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# The 3rd International Forum on Nuclear Non-Proliferation



Nuclear Non-Proliferation
Study Group

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# プログラム　PROGRAM

敬称略(Honorary titles are graciously omitted.)

## 2月23日（月） Feb.23 (Mon)

| | | |
|---|---|---|
| 13:00-13:15<br>**開会挨拶**<br>Opening Address | **小佐古　敏荘**<br>（核不拡散国際フォーラムプログラム委員長） | **Toshiso Kosako**<br>(Chairperson, Program Committee for the International Forum on Nuclear Non-Proliferation) |
| 13:15-14:15<br>**特別講演**<br>Special Speech<br>14:15-14:30<br>コーヒーブレイク<br>Coffee Break | **『日本の原子力政策の現状と課題』**<br>**伊原　義徳**<br>（前原子力委員会委員長代理） | **"The Issues and the Present State of Nuclear Energy in Japan"**<br>**Yoshinori Ihara**<br>(Former Vice-Chairman of the Atomic Energy Commission) |
| 14:30-17:00<br>セッション1<br>Session 1 | **〔プルトニウムの平和利用について〕**<br>**司　　会：ジョン・テイラー**<br>（米国電力研究所名誉副会長）<br>**パネリスト：ベルトラン・バレ**<br>（仏国CEA原子炉局長）<br>**ネビル・チェンバレン**<br>（英国原子燃料会社副会長）<br>**ピョートル・フォミチェンコ**<br>（ロシアクルチャトフ研究所新型炉物理・技術研究部安全物理研究室長）<br>**飯田　浩史**<br>（産経新聞東京本社論説委員長代行）<br>**梶井　孝泉**<br>（関西電力株式会社支配人原子力・火力本部副本部長）<br>**フィリップ・サヴェリ**<br>（OECD/NEA事務局次長） | **[The Peaceful Use of Plutonium]**<br>Moderator: **John J. Taylor**<br>(Vice-President Emeritus, EPRI, USA)<br>Panelists: **Bertrand Barré**<br>(Director, Nuclear Reactor Directorate, CEA, France)<br>**Neville Chamberlain**<br>(Deputy Chairman, BNFL, UK)<br>**Petr Fomitchenko**<br>(Head of Safety Physics Laboratory, Department of Physical & Technical Studies of Advanced Reactors, Kurchatov Institute, Russia)<br>**Hiroshi Iida**<br>(Editorial Writer, The Sankei Shimbun, Japan)<br>**Yoshimitsu Kajii**<br>(Senior General Manager, Vice Chairman, General Office of Nuclear and Fossil Power Production, KEPCO, Japan)<br>**Philippe Savelli**<br>(Deputy Director, OECD/NEA) |

**The 3rd International Forum on Nuclear Non-Proliferation**

# プログラム　PROGRAM

## 2月24日（火） Feb.24 (Tue)

| | | |
|---|---|---|
| 9:30-10:30<br>基調講演<br>Keynote Speech | **「核不拡散体制の意義と課題」**<br>**ジャヤンタ・ダナパラ**<br>（国連軍縮担当事務次長、1995年NPT再検討延長会議議長） | **"The Issues and the Significance of the NPT Regime"**<br>**Jayantha Dhanapala**<br>(Under Secretary-General for Disarmament Affairs, U. N., Chairman of the 1995 Nuclear Non-Proliferation Treaty Review and Extension Conference) |
| 10:30-12:30<br>セッション2<br>Session 2 | **〔最近の核不拡散情勢と課題〕**<br>**司　　会：黒沢　満**<br>（大阪大学大学院国際公共政策研究科教授）<br>**パネリスト：阿部　信泰**<br>（外務省軍備管理・科学審議官）<br>**ジョージ・バン**<br>（米国スタンフォード大学国際安全保障軍備管理センター教授）<br>**納家　政嗣**<br>（上智大学国際関係研究所教授）<br>**アネッテ・シャーパー**<br>（独国フランクフルト平和研究所上級研究員）<br>**トーマス・シェア**<br>（IAEA保障措置局査察実施A部課長）<br>**沈　丁立**<br>（中国復旦大学アメリカ研究センター教授・副所長） | **[The Issues and the Recent Situation of the Non-Proliferation Regime]**<br>Moderator: **Mitsuru Kurosawa**<br>(Professor, School of International Public Policy, Osaka University)<br>Panelists: **Nobuyasu Abe**<br>(Director-General for Arms Control and Scientific Affairs, MOFA, Japan)<br>**George Bunn**<br>(Consulting Professor, Stanford University, Center for International Security & Arms Control, USA)<br>**Masatsugu Naya**<br>(Professor, Institute of International Relations, Sophia University, Japan)<br>**Annette Schaper**<br>(Senior Research Associate, Peace Research Institute, Frankfurt, Germany)<br>**Thomas E. Shea**<br>(Section Head, Department of Safeguards, IAEA)<br>**Dingli Shen**<br>(Professor and Deputy Director, Center for American Studies, Fudan University, China) |
| 12:30-14:00<br>昼食<br>Lunch | | |
| 14:00-17:00<br>セッション3<br>Session 3<br><br>15:30-15:45<br>コーヒーブレイク<br>Coffee Break | **〔アジアのエネルギー情勢と原子力協力〕**<br>**司　　会：ドナルド・ガァーティン**<br>（米国アトランティック・カウンシルエネルギー・環境プログラム担当部長）<br>**パネリスト：ソンフン・チョン**<br>（韓国民族統一研究院研究委員）<br>**ヨン・ジン・チェ**<br>（朝鮮半島エネルギー開発機構事務局次長）<br>**スジャティ・ジワンドノ**<br>（インドネシア戦略・国際問題研究所理事）<br>**今村　努**<br>（科学技術庁長官官房審議官）<br>**下山　俊次**<br>（日本原子力発電株式会社常任監査役）<br>**汪　永平**<br>（中国核工業経済研究所核工業計画部次長） | **[The Current Energy Status in Asia and Nuclear Cooperation]**<br>Moderator: **Donald L. Guertin**<br>(Director and Senior Research Fellow, Energy & Environment Program, The Atlantic Council of the United States)<br>Panelists: **Seongwhun Cheon**<br>(Research Fellow, Korea Institute of National Unification, Korea)<br>**Young-Jin Choi**<br>(Deputy Executive Director, KEDO)<br>**Soedjati Djiwandono**<br>(Member, Board of Directors, CSIS, Indonesia)<br>**Tsutomu Imamura**<br>(Deputy Director-General, Atomic Energy Bureau, STA, Japan)<br>**Shunji Shimoyama**<br>(Senior Auditor, JAPCO, Japan)<br>**Yongping Wang**<br>(Vice-Director of Nuclear Industry Planning Division, China Institute of Nuclear Industry Economics, China) |

# プログラム　PROGRAM

## 2月25日（水）　Feb.25　(Wed)

特別セッション Special Session

### 余剰核兵器解体プルトニウムの処分　Disposition of Excess Weapons Plutonium

**9:30-12:30**
午前セッション Morning Session

10:50-11:05 コーヒーブレイク Coffee Break

**〔米、露の視点〕**

司　　会：**ハロルド・ベンゲルスドルフ**
（元米国国務省核不拡散上級部長）

パネリスト：**スティーブン・アオキ**
（米国国務省地域不拡散部長）
**エフゲニー・クドゥリャフチェフ**
（ロシア原子力省核化学部課長）
**ジョン・テイラー**
（米国電力研究所名誉副会長）

**[View from the US and Russia]**

Moderator: **Harold D. Bengelsdorf**
(Former Senior Director, Nonproliferation Office, DOS, USA)

Panelists: **Steven Aoki**
(Director, Office of Regional Nonproliferation, DOS, USA)
**Evgeny Kudryavtsev**
(Head of Division, Nuclear Chemical Department, MINATOM, Russia)
**John J. Taylor**
(Vice-President Emeritus, EPRI, USA)

12:30-14:00 昼食 Lunch

**13:30-17:15**
午後セッション Afternoon Session

15:00-15:15 コーヒーブレイク Coffee Break

**〔露の余剰核兵器解体プルトニウム処分へのアプローチ〕**

司　　会：**鈴木　篤之**
（東京大学工学部システム量子工学科教授）

パネリスト：**スティーブン・アオキ**
（米国国務省地域不拡散部長）
**ティエリー・デュジャルダン**
（仏国CEA国際関係局次長）
**ロバート・ギャズビー**
（カナダ原子力公社 MOXプロジェクト部長）
**イゴール・クレシェフ**
（ロシア原子力省国際協力・核不拡散部次長）
**須田　明夫**
（外務省外務参事官（軍備管理・科学担当））
**植松　邦彦**
（動燃事業団副理事長）

**[Approach to Russian Excess Weapons Plutonium Disposition]**

Moderator: **Atsuyuki Suzuki**
(Professor of Nuclear Engineering, Department of Quantum Engineering and Systems Science, University of Tokyo)

Panelists: **Steven Aoki**
(Director, Office of Regional Nonproliferation, DOS, USA)
**Thierry Dujardin**
(Executive Deputy Director, International Relations Division, CEA, France)
**Robert D. Gadsby**
(Director, MOX Project, AECL, Canada)
**Igor Kuleshov**
(Deputy Head, Division of International Non-Proliferation, MINATOM, Russia)
**Akio Suda**
(Deputy Director-General for Arms Control and Scientific Affairs, MOFA, Japan)
**Kunihiko Uematsu**
(Executive Vice President, PNC, Japan)

# SPECIAL SPEECH

# The Issues and the Present State of Nuclear Energy in Japan

Former Vice-Chairman of the Atomic Energy Commission
Yoshinori Ihara

## Introduction

Japan, in starting research, development and utilization of nuclear energy in the middle of 1950's, established the Atomic Energy Basic Law. This Law stipulates in the first place that the development and utilization of nuclear energy in Japan shall be limited to peaceful purposes, and at the same time, prescribes that an Atomic Energy Commission shall be set up "for the purposes of carrying out the planned national policies on the research, development and utilization of atomic energy and of realizing the democratic operation of atomic energy administration."

The Atomic Energy Commission set up the "Long-Term Program for Research, Development and Utilization of Nuclear Energy" in the same year of its establishment (1956), which was revised several times, and the 8th Long-Term Program was enacted in 1994.

Although the path of nuclear energy development and utilization that Japan set out on since the time of establishing the Basic Law to the present has not always been flat and easy, it is considered that, when everything is said and done, the way progressed smoothly. Presently, nuclear power generation in Japan supplies one third of the total need for electric energy. Moreover, the utilization of radiation and radioisotopes has spread over very wide fields and includes medical treatment, agriculture, industry, environmental preservation and basic research; consequently, nuclear energy utilization has dug deeply into our daily life.

## I. Purpose of Nuclear Energy Development

The purpose for nuclear energy development in Japan is to ensure energy stability and to improve the quality of life for Japanese people. Although it is said that Japan has reached affluence as a society, it is expected that the stable supply of quality electric power should be maintained towards the highly integrated future of the information age. However, the energy supply structure of Japan is quite fragile. The degree of primary energy dependency on imports is at a level of 84%, and this dependency increases to 94% when adding the fact that nuclear power generation is fueled from the import of uranium.

