection against larger terrorist attacks, including material in stockpiles and in transit.
7. Understanding of the invulnerability/vulnerability paradox could be a restraint against nuclear alerting activity and a restraint against making nuclear and conventional threats in crises that encourage nuclear alerting activities in other states.
8. Each nuclear weapons state is obligated to its people to ensure that its weapons would not detonate through either an accident or a terrorist attack with conventional weapons, high explosives, or incendiary weapons.
9. Operational plans, doctrines, and national warning systems need to be revisited to ensure that nuclear retaliation would never occur under the false assumption that an adversary has already initiated the use of nuclear weapons.

The common interest among all governments to prevent nuclear terrorism can lead to new forms of cooperative arms control in the future.

Nuclear Trafficking Routes: Dangerous Trends in Southern Asia

November 22, 2004
Andrew Prosser, Center for Defense Information
http://www.cdi.org/PDFs/TraffickingSmuggling.pdf
17 pages

While 370 out of 660 recorded incidents of illicit nuclear and radioactive material trafficking from 1992 to 2002 either took place in the former Soviet Union or involved materials that originated there, such trafficking has affected over fifty countries on five continents. The Khan network reached from South and Southeast Asia to the Middle East, Africa, and Europe and exchanged centrifuge equipment, nuclear material, design data, blueprints, and the know-how needed to produce enriched uranium. India and Pakistan, nonparticipants in the global nonproliferation accords, have fueled a regional market for the illicit supply of nuclear material and equipment. While entire weapons are never trafficked on the black market, their components are transferred as nuclear material and equipment. Proliferation materials are also found in the movement of weapons-related technical expertise.

Networks trafficking in drugs, weapons, and other illicit commodities are well-suited for nuclear smuggling. All countries must take proactive measures to curb nuclear trafficking and should redouble their efforts to fight other criminal activities. External assistance should emphasize intelligence sharing to learn more about the routes and patterns of this traffic and the terrorist roles therein.

Where perception of insecurity drives states to seek clandestine weapons from nuclear traffickers, the underlying threats to security must be remedied. Lasting solutions will need to focus on ameliorating the decrepit social and economic conditions where terrorism flourishes.

Seminar on Innovative Approaches to Nuclear Nonproliferation and the Nuclear Fuel Cycle

2004
IAEA, Rapporteur's Report
http://www.iaea.org/NewsCenter/News/PDF/ngo_forumrep06022004.pdf
15 pages

On February 5-6, 2004, twenty-seven experts from research institutes and academia and fifteen journalists met at the IAEA in Vienna for discussions. The seminar was divided into four panel sessions resulting in the following observations and recommendations:

Panel 1: Nuclear Verification in a Noncooperative Environment
This panel focused on the general principles of verification within a historical context. The conclusions of this panel were that the burden of proof should be shifted from the IAEA to the NPT states parties, that the IAEA should adopt a new corporate culture, that multilateralism had limitations that might make regional models more useful tools, and that the IAEA must continue to investigate ways to further improve the safeguards system. Also key were the need to reevaluate what constitutes a *significant quantity* and to focus on developing remote monitoring, environmental sampling, nuclear forensics, and the tagging of sensitive nuclear materials and technologies. New regimes must also better understand the connection between the level of trust and the corresponding levels of cooperation expected from states and determining new approaches such as forfeiting nuclear materials, equipment, and technology acquired while party to the NPT if a country decides to withdraw from that treaty.

Panel II: Innovative Approaches to Managing the Nuclear Fuel Cycle: Overview, Enrichment, Reprocessing, and Spent Fuel
This session focused on the management of the nuclear fuel cycle, with particular emphasis on the prospects for multinationalization. This panel concluded that a multinationalization project would take years to achieve and that issues such as export controls and the nuclear black market will take precedence. The best way to approach multinationalization is to begin with the commercial sector by consulting with representatives from the nuclear industry and seeking their opinions on proceeding with this concept. The panel also believed it would be easier to achieve multinationalization at the back end of the fuel cycle but would be of less immediate value. Such a proposal would require US support but also would require another state or states to take the lead.

Panel III: Enhancing Nuclear Security
This panel focused on the identification of key challenges and responses as well as an assessment of the current threat of nuclear terrorism. The three main threats noted are detonation of a nuclear explosive device, the use of a radiological dispersal device, and the sabotage of a nuclear facility or nuclear material transport.

Panel IV: International Media Forum
The role of the media in reporting nonproliferation news and in helping to drive the nonproliferation agenda was discussed. Two primary needs were identified: more informed journalists and a weapons of mass destruction czar to be a single spokesman for interviews.

General Conclusions – The need for a multinational depository and for universal export standards is clear. A similar seminar is planned in 2005.

Strengthening Nonproliferation Rules and Norms: The Three-State Problem

2004
George Perkovich
2005 NPT Review Conference
http://www.unidir.org/pdf/articles/pdf-art2187.pdf
Pages 21-32

The NPT is not universal. In particular, two states are/were signatories but are not in full compliance (Iran and North Korea). Also, three states were never signatories—India, Pakistan, and Israel. India and Pakistan have demonstrated possession of nuclear weapons, are self-proclaimed nuclear weapon states, and are pressing for technology embargoes to be removed. Israel neither confirms nor denies possession of nuclear weapons, causing turmoil within the region and within the nonproliferation regime. This paper deals with the latter three states.

Alternative 1: Through bilateral diplomacy, hector India, Pakistan, and Israel to abandon nuclear weapons and join the NPT as a non-nuclear weapon state: While understandable, this scenario is not likely.

Alternative 2: Allow associate membership in the NPT that would permit the three to retain their nuclear programs but would inhibit further development and explosive testing of nuclear devices and would require the countries to cooperate with international nuclear export controls and to participate in the phased elimination of fissile material production

Alternative 3: Adopt *Universal Compliance,* which is a performance-based regime applicable to states, corporations, and individuals: The three states would be held accountable to all nonproliferation obligations and measures that the five prior nuclear-weapon states undertake: 1) proscribe further national acquisition of fissile material production facilities; 2) secure all nuclear material; 3) stop illegal transfers; 4) devalue the political and military currency of nuclear weapons; and 5) commit to conflict resolution. The United States and others would continue not to sell nuclear reactors to the three states pursuant to the NSG as long as the proposed recipient operates nuclear facilities that are not under international safeguards. States possessing nuclear weapons should be judged by their contribution to the global interest in preventing the spread and use of nuclear weapons.

Specific policy approaches for South Asia:

- Secure nuclear capabilities against terrorist acquisition, including weapons, materiel, and know-how
- Implement nuclear risk-reduction measures such as establishment of national risk-reduction centers in both countries to administer agreed-upon confidence-building measures; commitment to not develop, produce, or use tactical nuclear weapons; agreement not to flight-test missiles in the direction of the other country and only from designated test ranges; and provide provision of advance notification of the movement of missiles for training purposes
- Phase out national fissile material production as part of participating in a process of nuclear regulation and agreement that includes China and ultimately all producers in a global challenge
- Resolve the Kashmir dispute
- Support political reform in Pakistan to a regime that inspires more confidence as stewards of nuclear weapon capabilities
- Promote stable conventional force balances
- Delineate a clear policy on doing nuclear business with the two countries

Specific policy approaches for Israel and the Middle East:

- Establish a zone free of weapons of mass destruction
- Exercise robust verification procedures and practices, including high levels of transparency in national policies, budgets, and facilities
- Take disarmament seriously – disavow development of new types of nuclear weapons, enable the Comprehensive Nuclear Test Ban Treaty, narrow the role of nuclear weapons in national security policies, and continue US-Russian nuclear reductions

The Proliferation Security Initiative: Towards a New Anti-Proliferation Consensus?

November 18, 2004
Fabrice Pothier
British American Security Information Council
http://www.basicint.org/pubs/Notes/BN041118.htm
6 pages

- *The Proliferation Security Initiative (PSI) is a US-led seventeen-country coalition of convenience seeking to strengthen nonproliferation cooperation and to develop legal instruments to control weapons traffic on land, in the air, and at sea.*

- *Each of the seventeen participating states has agreed to a politically binding* Statement of Interdiction Principles*; sixty additional countries are reported by the US State Department to have shown support for the initiative and its principles.*

- *The successful enlargement of the initiative makes it increasingly imperative for European countries and institutions to raise the issue of the governance of the PSI.*

- *A new UN Security Council resolution extending jurisdiction of states beyond territorial sea, appears to be the most comprehensive and feasible option for closing legal loopholes. Against US reluctance to engage on this option, European countries, especially the two European permanent members of the Security Council, together with Russia could pull in this direction.*