Although nuclear energy can be regarded as quasi-domestic energy in the form of technology concentrated energy, it is indispensable to effectively maximize the utilization of the source of uranium, all of which is imported, and therefore, promotion of the nuclear fuel cycle should be the base for the policy.

Moreover, it is also important to have the viewpoint that Japan should make efforts in the preservation of the global environment through nuclear energy utilization, even against the worsening global environment of recent years, to contribution towards our global society.

## II. Basic Policy

The basic policy that Japan should hold for the development and utilization of the nuclear energy contains the following:

(1) Development of a nuclear energy policy as a nation committed to peaceful use of nuclear energy,
(2) Establishment of a consistent system of nuclear power generation by light water reactors,
(3) Ensure progress in development of the nuclear fuel cycle on the basis of a clear future outlook, and
(4) Diversified development of nuclear science and technology and reinforcement of basic research.

## III. Present Situation of the Policy

### 1. Establishment of International Confidence Concerning Nuclear Non-Proliferation

Japan, in progressing nuclear energy development and utilization beginning with the nuclear fuel cycle and under the infinite extension of the Non-Proliferation Treaty (NPT), should contribute towards the maintenance and reinforcement of this regime based upon the security and trends of international politics and economics, and what is more, Japan should wipe out international concerns about the Japanese nuclear fuel cycle project for the establishment of the international confidence.

The future of Japan will see a large increase in the number of safeguards operations due to the increase in the number of nuclear energy facilities; beginning with a private reprocessing plant. Therefore, in accordance with the strengthening of safeguards (the Programme 93 + 2) by the International Atomic Energy Agency (IAEA), Japan will improve its system which is capable of implementing the inspection, analysis of nuclear material and information processing with sufficient confidence.

Furthermore, in addition to the duties demanded by the NPT regime, Japan will hold the principle that "Japan never holds surplus plutonium" as its own policy, improve the transparency for plutonium utilization plans, and clarify the present situation of plans both domestically and internationally.

An international guideline for the management of plutonium in each country has been adopted by nine countries, including Japan, for improvement in transparency.

2. Nuclear Power Generation Based on a System of Light Water Reactors

Light water reactors (LWRs) are the reactors that have recorded good performance throughout the world and in Japan as well, and it is expected that the LWRs will form the mainstream of nuclear power generation for a long period to come. Therefore, Japan will further improve the safety, economic efficiency, measures against high aging problems, and reduction in radiation exposure of employees. In addition, Japan will tackle a high sophistication of fuel and core functions improved for high burnup fuel and mixed oxide fuel (MOX).

Japan's capacity for commercial nuclear power generation amounts to approximately 45 million kW, which is expected to exceed 70 million kW by 2010. Nevertheless, in order to ensure the above-mentioned power generation volume, and although it is required to secure new sites in addition to the existing sites, the acquisition of sites has been growing more and more difficult in recent years.

3. Drafting of a Concrete Nuclear Fuel Cycle Program

Japan has been actively pursuing the development of domestic power reactors and the establishment of the nuclear fuel cycle. In 1967, The Power Reactor and Nuclear Fuel Development Corporation (PNC) was established to perform nuclear research and development on behalf of the Japanese government. In addition to the development of the heavy-water-moderated light-water-cooled advanced thermal reactor (ATR) and the sodium-cooled fast breeder reactor (FBR), PNC has become Japan's primary research institution for the promotion of nuclear fuel cycle related technology for the efficient use of uranium resources.

Since the establishment of the PNC, although there were some delays, a spent fuel reprocessing plant, mixed oxide fuel fabrication plants, the experimental fast breeder reactor Joyo, and the prototype advanced thermal reactor Fugen were completed. Construction of the prototype fast breeder reactor Monju was completed and its performance tests have started. Moreover, the construction and operation of a private reprocessing plant and a uranium enrichment plant have been advanced by Japan Nuclear Fuel Limited. During this period, the global situation changed greatly. From the viewpoint of the prevention of nuclear weapon proliferation, the U.S.A. abandoned reprocessing and fast breeder reactor development, which affected some countries and consequently, Canada, Sweden and Germany have reconsidered their nuclear fuel cycle policies.

This tendency is also accelerated by the existence of a world-wide surplus of natural uranium caused by the recent progress in nuclear disarmament and the stagnant growth of the world's nuclear power generation.

## 4. Review of The Advanced Thermal Reactor Plan

In regards to the demonstration reactor succeeding the prototype advanced thermal reactor Fugen, negotiations between the Electric Power Development Co., Ltd. (the construction implementing company) and the local fishermen near the construction site, faced rough going, and the negotiation settlement was prolonged.

In 1994, the pending issue of a local agreement was settled at long last. As a result of reviewing the construction cost, it was learned that the initial estimate had to be increased by 50%. The initial estimate itself expected that 60% of the construction cost would be financially sponsored by the Japanese government and electric utility companies. In the end this 50% increase in the construction cost, in addition to the existing burden of 60%, exceeded the burden limit.

The Atomic Energy Commission deliberated on this issue from the viewpoint of economic efficiency, nuclear fuel cycle and R&D, and as a result, the following review was made:

(1) Because the project plans were successfully delayed year by year over a period of ten years, any drastic rationalization design was not made, and even if rationalization was intended, technological demonstration would take a long period of time.

(2) The role of the advanced thermal reactors for MOX use will be replaced based on plans for the use of MOX fuel in LWRs.

Taking the above-mentioned deliberations into consideration, it was determined that it is appropriate to abandon the project. And, as a substituting project, it is pertinent to adopt the advanced boiling water reactor (ABWR) which permits the loading of MOX fuel in the full reactor core.

This review resulted in a very regrettable outcome for the Atomic Energy Commission in that the successful results of research and development were not followed through to practical operation.

5. Sodium Leakage in the Secondary Heat Transport System of the Prototype Fast Breeder Reactor Monju

At the end of 1995, Japan suffered its first ordeal in the development of the fast breeder reactor. A sodium leakage in the secondary heat transport system occurred at Monju. To be precise, the history of the world's fast breeder reactor development had already experienced 154 sodium leakages, and the leakage from the Monju accounted for the 155th time. The research made hitherto has confirmed that the cause of the sodium leakage resulted from the breakage of a thermometer installed in the secondary heat transport system. The thermometer breakage was due to the incorrectly designed sheath and, what is more, in repairing the line-disconnected thermometer, a line which was forcibly thrusted into the secondary heat transport system stayed bent, and the line consequently made the vibration of the sheath tube greater. Responsibility of the nuclear reactor manufacturer is great, and at the same time, the fact that the experience from thermometer problems from the predecessor Joyo was not utilized indicates the difficulties in succeeding with preceding technologies.

Because of a leakage from the secondary heat transport system which is not connected directly to the reactor core, there was no influence from the radioactive substances upon the employees and local public, and from the viewpoint of disaster prevention, the safety of nuclear facilities was ensured.

Nevertheless, it is regrettable that the subsequent measures taken by PNC were very impertinent and it was lethal that PNC reportedly concealed information and told lies. Consequently, feelings of anxiety about and disbelief in nuclear energy spread and heightened among the Japanese people.

Taking this opportunity, the local governors made a proposition titled "How to Review the Future Policy of Nuclear Energy." In response to this proposition, in 1996 the Atomic Energy Commission opened "A Roundtable Conferences on Nuclear Energy Policy" as an arena to widely discuss relevant national issues.

6. Utilization of Plutonium in LWRs

The long-term target of the nuclear fuel cycle is the effective utilization of plutonium by optimal integration of fast breeder reactor and reprocessing/fuel fabrication process, and research and development has to be continued for a considerably long period of time to reach the target. Therefore, it is suggested to use plutonium as the MOX fuel in LWRs for the time being from the viewpoint of the establishment of technologies necessary for nuclear fuel recycling, and on the basis of practical use and improvements of the system for the future fast breeder reactor age.

At the present, in nuclear power plants uranium is converted into plutonium in the reactor, and the fission energy of this plutonium accounts for one third of the energy obtained from nuclear power generation.

The MOX fuel in the LWRs has been used mainly in Europe and already has recorded good performance using more than 1,600 assemblies loaded. Thus, MOX fuel, as well as uranium fuel, has been of practical use. Good results have been obtained by the burnup test for a small number of assemblies also in Japan, besides the experience of loading more than 600 MOX fuel assemblies at Fugen.

The use of plutonium in LWRs is expected to assume a substantial role in the energy supply. Electric utilities which have nuclear power plants have made out their implementation plans and intend to use the MOX fuel in a total of 16 to 18 LWRs by 2010.

7. Storage of Spent Fuel

Presently, spent fuel generated from nuclear power plants in Japan amounts to approximately 900 tons annually. Meanwhile, the processing capacity of the reprocessing plant which is under construction at Rokkasho Mura only has the capacity of 800 tons annual, and therefore, 100 tons will remain unprocessed annually.

And so, the on-site storage capacity at several power plants will be enhanced as a measure presently available. Moreover, improvement in the environment, including revision of the relevant law, has been examined so that storage away from the power plant site can be available by 2010.

8. Disposal of Radioactive Wastes

A. Disposal of High-Level Radioactive Waste

It is the duty of our contemporary generation, who benefit from nuclear energy, to establish a disposal method for radioactive wastes, in particular the high-level radioactive waste.

Japan's basic waste management policy is to 1) solidify the waste into a stable form by adding glass to the high-level liquid radioactive waste which results from spent fuel reprocessing (vitrification), 2) store the waste for a period of 30 to 50 years to allow the waste to cool, then 3) move the waste to a deep geological waste disposal site. The Japanese government and the private sector collaborated to create The Steering Committee on High-Level Radioactive Waste Project (SHP) to promote the investigation and research into the establishment of a disposal project by the year 2000.

The Atomic Energy Commission, in order to examine measures for the embodiment of high-level radioactive waste disposal, set up the Special Committee on High-Level Radioactive Waste Disposal to perform a wide review of the social and economic aspects. Also established was the Advisory Committee on Nuclear Fuel Cycle Backend Policy to perform a technological review of R&D projects pertaining to waste disposal.

The report from the Advisory Committee expects that the technological reliability in the deep geological disposal will be substantiated by the year 2000, and shows how to progress research and development in selecting candidate disposal sites and showing technological base to set up safety standards.

In the draft report from the Special Committee, the following was described:

"As to the radioactive wastes we have created, we, the present generation, have a duty to establish the disposing system so that we do not leave this burden to the next generation. Furthermore, it is necessary to ensure 'impartiality' between electric power users and the inhabitants near disposal sites. As to such problems, it is necessary to form an agreement through wide discussions with all Japanese citizens. In implementing our duty, we need to follow a transparent procedure, and the disclosure of information has to be thoroughly made."

The Special Committee members will seek wide opinions from the Japanese public before summarizing a final report.

B. Decommissioning of Nuclear Facilities

The Japan Atomic Power Company has decided to terminate its 32-year operation of the Tokai-1 nuclear power plant and will begin decommissioning the facility in 1998. Although Japan has experienced the dismantling of the Japan Atomic Energy Research Institute's Japan Power Demonstration Reactor (JPDR), Tokai-1 will be Japan's first experience decommissioning a commercial nuclear plant.