- *The lack of a plan to define and codify within the PSI a threshold of probable cause or a burden of proof for suspicions of weapons trafficking is another area of concern. A more assertive European group could turn this situation into an opportunity to engage with the United States and the international community on the development of a new framework that redefines the idea of 'just war' or 'just intervention.'*

- *The effectiveness of the PSI in increasing the risk and costs of weapons trafficking has still to be demonstrated.*

PSI is an activity rather than an organization and provides the blueprint for true counterproliferation action that is up-to-the-minute, practical, and efficient.

The extension of the doctrine of preemptive self-defense without a plan to define and codify within the PSI a threshold of probable cause or burden of proof for suspicions of weapons trafficking is another area of concern. The line separating legitimate prevention from unlawful intervention has yet to be defined.

Any state may participate in the PSI provided the state can contribute practically to the initiative; however, this threshold effectively bars developing countries from the initiative, because their armed forces, coast guards, and law enforcement agencies are often weak or in a state of flux.

PSI is promoted as an innovative way to increase the risk and costs related to weapons trafficking. PSI is seen as an opportunity to engage European governments toward renewed multilateralism as an effective and legitimate framework to address global security issues such as weapons proliferation. However, questions about interactions with other new anti-proliferation instruments such as the Container Security Initiative and the UN Security Council resolution 1540 on weapons of mass destruction have arisen.

A successful result of PSI was the interdiction in October 2003 of centrifuge parts bound for Libya.

Let a Thousand Reactors Bloom

September 2004
Spencer Reiss
Wired Magazine
http://www.wired.com/wired/archive/12.09/china_pr.html
6 pages

As China plans to build thirty new nuclear reactors by 2020 to meet future energy demands, global concern about the potential increase of proliferable nuclear materials is growing. However, the Chinese have countered with a pebble-bed reactor design (HTR-10) whose safety is a matter of physics (intrinsic) versus operator skill or reinforced concrete. Instead of white-hot fuel rods, the HTR-10 is powered by 27,000 billiard-sized graphite balls packed with tiny flecks of uranium. Instead of superheated water – intensely corrosive and highly radioactive – the core is bathed in inert helium. The reactor does not require a pressure dome or a spent-fuel pond. This reactor is meltdown-proof. The fuel is sealed inside layers of graphite and impermeable silicon carbide designed to last one million years. Depleted balls go straight into the lead-lined steel bins in the basement. Multiple reactors can be daisy-chained around one or more turbines, all monitored from a single control room.

China is also looking at the thermochemical water-splitting capability of its reactors to generate hydrogen for fueling cars. The Institute of Nuclear and New Energy Technology plans to begin researching hydrogen production by 2006.

The NPT and Nuclear Proliferation: Matching Expectations to Current Realities

February 2004
Emily B. Landau
Strategic Assessment
http://www.tau.ac.il/jcss/sa/v6n4p5Lan.html
8 pages

Two modes of action tailored to the NPT have received recent focus: strengthening the treaty's verification mechanisms to heighten its capability to uncover and effectively confront signs of noncompliance on the part of non-nuclear weapons states and urging the nuclear weapons states to give more content to their own commitment to reduce their nuclear arsenals. When the NPT was initially negotiated, diplomats agreed that all nations had a right to acquire nuclear weapons to defend themselves. If non-nuclear weapons states agreed not to exercise this right, they deserved to be compensated accordingly. Therefore, the NPT was based largely on the goodwill of states to acquiesce within a world where nuclear weapons are a source of insecurity in international relations. The NPT is not equipped to stop determined proliferators and may even enable proliferation.

In addition to international efforts to strengthen the verification mechanisms of the NPT, national security interests must also be considered in a much more direct manner. If state interests cannot be seriously addressed within the framework of broad global arrangements, they will have to be more heavily supplemented with regional security arrangements. Regional arrangements are better equipped to take a range of security interests seriously through focused interstate dialogue. Such arrangements may consist of different types of arms control measures and security assurances and will also facilitate ongoing dialogue among member states to deal with changing international and regional realities on a continual basis. By limiting the number of states directly involved in each arms control agreement, regional security arrangements are likely to reduce the negative effect of conflicting interpretations.

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