It is necessary for the decommissioning of nuclear facilities to progress under the responsibility of a nuclear power installer/owner through cooperation with the local community, on the major premise of safety assurance.

9. Diversified Development of Nuclear Science and Technology

Besides power generation, nuclear energy has a wide scope of application such as heat supply with the high-temperature gas-cooled reactor, nuclear propulsion of ships, radiation utilization and nuclear fusion.

A. Basic Research and Development of Base Technology

In photon science, neutron science, ion and positron science, and highly developed computer science, research activities have been carried out to develop new nuclear energy potential.

In the fields of radio-biological effect, beam utilization, materials, "soft" science technology, and the development of infrastructure technology, linking the basic research with the project research has been promoted in order to create a breakthrough in existing nuclear technology.

B. Furthering of Nuclear Energy Utilization

A High-Temperature Engineering Test Reactor (HTTR), which is capable of supplying high-temperature heat, will be completed in 1998. The nuclear-powered ship Mutsu has already completed decommissioning work after the termination of its experimental navigation and its hull has been remodeled into the Mirai, an ocean and earth survey ship.

C. Radiation Utilization

The large-scale Synchrotron Radiation Facility (SPring-8) was completed and joint use started in 1997. The Heavy Ion Medical Accelerator in Chiba (HIMAC) has been performing remedial irradiation since 1994 and has been achieving favorable results.

Using the Takasaki Ion Accelerators for Advanced Radiation Application (TIARA), development of new functional materials using various kinds of ion beams and research on biotechnology have been conducted. The number of entities using radio isotope or radiation generating equipment has reached about 5,000, and the equipment has been utilized in the diverse fields of positron CT, prevention of breeding and extermination of harmful insects, desulfurization of exhaust gas and DNA analysis.

D. Nuclear Fusion

Japan Atomic Energy Research Institute's JT-60 achieved a critical plasma condition and obtained the best nuclear fusion product. Large-scale helical equipment for joint utilization with universities will be completed.

The International Thermonuclear Experimental Reactor (ITER) Project, with cooperation of three countries (Japan, U.S.A. and Russia) and the European Union, has been progressing engineering design activities smoothly, and it has been determined that the original termination date (1998) of these activities will be extended by 3 years to 2001.

## IV. Present Issues

### 1. Roundtable Conferences on Nuclear Energy Policy

In holding Roundtable Conferences, not only experts in the field of nuclear energy but also researchers, even in various fields of sociology and cultural science, leaders of local governments, critics, and other learned people, plus those people who have critical opinions toward nuclear energy, and people who were selected from the general public, participated in the conferences. Completely open discussions, 11 in total, were eagerly unfolded with various operational contrivances.

In the conference, first, the necessity of bi-directional offer and disclosure of information was addressed. In response to this necessity, the Atomic Energy Commission disclosed proceedings from the advisory committee and opinions were raised from the Japanese people concerning the process of policy making. Discussions on nuclear energy were made from all possible aspects such as: 1) role of nuclear energy in Japan's energy supply, 2) public acceptance of nuclear energy with respect to public concerns for safety, and 3) the transfer of Japan's presently affluent society into the next generation based not only on a stable and secure source of energy, but also upon worldwide and historical viewpoints.

Although there was the opinion, from religious and anti-scientific standpoints, to stop nuclear energy development, the majority of opinions seemed to be that nuclear power generation, which actually accounts for one third of the total generated electricity of Japan, should hold safety first as the principle before further prudent progress in development.

However, recognizing the necessity of nuclear energy, there were some opinions raised against siting nuclear facilities near their communities, which is what is called NIMBY, "Not In My Back Yard."

The development and utilization of nuclear energy in Japan, which started in the middle of the 1950s has now been continuing for almost half a century, has experienced several incidents but has not resulted in any accidents causing serious human injury by radiation nor not shown any significant influence outside the facility sites.

Therefore, the issue is how to position nuclear power in the maturation of society, based on the positive achievements in safety mentioned above.

## 2. Specific Measures Relating to Nuclear Fuel Cycle

Reflecting upon the discussions made concerning nuclear power policy at the Roundtable Conference, and suggestions from moderators, and taking the examination results by the Advisory Committee for Energy of the Ministry of International Trade and Industry into consideration, the Atomic Energy Commission determined the "Regarding the Immediate Specific Measures for the Nuclear Fuel Cycle" at the beginning of 1997. In this determination, first of all, the initial basic concept of the development and utilization of nuclear energy in Japan (i.e., from the viewpoints of natural resources restriction and environmental preservation in which Japan is situated), it was confirmed that it is indispensable for Japan to smoothly develop the nuclear fuel cycle for the long-period stable progress in nuclear energy generation. Based on that confirmation, including the steady promotion of construction of a reprocessing plant, and recognizing the importance to establish the nuclear fuel cycle in Japan, a specific concept and measures were presented with respect to urgent issues such as plutonium utilization at light water reactors, and management of spent fuel. At the same time, future concepts for radioactive waste disposition and fast breeder reactor development were also presented.

This decision was approved later by a Cabinet meeting, and thus reconfirmed by the Japanese government to this issue.

## 3. The Fire and Explosion Accident at PNC's Bituminization Demonstration Facility

In March 1997, a fire and explosion accident occurred at the Bituminization Demonstration Facility at PNC's Tokai plant. Although there was leakage of radioactive material in the site, the degree of employee exposure to radiation was negligible and there was no significant leakage of radioactive material outside the site.

But the counteraction to the accident was awkward, and differing reports about the actual result and attempts to conceal information were made, incurring the anxiety and disbelief of the

Japanese people again. Furthermore, this accident resulted in exerting influences to the nuclear fuel cycle development.

4. Restructuring of The Power Reactor and Nuclear Fuel Development Corporation (PNC)

The Science and Technology Agency which is the supervisory authority of PNC urged the clarification of the cause of the Tokai accident, and at the same time established the PNC Reform Examination Committee to restructure PNC. As a result of discussions from the Committee, it was determined that PNC will be reorganized into a new organization. The main projects should be the fast breeder reactor development, the nuclear-related fuel cycle technology development and the research and development of processing and disposition of high-level radioactive wastes. The three projects, overseas uranium exploration, uranium enrichment and the development of an advanced thermal reactor, shall be abolished after an appropriate period of time.

5. Special Committee on Fast Breeder Reactors

From input at a roundtable conference, the roundtable moderator suggested that special committee should be established under the Atomic Energy Commission. As a result, the committee met 12 times regarding the fast breeder reactor and these committee meetings embodied a wide range of discussions. The report from these meetings is summarized as follows:

"The fast breeder reactor can improve the utilization efficiency of uranium much higher than that of the light water reactors by recycling nuclear fuel number of times without disposing of it after one use. Moreover, the fast breeder reactor is capable of decreasing the burden of waste disposition, and therefore research has been carried out for a long period of time. Nevertheless, the perspective for practical use from the viewpoint of economic efficiency has not been established yet, and there arose opinions not to continue the development. Against these opinions, the majority of committee members raised objections to stopping the development of the fast breeder reactor because the experimental reactor Joyo has achieved successful results and the prototype reactor Monju was constructed, the research is continuing, and consequently research and development should be progressed, taking into account the overseas experiences as references.

As to the handling of the Monju, it is desired to implement research and development on the premise such that prudent operation and control should be performed. Moreover, it is appropriate to progress the development of a fast breeder reactor as a future promising alternative for non-fossil energy resources."

### 6. Reform of Administration and Finance

As a result of Japan's total efforts for half a century since the end of World War II, it has become a country which holds the No. 2 rank in world economic power and now belongs to the world's leading group in the aspect of science and technology. During this period, however, institutional fatigue began to be seen in various administrative systems and without reform of the present systems Japan will have no bright future. In consequence, under the present administrative power, it was decided to implement large-scale financial and administrative reforms.

As to the nuclear energy administration, the Atomic Energy Commission and the Nuclear Safety Commission, which are advisory organizations to the Prime Minister, will be transferred to the newly established Cabinet Agency, and along with the reorganization of ministries and agencies, integration of control issues have been examined for review. Fortunately, under the strict financial situation, the science and technology policy keeping abreast with the environmental policy is specified as the priority policy of Japan and the necessary expenditures will be ensured. However, it may be necessary to review large-scale R&D projects.

## V. Nuclear Fuel Cycle Policy and Nuclear Armament Issue

Japan has been limiting itself to the peaceful use of nuclear energy ever since the establishment of the Atomic Energy Commission. As ever, it is unlikely in the future that Japan will be armed with nuclear weapons. In spite of Japan's principle, with respect to Japan's nuclear fuel cycle policy, there are concerns in some foreign countries that Japan will be armed with nuclear weapons sooner or later. This is the greatest misunderstanding. The world common sense that "a large power which has economic power and high technologies has nuclear weapons" does not apply at least to Japan. The reasons are as follows:

### 1. Psychological and Historical Reason

Japanese people who experienced the atomic disasters at Hiroshima and Nagasaki abhor nuclear weapons. There is no logic of retaliation at all.

2. Institutional Reason

Assurance of peaceful utilization has been held through the ensurance of peaceful utilization by the Atomic Energy Basic Law and the restrictions against diversion by the bilateral agreements and various systems such as IAEA (International Atomic Energy Agency) safeguards.

3. Realistic Reason

In Japan, there is no authority that is responsible for the production of nuclear weapons. There are no scientists or engineers who are willing to be engaged in the development of nuclear weapons. Attempts at changing this situation cannot evade the supervision of the mass media, which is totally against nuclear armament. If Japan starts the production of nuclear weapons and is punished with economic sanctions, the economy of Japan will collapse and the Japanese people will suffer hardships. Such a choice cannot be possible.

**Conclusion**

In order for Japan to conquer its fate of having a small national territory with few natural resources, the author thinks that it is necessary for Japan to progress with the development and utilization of nuclear energy. Nuclear energy is an important area of study in the field of science and technology and Japan must clarify what it needs from science and technology in the 21st century.

Since research and development of nuclear energy takes a very long period of time, just as other large science and technology projects, there is fear of losing future direction and being buried in the changes of society unless the long-term perspective is always kept clear and unless there is a positive attitude to purse the ultimate goal.

Currently, the development of nuclear energy will continue to exist in this society which is dependent upon petroleum as its primary energy source. However, the author believes in the future nuclear energy will gradually replace petroleum as the major source of energy for the future of human civilization.

# 日本の原子力政策の現状と課題

1998.2.23.
伊原　義徳

はじめに

わが国は、１９５０年代半ばに原子力の研究、開発及び利用を始めるにあたり、原子力基本法を定めました。この法律は、わが国の原子力開発利用を平和の目的に限ることを第一に定めるとともに、「原子力の研究、開発及び利用に関する国の施策を計画的に遂行し、原子力行政の民主的な運営を図るため」原子力委員会を置くとしています。

原子力委員会は、設置された年（１９５６年）に「原子力開発利用長期基本計画」を定め、その後数次にわたる改訂を行い、９４年には第八次長期計画を定めています。

基本法制定から現在までのわが国の原子力開発利用の道のりは、必ずしも平坦ではなかったものの、総じて言えば順調に進展して来たと考えられます。現在、わが国の原子力発電は総発電電力量の三分の一を供給しており、また、放射線及び放射性同位元素の利用は、医療、農業、工業、環境保全、基礎研究など広い分野に普及し、原子力利用は我々の身の回りの生活に深く浸透しています。

1. 原子力開発の目標

わが国の原子力開発の目標は、エネルギーの安定確保と国民生活の質の向上です。わが国は豊かな社会を実現しているとは言え、将来の高度情報化時代に向かって質の良い電力の安定した供給が期待されています。しかし、わが国のエネルギー供給構造は極めて脆弱です。一次エネルギーの輸入依存度は８４％－－輸入ウランに依存する原子力発電を加えれば９４％－－に達します。

原子力は、技術集約型エネルギーとして準国産エネルギーと考えることも出来ますが、全量輸入に頼るウラン資源を最大限に有効利用することが不可欠であり、従って核燃料サイクルの推進が政策の基本となります。

また、近年の地球環境の悪化に対し、原子力利用により地球環境の保全に努め、人類社会に貢献すると言う視点も重要です。

2. 基本方針

わが国が採るべき原子力開発利用の基本方針は、次の通りです。

（1）原子力平和利用国家としての原子力政策の展開
（2）整合性のある軽水炉原子力発電体系の確立
（3）将来を展望した核燃料サイクルの着実な展望
（4）原子力科学技術の多様な展開と基礎的な研究の強化

3. 政策の現状

１．核不拡散に向けての国際的信頼の確立

わが国が、核燃料サイクルを始めとする原子力開発利用を進めるに当たっては、核拡散防止条約（ＮＰＴ）の無期限延長体制の下に、安全保障や国際政治経済動向を踏まえてこの体

制の維持・強化に貢献し、わが国の核燃料サイクル計画に対する国際的な懸念を払拭し、国際的信頼の確立を図らなければなりません。

今後、わが国においては、民間再処理工場を始めとする原子力施設の増加に伴い、保障措置業務が大幅に増加するので、国際原子力機関の保障措置の強化（９３＋２体制）に応じて、査察、核物質の分析、情報処理などが十分な信頼性を持って実施出来る体制を整備します。

また、ＮＰＴ体制から要求される義務に加え、自発的政策として「余剰のプルトニウムを持たない」との原則を堅持し、プルトニウム利用計画の透明性を高め、計画の現状を国の内外に明らかにしていきます。

国際的にも、各国のプルトニウム保有量を明示する国際指針が日本を含む九か国によって策定され、透明性の改善が図られています。

## ２．軽水炉体系による原子力発電

軽水炉は、世界的にもまたわが国においても十分な実績を持った炉型であり、今後長期にわたり原子力発電の主流を担うことになると考えられます。そのため、安全性の一層の向上を図るとともに、経済性の向上、高経年化対策、従業員被ばく低減などを図ります。また、高燃焼度化燃料、混合酸化物（ＭＯＸ）燃料に対応した燃料・炉心機能の高度化に取り組みます。

わが国の商用原子力発電の設備容量は、約四千五百万キロワットであり、２０１０年には七千万キロワットを超えることが期待されています。しかしながら、上述の発電容量を確保していくには、既存サイトでの増設に加えて新規サイトの確保が必要ですが、立地は年々困難になってきています。

## ３．核燃料サイクルの具体化

わが国は、国産動力炉の開発とそれに係る核燃料サイクルの確立を目標として来ました。１９６７年には動力炉・核燃料開発事業団が設立され、重水減速軽水冷却新型転換炉（ＡＴＲ）とナトリウム冷却高速増殖炉（ＦＢＲ）の開発を行い、さらに、ウラン資源の有効利用を目指す核燃料サイクル技術開発を行う中心的機関となりました。

動燃事業団の発足以来、多少の遅れはあったものの、使用済み燃料再処理工場、混合酸化物燃料加工施設、高速増殖実験炉「常陽」、新型転換原型炉「ふげん」が完成して運転実績を重ね、高速増殖原型炉「もんじゅ」も建設を完了して試運転となりました。また、日本原燃（株）による民間再処理工場の建設とウラン濃縮工場の建設、運転も進められています。

この間、世界の情勢は大きく変化し、核兵器拡散防止の観点から米国が再処理と高速増殖炉の開発を断念し、これが一部諸国に影響して、カナダ、スエーデン、ドイツなどで核燃料サイクル政策の見直しが行われてきました。最近の核軍縮の進展と世界的な原子力発電の伸び悩みにより、天然ウランの世界的余剰が生じているのもこの動きを助長しています。

## ４．新型転換実証炉計画の見直し

新型転換原型炉「ふげん」に続く実証炉については、建設実施主体である電源開発（株）と建設予定地点の地元漁業者との交渉が難行し、解決が延び延びになっていました。９４年にようやく地元問題が解決し、建設費の見直しが行われた結果、当初見積もりを五割り近く

超過することが分かりました。当初見積もり自体が建設費の六割を国と電気事業者からの資金援助によるもので、それが更に五割増しでは負担限度を超えるとなりました。

原子力委員会では、経済性、核燃料サイクル、研究開発などの観点からこの問題を審議した結果、

『(1)計画が十年間にわたり一年ずつ引き伸ばされたため、抜本的合理化設計が行われず、今後合理化に努めても技術実証に長期を要する

(2)新型転換炉の役割が、軽水炉によるＭＯＸ燃料利用により代替可能であることなどから計画を中止することが妥当である。

また、これに代わる計画として、全炉心にＭＯＸ燃料が装荷可能な改良沸騰水炉(ＡＢＷＲ)が適切である。』

と決定しました。

この見直しは、研究開発の成果を実用化に繋げることが出来なかったという点で、原子力委員会にとっては大変残念なものとなりました。

5．高速増殖原型炉「もんじゅ」二次系ナトリウム漏れ

９５年末に、「もんじゅ」の二次系ナトリウム漏れというわが国の高速増殖炉開発において始めての試練を受けました。もっとも、世界の高速増殖炉開発の歴史では、既に１５４回のナトリウム漏れを経験しており、「もんじゅ」の漏洩は１５５回目です。これまでの調査により、ナトリウム漏洩の原因は二次系配管に設けられた温度計の破損によると確認されました。温度計破損の原因は、鞘管の設計ミスがあったうえ、断線した温度計の修理に当たって、無理してねじ込んだ線が曲がっていたため、鞘管の振動が大きくなったことによるものでした。原子炉製造事業者の責任は重大ですが、先行の「常陽」の温度計の経験に学べなかったことは、技術の継承問題の難しさを示しています。

原子炉の炉心に直接触れていない二次系からの漏れなので、周辺公衆や従業員への放射性物質による影響はなく、災害防止上の観点から、原子力施設の安全は確保されたのです。しかし、残念ながらその後の動燃事業団の対応が極めて不適切であり、情報を隠した、更には嘘をついたと伝えられたことは致命的でした。そのため、国民の間に原子力に対する不安感と不信感が高まりました。

これを契機として地元自治体から「今後の原子力政策の進め方について」と言う提言がなされました。これを受けて原子力委員会は広く国民的な議論をする場として、９６年に原子力政策円卓会議を設けました。

6．軽水炉でのプルトニウム利用

核燃料サイクルの長期的目標は、高速増殖炉と再処理・燃料加工プロセスの最適な組み合わせによるプルトニウムの有効利用ですが、その実現には相当期間の研究開発が続けられなければなりません。そこで、将来の高速増殖炉時代に向けた実用規模の核燃料リサイクルに必要な技術の確立、体制の整備の観点から、当面、プルトニウムをＭＯＸ燃料として軽水炉に使用することが考えられます。

現在の原子力発電所においても、原子炉内でウランがプルトニウムに転換され、このプルトニウムの核分裂エネルギーが原子力発電から得られるエネルギーの三分の一を担ってい

ます。軽水炉でのＭＯＸ燃料使用は、欧州を中心に１６００体を超える装荷実績があり、ウラン燃料と同様に実用化されています。わが国でも、少数体燃焼試験で良い成績が得られている他、「ふげん」における６００体以上のＭＯＸ燃料装荷実績があります。

軽水炉でのプルトニウム利用は、エネルギー供給の面で一定の役割を果たすことが期待されます。電気事業者は、原子力発電所保有各社において実施計画を立て、２０１０年までに累計１６～１８基の軽水炉でＭＯＸ燃料の使用を図ることとしています。

## ７．使用済み燃料の貯蔵

現在、わが国の原子力発電所から発生する使用済み燃料は、年間９００トン程度になります。一方、六ケ所村に建設中の再処理工場の処理能力は年間８００トンなので、年間１００トン程度の積み残しが発生します。

そこで、当面の対策として、幾つかの発電所において所内貯蔵能力の増強が図られるにしても、２０１０年頃までには発電所の敷地外における貯蔵も可能となるよう、法律の改正も含めた環境の整備が検討されています。

## ８．放射性廃棄物処分

### １）高レベル放射性廃棄物の処分

放射性廃棄物特に高レベル放射性廃棄物の処分方策を確立することは、原子力による便益を享受している我々現世代の責務です。

わが国の基本方針は、使用済み燃料の再処理の結果発生する高レベル放射性廃液にガラス成分を加え、安定な形態に固化し、３０年から５０年間程度冷却のための貯蔵を行い、その後、深い地層中に処分することとしています。２０００年には処分事業の実施主体の設立を図るため、現在官民協力による「高レベル事業推進準備会（ＳＨＰ）＊」がそのための調査・研究を進めています。

原子力委員会は、高レベル放射性廃棄物の処分の具体化に向けた検討を行うため、社会的・経済的側面を含む幅広い検討を行う懇談会と、処分に関する研究開発計画など技術的検討を行う専門部会とを設け、総合的検討を行って来ました。

専門部会報告書では、２０００年までに地層処分の技術的信頼性を示し、処分予定地の選定及び安全基準の策定に資する技術的な拠り所を示すにあたっての研究開発の進め方を示しています。

懇談会の報告書案では、

『われわれが発生させた廃棄物については、我々の世代がその処分制度を確立し後世代に負担を残さないという責務があります。また、原子力発電電力消費地域住民と処分場立地地域住民との間の「公平」を確保することも必要です。こうした問題については、国民各層の幅広い議論による合意形成が必要です。実施に当たっては、透明性の高い手順を踏むことが必要で、情報公開を徹底しなければなりません。』

と述べられています。

この報告書案は、広く国民の意見を求めた上、最終報告書にまとめることとしています。

＊ SHP:  Steering committee on High-Level-Radioactive-Waste Project

２）原子力施設の廃止措置

日本原子力発電（株）の東海１号発電炉が、３２年間にわたる運転を終了し、９８年には施設の廃止に着手することとなりました。わが国では、日本原子力研究所の動力試験炉（ＪＰＤＲ）の完全な解体撤去の経験がありますが、商用原子力発電所の廃止措置は初めてのことです。

原子力施設の廃止措置は、原子力施設設置者の責任の下に、安全確保を大前提として、地域社会との協調を図りながら進めることが必要です。

９．原子力科学技術の多様な展開

原子力は、発電以外にも、高温ガス炉による熱供給、船用動力、放射線利用、核融合など広範な応用範囲を持っています。

１）基礎研究・基盤技術開発

光量子科学、中性子科学、イオン・ポジトロン科学、高度計算科学などにおいて、原子力の新たな可能性を切り開く研究活動が盛んです。

放射線生物影響、ビーム利用、材料、ソフト系科学技術の各分野で、既存の原子力技術にブレーク・スルーを引き起こし、基礎研究とプロジェクト研究とを結びつける基盤技術開発が進められています。

２）原子力利用分野の拡大

高温の熱供給が出来る高温工学試験研究炉が９８年に完成します。原子力船「むつ」は、実験航海の終了後解役作業を終え、船体は海洋地球研究船「みらい」に改造されました。

３）放射線利用

大型放射光施設（ＳＰｒｉｎｇ－８）が完成し、９７年から共用を開始しました。重粒子線がん治療装置（ＨＩＭＡＣ）は９４年から治療照射を行い、良好な成績を挙げています。

イオン照射研究施設（ＴＩＡＲＡ）において、種々のイオン・ビームを利用した新機能材料の開発やバイオ技術の研究が行われています。

放射性同位元素または放射線発生装置の使用事業所は約五千ヶ所に達し、ポジトロンＣＴ、害虫防除、排ガス脱硫、ＤＮＡ解析など多方面に活用されています。

４）核融合

日本原子力研究所のＪＴ－６０は、臨界プラズマ条件を達成し、最高の核融合積を得ており、大学共同利用の大型ヘリカル装置も完成します。

日本、米国、ＥＵ及びロシアの四極の協力による国際熱核融合実験炉（ＩＴＥＲ）計画は、工学設計活動を順調に進めて来ましたが、その終了を９８年から三年間延長することになりました。

4.　当面の課題

１．原子力政策円卓会議

円卓会議の開催に当たっては、原子力の専門家だけでなく、広く人文・社会科学系に至るさまざまな分野の研究者、地方自治体の首長、評論家、文化人など、さらには原子力に批判的な意見を持つ方々、あるいは公募による一般参加者などの参加を得て、完全公開のもとに様々な運営上の工夫を行いながら、熱心な討論が十一回にわたって行われました。

会議においては、まず、双方向性の情報公開・提供の必要性が指摘され、原子力委員会は、それを反映して専門部会などの議事を公開し、政策決定の過程で国民から意見を募集することを始めました。また、エネルギー供給の中での原子力の位置付けという問題や、「どこまで安全なら安心なのか」という社会的受容性の問題も含めて、単にわが国のエネルギー確保という観点だけでなく、世界的・歴史的な視点を踏まえ、現代の世代が豊かな社会を次の世代にどう引き継いで行くのかという問題などあらゆる面からの討議が行われました。

宗教的立場あるいは反科学的立場から、原子力開発は止めるべきとの意見もありましたが、現にわが国の総発電電力量の三分の一を占める原子力発電は、安全第一で慎重に進めるべきとの考えが多かったように思われます。ただし、たとえ原子力の必要性は認識しても、原子力施設を自分の近くに立地することには反対という、いわゆるＮＩＭＢＹ(Ｎｏｔ Ｉｎ Ｍｙ ＢａｃｋＹａｒｄ)の考え方も提起されました。

１９５０年代半ばに始まり、ほぼ半世紀にわたる歴史のあるわが国の原子力開発利用が、幾つかの事故を経験しながらも、その間放射線による人身事故を起こさず、施設の敷地の外に有意な影響を与えることもなかったという安全実績を踏まえながら、社会の成熟化の中でどのように位置づけられていくかが問題となっている訳です。

## ２．核燃料サイクルに係わる具体的な施策

原子力政策円卓会議における議論やモデレータからの提言を受け、また、通商産業省総合エネルギー調査会の検討結果も勘案し、９７年始めに、原子力委員会は、「当面の核燃料サイクルの具体的な施策について」を決定しました。

この決定では、まず、わが国における原子力開発利用の当初からの基本的考え方、すなわち、わが国の置かれている資源的な制約や環境保護の観点から、原子力発電を長期に安定的に進めていく上で、核燃料サイクルを円滑に展開していくことが不可欠であることが確認されました。その上で、再処理工場の建設の着実な進展を含め国内における核燃料サイクル確立の重要性を認識して、軽水炉でのプルトニウム利用や使用済み燃料の管理といった喫緊の課題について、具体的な考え方を示すとともに、放射性廃棄物処分対策や高速増殖炉開発についての今後の考え方を示しました。

この決定は、数日後に閣議において了解され、この問題に対する政府の方針が再確認されました。

## ３．動燃アスファルト固化建屋の火災・爆発

９７年３月には、動燃東海事業所のアスファルト固化建屋で火災・爆発が起きました。敷地内に放射性物質の漏洩がありましたが、従業員の放射線被ばくは無視できる程度で、敷地外への放射性物質の有意の漏洩はありませんでした。

しかし、事故対応が拙劣で、実態と異なる報告や隠蔽工作が行われ、再び国民の不安と不信を引き起こす結果となり、ひいては、これが核燃料サイクルの展開に影響を及ぼす事態となりました。

## ４．動力炉・核燃料開発事業団の改革

動燃事業団の監督官庁である科学技術庁では、事故原因の究明を行うとともに、動燃改革

検討委員会を設けて、徹底した改革を行うこととしました。検討委員会での検討の結果、

『動燃事業団を改組して新法人を組織する。主たる事業は、高速増殖炉開発及び関連核燃料サイクル技術開発と高レベル放射性廃棄物処理処分研究開発とし、海外ウラン探鉱、ウラン濃縮、新型転換炉開発の三事業は適切な期間を置いて廃止する』

こととなりました。

5．高速増殖炉懇談会

円卓会議モデレータの提言を受けて、原子力委員会に設けられた高速増殖炉懇談会は、十二回に及ぶ熱心な幅広い討議を行いました。報告書の要点は次の通りです。

『高速増殖炉は、燃料の使い捨てでなく複数回のリサイクルによってウランの利用効率を軽水炉に比べて極めて高く出来る上、廃棄物の負荷を減少できるということで、長年にわたり研究開発が進められました。しかし、未だ経済性などの点から実用化の見通しがなく、開発を続けるべきでないという意見が出されました。これに対し、実験炉「常陽」が成果を収め、原型炉「もんじゅ」も建設され、研究は進展しているので、海外の経験を参考にしながら研究開発を進めるべきで、中止すべきではないという意見が大勢を占めました。

「もんじゅ」の取扱については慎重な運転管理が行われることを前提に、研究開発が実施されることを望みます。また、高速増殖炉の開発は、将来の非化石エネルギー源の一つの有力な選択肢として進めることが妥当と考えます。』

6．行財政改革

わが国は、敗戦後半世紀に及ぶ国を挙げての努力の結果、世界第二位の経済力を持つ国となり、科学技術の面でも世界のトップ・グループに属するようになりましたが、その間各種制度に疲労現象が見られるようになり、今のままでは国の将来が危ういと思われるようになって来ました。そこで、現政権のもと、大掛かりな財政改革と行政改革が図られることとなりました。

原子力行政についても、内閣総理大臣の諮問機関である原子力委員会と原子力安全委員会とが新設の内閣府に移され、また各省庁の再編成に伴い所管事項の整理統合が検討されるなど、見直しが図られることになりましょう。

幸い、厳しい財政状況の下でも、科学技術政策については環境政策と並んで国の重点施策とされているので、必要な経費の確保は図られるでしょうが、大型研究開発プロジェクトについての見直しは必要でしょう。

5.　核燃料サイクル政策と核武装問題

わが国は、原子力委員会発足以来、原子力の平和利用に徹してきました。今後ともわが国が核武装することはあり得ませんが、諸外国の一部には日本が核燃料サイクル政策にかこつけて、いずれ核武装に踏み切るであろうとの観測があります。これは大変な誤解であり、「経済力があり高度技術を持つ大国は、核兵器を持つ」という世界の常識は、わが国には当てはまりません。その理由は次の通りです。

1）心理的、歴史的理由

広島、長崎の原爆被害を受けた日本は、国民の全てが核兵器を嫌悪しています。「報復」の

理論は全くありません。

２)制度的理由

原子力基本法による平和利用確保、二国間協定による転用制約、国際原子力機関の保障措置などの諸制度により、平和利用の担保が図られています。

３)現実的理由

日本では、核兵器生産を所管する官庁がありません。核兵器の開発に従事する科学者・技術者はいません。この状態を変えようとしても、核武装に反対するマス・メディアの監視は逃れられません。核兵器生産に踏み切って、経済制裁を受ければ、日本経済は崩壊し、国民は飢えと寒さに苦しみます。そのような選択はあり得ません。

むすび

科学技術創造立国を目指すわが国が、国土が狭く資源に恵まれないという宿命を克服し、更に科学技術面での国際貢献を目指すとき、２１世紀の科学技術に求められる条件を明らかにしながら、科学技術活動の重要分野である原子力開発利用を発展させていくことが必要だと考えます。

原子力の研究開発は、他の巨大科学技術と同様に永い開発期間を要するので、常に長期展望を明確にし、究極の姿を求める姿勢がないと、本来の方向を見失い社会の変化の中に埋没する恐れがあります。原子力開発は、石油文明と共存して、また、将来これに替わって人類文明をその根幹の部分で支える、調和のある総合科学技術へと発展して行くものと期待して、話の締めくくりと致します。

# SESSION 1

January 19th 1998

## Plutonium Recycling for a « sustainable » Nuclear Development

*by* Bertrand BARRÉ, CEA France


### Abstract

Present day nuclear reactors are sturdy, reliable, and can be safely operated to generate cost-competitive baseload electric power. On the other hand, they make poor use of the energy content of the Earth uranium resources. Even with high burnup fuel, a LWR operated in open cycle uses only 1% of the energy theoretically available. This is not enough to make nuclear energy « sustainable » on the long run. A much higher energy use can be achieved in fast neutron reactors, the industrial feasibility of which has been demonstrated. Because of the slow development of nuclear power throughout the world, the time when FNR reach economic competitiveness appears far away, but in view of the stakes, their continued development remains worthwhile. In the meantime, plutonium recycling in MOX LWR fuel allows for some uranium and SWU saving, reduces the plutonium content in the high level wastes, and maintains the reprocessing route. The French government has decided to abandon Superphénix, but to pursue the present reprocessing-recycle policy, and to maintain the R&D program aimed at the long term development of the FNR.


### 1. The Sustainability of Nuclear Energy.

Last year, some 430 nuclear reactors throughout the world have produced around 2400 billion kWh of electric power, i.e. more than 17% of the world total electric supply. This is much and this is little. This is much as it is equivalent to the oil production of Saudi Arabia ; this is much because it is equivalent to all the world electric consumption back in 1960 ; this is much, because it avoided sending into the atmosphere as much carbon dioxide as all the cars in Europe did send. But it is far less, maybe four or five times less than was expected in the early seventies.

In the XXIst century, the Earth population will keep growing, albeit at a much reduced rate, and one can hope that the development gap between industrialised and developing countries will be partly bridged. This will only be possible through a doubling - or so - of our present energy consumption, and this, in turn, means that we shall need all the energy sources available, and notably that we need nuclear energy to be a significant part of the world energy mix over the long run.

Present day LWR - which constitute over 85% of the operating nuclear plants in the world, do not allow for such « sustainability ». They are sturdy, reliable, and can be operated in full safety to generate electric power with a high degree of reliability. Even with today's low gas prices on the world market, they can, and they do in many countries, generate cost competitive baseload power. But they make a poor use of the energy contained in Earth uranium resources - whatever their actual figures.

Even with high burnup fuel (and there appears to be no incentive to go much beyond 60 GWd/t), a LWR operated in open cycle mode extracts roughly 1% only of the total energy theoretically available in uranium ores. With this kind of efficiency, uranium resources are smaller than oil or gas resources, and do not qualify for sustainability.

Since the late 40s, it is well known that plutonium fuelled fast neutron reactors, FNR, can achieve a much better efficiency and extract, through multiple recycling, around 70% of uranium's energy content. With this kind of efficiency, uranium resources can be compared to coal's and last for centuries.

## 2. Status of Fast Neutron Reactors Development in France.

Among several possible FNR technologies, only one has been fully demonstrated up to the industrial scale : it uses fuel pins with MOX uranium/plutonium oxide pellets clad in stainless steel and cooled in liquid sodium. Core designs may vary somehow between « pool » and « loop » primary circuits, but all these reactors exhibit many more similarities then differences. To this generic technology belong, in Japan, Joyo and Monju, and in France, Rapsodie, Phénix and Superphénix.

Operated by the CEA between 1967 and 1983 in Cadarache, Rapsodie has brought a major contribution to the development of MOX fuel for FNR. It has been decommissioned and is presently in the early phases of dismantling.

The 250 MWe Phénix demonstration reactor, which belongs to the CEA(80%) and EdF (20%), has been in operation in Marcoule since December 1973. It was first used to demonstrate the feasibility of a complete liquid metal fast breeder system, and then as an experimental reactor to qualify fuel and materials under FNR operating conditions. Phénix has achieved a number of very significant performances :

- As a power reactor, it has been connected for 97 000 hours to the French grid ;
- It totals 3 800 equivalent days at full power ;
- It is completely fuelled by its own recycled and bred plutonium ;
- It has actually demonstrated a *measured* breeding ration of 1.15 ;
- One experimental subassembly, BOITIX 9, has reached a burnup of 144 GWd/t ;
- It has experienced only 15 clad failures while irradiating over 170 000 fuel pins.

In 1989 and 1990, Phénix experienced several scrams triggered by very short negative reactivity transients, the explanation of which is not yet fully proven. This led to a shutdown period during which an extensive revamping of the secondary circuits was undertaken. During the first half of 1995, the reactor performed another cycle at power, the 49$^{th}$, where no transient did occur. It is now ready to resume operation at power, to perform experiments mostly related to the transmutation of long lived radioactive wastes. During the Year 1999, another planned long shutdown will allow to reinforce against seisms some auxiliary buildings and to perform non destructive ultrasonic testing of some internal structures of the primary vessel. The reactor should then resume operation to carry out experimental irradiations until the end of the year 2004. The instrumentation of the reactor has been increased in order to better monitor negative reactivity transients, should any occur.

Superphénix, a 1200 MWe LMFBR located at Creys-Malville, along the Rhône river, was built and operated by NERSA, a utility owned by Electricité de France (51%), the Italian ENEL (33%), and a consortium of German, Belgian and Dutch utilities.

Construction of the plant started in 1976, in the wake of the first Oil crisis and of the launching of the « quantitative » French nuclear equipment program of late 74. Its main purpose was then to demonstrate the feasibility of a *full industrial size* fast neutron reactor, at a time when the nuclear programs throughout the World appeared very active, and it looked like there might exist a risk of uranium shortage around the turn of the century. First criticality was achieved in September 1985, then full power in December 1986.

Shut down for 20 months in April 87 because of a sodium leak in the fuel handling vessel, it was again shutdown in July 89 because of an oxygen contamination of the primary sodium. For a mixture of regulatory and political reasons, it could not restart within less than two years, and this means all the authorisation had to restart from scratch.

Fully re-licensed, Superphénix was authorised to restart in August 1994, with a new assignment, the « Knowledge Acquisition Program », with three complementary goals :

1. obtain industrial experience in the operation of liquid metal fast reactors ;
2. demonstrate the flexibility of fast neutron reactors to breed or burn plutonium (CAPRA program) ;
3. perform R&D on the transmutation of long-lived radwastes.

As a matter of fact, in 1990 the World nuclear programs had not developed, and by far, as was expected in 1976, and breeding - already fully demonstrated by Phénix - did no longer appear urgent. Conversely, plutonium stockpiles were growing, and fast reactors appeared attractive to burn plutonium even of poor isotopic quality (like the plutonium found in irradiated MOX fuel elements). On the other hand, under a Law enacted by the French Parliament in December 1991, R&D had to be carried out to explore alternative ways of disposing of long-lived radioactive wastes. Among those ways was the transmutation into stable or shorter-lived isotopes. There again, because of their much higher neutron fluxes, fast neutron reactors appeared attractive.

Because of a small Argon gas leak in an intermediary heat exchanger, Superphénix had only a short run in the second half of 1994, and restarted after repair in December 1995. It operated very successfully during all the year 1996, during which a special Blue Ribbon Panel appointed by the Government confirmed its usefulness for R&D purposes, and it then entered its regular 10-year extended shutdown.

Following a lawsuit by several antinuclear organisations, the French Conseil d'Etat decided, at the end of February 1997, to void the Creation Decree of the plant. Then, following general elections in April 1997, the new French Government decided to abandon Superphénix, considered to be too expensive. The French Government and the French Safety Authority emphasised that *safety was not at issue* !

### 3. « MOX » Plutonium Recycle in Light Water Reactors

As soon as 1985, it was obvious that, for a long period of time, there would not be enough fast neutron reactors to use all the plutonium recovered in reprocessing the spent fuel of the French LWRs in the la Hague Plant.

It was then decided to recycle plutonium, as mixed (U,Pu) oxide « MOX » fuel in some of the French 900 MWe PWRs. MOX fuel had been experimentally tested as early as 1963 in the Belgian BR3 PWR and was already in use in some German and Swiss reactors. In France, some advanced MOX elements were already under test by the CEA in the experimental CAP PWR in Cadarache.

The first reload containing one third of MOX elements was loaded in the St Laurent B1 reactor of EdF in 1987. Today 13 EdF PWRs are routinely loaded with 1/3 MOX elements and 3 more are authorised to do so. 12 additional 900 plants are technically identical, but plutonium recycle was not included in their authorisation Decree : EdF is progressively carrying out public proceedings in order to obtain additional authorisations. 28 900 MWe plants would be largely enough to recycle all the plutonium reprocessed in the la Hague UP2-800 plant, dedicated to EdF needs, and refabricated in the new MELOX plant, operated by COGEMA in Marcoule.

Today, MOX fuel is only licensed to reach a maximum burnup of 37 GWd/t, while standard LEU fuel is licensed for 52 GWd/t. This means that MOX fuel assemblies stay only three one-year cycle in the reactors while uranium assemblies stay one extra cycle. This difference is only a reflection that MOX is a much « younger » fuel, with a lot less return of experience, but the goal of EdF is to obtain full parity between the two kinds of PWR assemblies, both in terms of burnup and economy.

There does not appear any technical reason why this goal could not be reached : both claddings are identical, and MOX pellets behaviour under irradiation differs from $UO_2$

pellets behaviour with both pluses and minuses. MOX pellets experience a higher release rate of fission gases, but they are more ductile than $UO_2$ pellets.

MOX recycle, on the other hand, can hardly be considered *by itself* a « sustainable » long term policy. At each cycle, the isotopic quality of the plutonium is downgraded, which makes its further recycle less economically attractive, and then even impossible if one wants to keep the core void factor negative. It is theoretically possible to overcome this limitation by recycling « homogeneously » plutonium mixed with more and more enriched uranium, but this appears hardly attractive at all, unless one wants to *destroy* plutonium rather than use its energy content. But even for this purpose, CAPRA type fast reactors appear much more promising.

With now more than ten years of experience in industrial MOX recycling - including two reprocessing campaigns in la Hague for demonstration purposes - one can underline the advantages of MOX recycling :

- MOX recycling saves natural uranium and SWU by roughly 15% ;
- the first MOX recycling divides by a factor 7 the number of fuel assemblies to be stored in storage pools (one needs the plutonium recovered from 7 to 8 spent fuel elements to fabricate 1 MOX assembly) ;
- MOX recycling is cost competitive, as the saving in uranium and enrichment costs balances more or less the excess in fabrication cost ;
- MOX recycling keeps open and industrially viable the reprocessing option, which is the key to a better uranium use in future fast neutron reactors.

## 4. Conclusion

Though it has decided to abandon Superphénix, the French government has indicated that MOX recycle will continue in French PWRs, *as shall continue* the long term R&D on fast neutron reactors.

We plan to carry out this R&D in full co-operation with our European partners and to collaborate with Russia and, of course Japan with which we have tight links. CEA and PNC have a very strong and active bilateral co-operation going on, in addition to the agreement which is in force, and active too, between the European partners and all four Japanese R&D organisation presently involved in fast neutron reactor R&D : PNC, JAERI, CRIEPI and JAPC.

We hope Phénix will be very soon allowed to resume operation at power. We are carrying out some experiments in the Russian BOR 60 reactor. We are planning a new irradiation reactor to be built in Cadarache, the Réacteur Jules Horowitz, which will have the capability to carry out some fuel and materials irradiations in representative fast neutron spectra. But we are also waiting for Joyo to undergo its Mark III revamping and for Monju to restart. We have today advanced Japanese assemblies ready to be irradiated in Phénix, there will be to-morrow advanced fuel assemblies sent to be irradiated in Monju ! The full development of fast neutron reactors is a long term endeavour, which shall require extensive collaboration among all the interested countries, and, mostly, between France and Japan.

Third International Forum on Nuclear Non-Proliferation
Tokyo, 23-25 February 1998

**The Peaceful Use of Plutonium - the Necessity for Recycling**

**L N Chamberlain**
**Deputy Chairman, BNFL**

**Abstract**

This talk will look at the important role that the recycling of nuclear fuel has to play in the management of plutonium for peaceful uses. It will be argued that plutonium should be seen as a vital global energy source rather than as a waste that needs to be stored or buried. The talk will cover the role of MOX in stabilising stockpiles and in minimising proliferation risks. MOX however is an interim step in the management of plutonium, with the ultimate long-term solution still being fast breeder reactors. The issues of both the safeguarding and the transport of civil plutonium are ones for which there are internationally established practices and techniques. These, along with BNFL's and others significant experience in the management of plutonium, should provide adequate reassurance that plutonium can be managed and recycled both safely and effectively.

Thamk you very much and good afternoon ladies and gentlemen. It is a great pleasure to be invited here to talk to you.

As you might expect, I am a firm advocate of the role of nuclear power and particularly of nuclear fuel recycling, so I want to start my presentation by explaining why.

The steadily increasing world population and the even more rapid increase in economic activity means that the world's demand for electricity could double or triple over the next fifty years. At the moment two thirds of this electricity is supplied by the burning of fossil fuels, with nuclear and hydro-power equally supplying the remainder. New renewables such as wind and wave power still supply only about 1% of electricity, and even the most optimistic projections for new renewables cannot meet the increasing demand. There is little scope for any expansion of hydro-power, so the bulk of the increased demand will have to be supplied either by the burning of even more fossils or by nuclear energy.

However, the world is increasingly recognising that the burning of fossils is not sustainable. The agreement at Kyoto was a first, but very small, step to reducing the emission of greenhouse gases. I believe that as the evidence for global warming grows, even stronger measures will have to be taken and the electricity generation industry, responsible at present for one third of society's $CO_2$ emissions, will have to respond.

With sufficient political will, nuclear power could be significantly increased, but in its present form of thermal nuclear power reactors, the uranium reserves will last no longer than the reserves of fossil fuels. Various estimates put the lifetime of economic uranium reserves at between 50 and 150 years, depending on the cost of extraction and demand. If we are to think long-term, as the nuclear industry must, then we need to continue to promote reactors that breed fuel. Ultimately, a 1 GWe Fast Breeder reactor can be fuelled by just 1.2 tonnes of depleted uranium per year. At that level of requirement, the cost of uranium becomes almost irrelevant, so with billions of tonnes in sea-water alone, uranium becomes a truly sustainable energy resource.

But Fast Reactors also require a supply of plutonium. They can be operated to breed more plutonium than they consume, to supply just enough for future operations or even to consume excess plutonium, but they still require an initial charge supplied from thermal reactors and from reprocessing. Indeed one of the early rationales behind reprocessing was to separate out the plutonium to fuel Fast Reactors. Our stocks of plutonium are now sufficient for this no longer to be a primary reason. But the main reason for reprocessing, as the best means of management of irradiated fuel, still remains.

Plutonium, we must remind ourselves, is generated as a by-product of uranium fission inside thermal reactors. But it is a very useful by-product as roughly one-third of the energy generated from the fuel comes from the fissioning of that plutonium. So with nuclear power generating 17% of the world's electricity, around 5% is currently generated by plutonium. A simple calculation, valuing electricity at 2.5p per kilowatt-hour, the UK pool price, puts the value of the electricity generated by plutonium at roughly £20 billion per year. So plutonium is already doing a valuable job, but it can do more, as I will show.

There are essentially two things that can be done with the plutonium once the irradiated fuel is removed from the reactor. It can either be left in the fuel for ultimate disposal or it can be separated out.

Firstly, there is the direct disposal route. This of course is the officially preferred route of the US administration for civil reactor fuel. Indeed this route is inevitable for much of the irradiated fuel since the world arisings of spent fuel significantly exceed the current, or any reasonable projection of, reprocessing capacity. So the mechanisms for the indefinite disposal of spent fuel will have to be developed. From the point of view of the plutonium, the potential hazard is that we could be creating plutonium mines, which could be accessed at some time in the future either at the national or sub-national levels, by people wishing to make weapons or simply for terrorist purposes. I do not want to explore this scenario too deeply. I simply wish to point out that, no matter how secure the repositories are, no matter how difficult it would be to extract the plutonium, repositories will never entirely eliminate the risk of recovery and reuse. Moreover, the less accessible we make the plutonium, the harder it will be to change our minds when the world rediscovers its real value.

I want at this point to quote what President Ford said in his Statement on Nuclear Policy in October 1976, 'I believe the avoidance of proliferation must take precedence over economic interests.' The conventional wisdom has long been, at least in the US, that separating out plutonium increases the risk of proliferation, and this has been the basis for the US turning its back on civil reprocessing. This view has not been supported in the UK, Japan and other countries. In our view, separated plutonium, if properly managed, can present less of a proliferation risk than direct disposal of unreprocessed spent fuel. Also, this argument is stronger today than it was 20 years ago. This brings me to the second option of separating out the plutonium by reprocessing.

There are four principal things that can be done with separated plutonium that I wish to discuss. Firstly, storage, secondly immobilisation followed by disposal, thirdly incorporation into Fast Reactor fuel, and fourthly recycling as thermal MOX fuel. There are also some other technical options, such as transmutation, but these are not economically viable options today, and may never be. I will take these four options in turn.

The storage of plutonium is of course not a long-term solution, but it can be done entirely safely and securely provided that storage is done by a relatively limited number of experienced operators subject to stringent international safeguards. In the UK we have over 40 years experience of managing and protecting plutonium. We are subject to international safeguards under the auspices of Euratom, the European Safeguards Agency and the IAEA in an overall national safety framework overseen by the Nuclear Installations Inspectorate. Our new THORP and SMP facilities have some of the most advanced safeguards and physical protection features, including Near Real Time Materials Accountancy. We estimate that BNFL's investment in security since the mid 1980's has exceeded £250 million in today's money values. The highly trained, specialist police force who guard our sites and material movements have never even had to draw a firearm to protect any nuclear material in over 40 years.

Secondly to consider immobilisation. Of the various methods to achieve this, the most promising is probably incorporation into a glass matrix by vitrification. There is much international experience of the vitrification of High Level Waste. Vitrification has some advantages from a proliferation viewpoint over direct disposal in that it makes the recovery and separation of the plutonium much harder but notably still not impossible. This option is being studied seriously, particularly in the US as a disposition route for military plutonium. There are however some significant technical and licensing problems associated with this option, which is still unproven. It is likely to be a very expensive and limited option that will be applicable primarily to a small part of the surplus plutonium stockpile.

The third option of incorporation into Fast Reactor fuel is no longer an imminent option except for the ongoing development programmes, but as I have already argued, is an option that must be kept open for the time when Fast Reactors will become economically attractive as an essential part of generating sustainable energy for the world.

The fourth option is to incorporate the plutonium into new fuel for thermal reactors. Mixed oxide or MOX fuel is now an established, proven technology which has been in existence for over 30 years since a reactor in Belgium was first loaded in 1963. In the same year MOX was loaded into the prototype Advanced Gas-Cooled Reactor, the WAGR, at Sellafield. Over 500 t of MOX fuel has now been manufactured world-wide, using about one third of the stock of separated plutonium. There are about 35 reactors licensed for the use of MOX. There could be 50-60 licensed reactors by the year 2000, and there are no fundamental technical problems to the use of MOX in most PWRs. The issues are mainly licensing and economical.

At BNFL we have manufactured all the MOX fuel for the UK's experimental Fast Reactors and have been operating a small scale MOX Demonstration Facility, MDF, for thermal reactor fuel for several years. Fuel from that facility has already been loaded into reactors in Germany and Switzerland. Our much larger Sellafield MOX Plant, SMP with a capacity of 120 tonnes of heavy metal per year is nearing completion, and has now entered a phase of public consultation prior to commissioning. The co-location of reprocessing and fuel plant, as at Sellafield and other sites, is a key element in reducing any proliferation risks by minimising the need for transport of plutonium in a separated form.

Of course, there will be a continuing need for the transport of plutonium in some form. In BNFL we have many years experience of the safe national and international transport of nuclear materials. We have a long association with our French and Japanese partners through our subsidiary PNTL, which, in addition to the transport of irradiated fuel from Japan to France and Britain, has made return shipments of High Level Waste and of plutonium for the MONJU reactor. We have been safely transporting plutonium for over 30 years, and more recently a number of MOX assemblies have been transported to European utilities by air and sea. Of course, all transport is subject to strict international regulation by the IAEA. The outstanding safety record is due to the design and development of the packaging, the experience and expertise of the operators and the rigorous checks that are carried out at every stage of the operation.

With a 30% MOX fuel loading, a thermal reactor can consume as much plutonium as it produces. When SMP and JNFL's JMOX plant are on-line and with an extension to the French MELOX plant, some time after the year 2000, there will be sufficient capacity to stabilise and reduce civil plutonium stockpiles; MOX fuel consuming as much as is separated by reprocessing. The IAEA estimates that the stocks of separated plutonium will roughly halve over a period of 10 years once these plants are operational. As more advanced reactors capable of higher MOX loading are developed and more reactors are licensed to use MOX, the entire production and consumption of plutonium will become increasingly stabilised.

There are five key advantages to MOX fuel which I want to outline:

Firstly, it can effectively stabilise or reduce the total plutonium inventory, both civil and military. Recycling plutonium is the only certain way of avoiding the potential for diversion.

Secondly, plutonium is itself a valuable energy source. Just one kilogram of plutonium, which I could easily carry in my hand, has the energy potential of one thousand tonnes of oil. Future generations may regard us as mad to throw away and make inaccessible such an energy source. And of course it is a carbon-free energy source, each kilogram of plutonium recycled saving the discharge of more than three thousand tonnes of $CO_2$.

Thirdly, such plutonium will remain visible, or for ex-military plutonium become visible, as part of the civil safeguards regime, so that the potential or opportunity for clandestine diversion will be minimised. The expertise built up in military uses of plutonium can be refocused on its civil uses, truly turning swords into ploughshares.

Fourthly, recycling reduces both the amount of waste and the number of spent fuel elements that will require ultimate disposal.

And fifthly, we will maintain and develop the skills and capabilities that will be needed longer-term when the, I believe, inevitable resurrection of nuclear power occurs and the need for efficient, commercial breeder power stations emerges.

The current economics of MOX fuel are often misunderstood. The fuel currently costs four to six times as much to fabricate as virgin uranium fuel, but it can save up to £50M over the lifetime of a reactor, principally by offsetting the cost of mining, purifying and enriching new uranium. MOX will become more widely economic with improved manufacturing experience and as more advanced reactors with higher burn-ups are developed. For these reactors the alternative to MOX is more highly enriched, more expensive uranium fuel, making MOX relatively attractive.

I want to finish my talk by addressing what are perceived as the three principal risks associated with the management of plutonium.

Firstly, there is the risk of a state deliberately diverting nuclear materials or facilities from civil to military use. This is predominately a political issue, which requires effective international surveillance and safeguards. As the world becomes more connected and surveillance techniques increasingly improve, I believe that the chances of a rogue state being able to default on its Non-Proliferation commitments will become increasingly remote. To strengthen this point I believe firmly in developing the notion of international partnerships for the management and control of all the relevant nuclear activities.

Secondly, there is the risk of the theft of nuclear materials by terrorist or other groups. This risk has been enhanced by the ending of the cold war and the release from strict military supervision of significant quantities of nuclear materials. It should be noted that there is no evidence of any credible risk of diversion of civil safeguarded material. However, the theft of any nuclear material is a risk that needs to be addressed very seriously and one that, if it were to occur, would undoubtedly have an adverse impact on the civil use of plutonium. The quicker that any plutonium at risk of theft or unauthorised trading is brought under international control, fabricated into MOX fuel and burnt in a nuclear power reactor, the better.

Thirdly, there is the risk of closing off the nuclear power option. This could perversely leave the world more open to the threat of nuclear proliferation. Nuclear materials exist and will continue to exist. They can best be controlled by ensuring that we maintain viable and peaceful outlets. All the arguments put by the anti-nuclear lobby must be seen in the context that their overall aim is simply to shut down the nuclear industry. We must continue to convince the public that the civil use of plutonium is actually a solution to plutonium proliferation and not part of the problem. We must also ensure that Governments receive a balanced view, and trust that they will be able to resist short-term single-issue populist lobbying and take seriously their moral obligations to heed the longer-term needs of world populations.

I have outlined a number of approaches to the management of plutonium. All of these will have to be pursued to some extent, but the most important of these for the immediate future is the thermal MOX option. Its pursuit is a key element of both the effective management of plutonium and of the long-term maintenance of nuclear power as an environmentally beneficial and sustainable energy resource.

Thank you.

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# OVERVIEW OF RRC "KURCHATOV INSTITUTE" PRINCIPAL STUDIES OF PLUTONIUM USAGE IN OPERATING AND FUTURE REACTORS

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An overview of Pu usage strategies, considered in Russian Research Center "Kurchatov Institute" and developed in collaboration with other scientific and industrial organizations is presented. The aspects of peaceful plutonium usage (also excess weapons Pu) are discussed. They comprise the evaluation of plutonium as a valuable source for nuclear power sector, its possible role in the optimization of the nuclear power sector in Russia. Various reactor concepts are briefly considered for Pu usage. Among them are operating reactors which have already found their place in the power sector (traditional LWRs and fast reactors) as well as emerging reactor concepts like modular high-temperature reactor, lead or steam-water cooled fast reactors and molten-salt reactor for closed fuel cycle. Overview of domestic and international activities of RRC KI in these fields is shortly presented. Among them is the comprehensive program aimed at the licensing of MOX fuel usage in VVER-1000 reactors (considered along with the implementation of the new fuel cycles) and efforts for its scientific qualification.

## INTRODUCTION

The world community has now reasons to be concerned about accumulation of plutonium, produced in operation of existent power reactors, as well as weapon-grade plutonium, released according to the arms reduction programs. Plutonium treatment problems are not only technical, ecological and economical, but also political, because they are directly connected with nonproliferation of nuclear weapons and social acceptability of the nuclear power.

Studies of Pu usage strategies have been always one of the main fields of interest at the Russian Research Center "Kurchatov Institute" and have been developed in collaboration with other scientific and industrial organizations. Plutonium treatment was always realized in RRC KI as one of the most important branches of technical culture. This treatment includes production, separation, storage, solving nonproliferation issues, and utilization. The latter became the most essential item in the studies mentioned above.

It is well known, that in Russia (as well as in some other nuclear countries), plutonium is considered as a valuable energy source which should be used, because in future it can become fuel of vital importance. The development of approaches to the use of this source is tightly connected with the progress in understanding of the role of plutonium in the nuclear power sector of Russia.

The key problem for all countries, considering recycling of plutonium, is the optimization of this process for the nearest term, middle-term and long-term future. From the very beginning of Russian nuclear power development, the choice of fuel cycle was based on the purpose to use natural resources in the most effective way. This is the reason why a closed fuel cycle option was accepted, and it resulted in a strategy of plutonium and radwaste treatment.

## STRUCTURE OF THE NUCLEAR POWER SECTOR

For the long-term future, the optimal utilization of plutonium will have many common features in Russia and other countries. For the nearest- and average-term future, the rational plans of plutonium utilization in Russia can significantly differ from similar plans of other countries [1]. But no doubt that the plutonium treatment option that we choose for middle-term future should become a good basis for the development of optimal fuel cycle in the far-term future.

The long-term nuclear power development program of the Soviet Union adopted in 1970s, provided for its large-scale and intensive development with the two-component power structure: at the initial stage - nuclear power plants (NPP) with thermal reactors to produce energy and accumulate plutonium for supplying fuel for NPPs with fast reactors at the first stage of their development. At a later phase of nuclear power development, NPPs with fast reactors should become a component of the future large-scale nuclear power, ensuring total neutron balance. Initially, the whole nuclear fuel cycle (NFC) was planned for such a two-component structure, that fuel would be supplied with the help of fast breeder reactors and by closing the fuel cycle with respect to uranium and plutonium. So, from the very beginning creation of a closed NFC was planned in the Soviet Union.

Nowadays, it is a common understanding that for the large-scale and long-range implementation of nuclear power (NP), nuclear power should be harmoniously included into the general energy system which is a natural part of the Earth infrastructure. Therefore, nuclear power system should satisfy at least the following requirements: cost effectiveness, sufficiency of resources, safety, acceptable environmental impact, and nonproliferation.

Two first requirements can be well met by using a two-component NP system involving thermal and fast solid fuel reactors. This NP structure would permit the natural resources (uranium and/or thorium) to be much more effectively used, uranium production to be reduced, and, hence, the radon penetration into the biosphere would be sufficiently lower.

The plutonium utilization options are considered now in RRC KI with account for the following facts:

- increase in plutonium stacks due to delay with construction of fast reactors and nuclear weapons reduction;
- positive experience gained outside of Russia in plutonium utilization in thermal reactors;
- significant reduction of available (developed) uranium deposits after disintegration of the USSR and increase in the uranium cost;
- growing concern of the society about long-lived toxic radwastes;
- significant uncertainty in the rate of the future nuclear power development.

In RRC KI a lot of efforts were made to elaborate methods for reaching the required breeding level, enhancing the safety of nuclear power units, and reducing the capital investments. They are currently known, and what is needed is time and funds for their realization.

Difficulties may be encountered with the public attitude to the level of environmental impact, which will be primarily determined by the quantities of radionuclides, both in the fuel cycle (uranium, plutonium) and in the radwaste disposals (minor actinides, fission products), and of those globally dispersed (carbon-14, tritium, krypton-85); and with the public attitude to the problem of nonproliferation of nuclear materials, which will be in the main determined by the availability of pure Pu in fuel cycle.

A number of approaches in treatment of the long-lived radwastes are considered now. In RRC KI, along with other studies, the nuclear-chemical concept of minimization of long-lived radwastes is now elaborated. This issue is closely related to the use of plutonium as a source of neutrons and energy required for their minimization.

For such a concept, the multi-component system was proposed (Fig 1.) [2], in which we consider processes concerned with the final use of recycled fuels, such as fluorides, in molten salt reactors (MSR):

- discharged fuel goes through dry gas-fluoride processing;
- after isotope correction uranium is recycled as a fuel in thermal and fast solid-fuel reactors;
- a fraction of plutonium, together with all minor actinides and some fission products (FP), is incinerated in a molten salt 'burner' reactor (MS-BR); stable and short-lived FP are removed from the burner reactor by the separation systems of the reactor itself (these problems can be solved by chemical and physical methods);
- the major part of plutonium is intended for thermal and fast solid-fuel reactors;
- stable and short-lived FP are directed to an interim storage facility from which (unless they can be useful in medical or industrial applications) they are sent to final disposal.

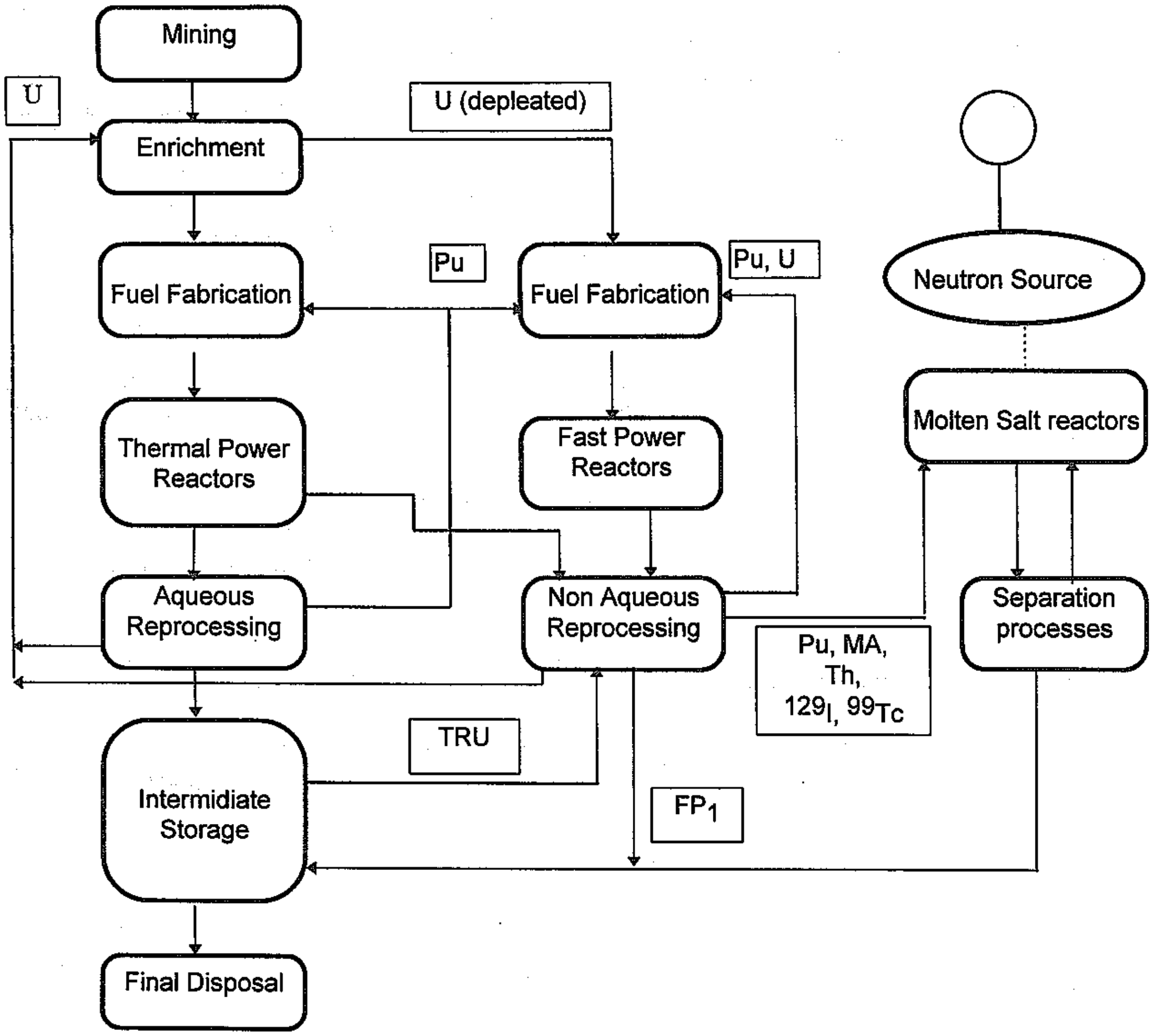


Fig.1. Multi-component nuclear energy system with closed fuel cycle for all actinides including Pu, and dangerous long-lived fission products ($FP_1$ - short-lived FP).

As far as the weapons-grade plutonium concerned, now in RRC KI the following principle is supported. When and if new advanced-reactor systems are constructed, on their merits as energy options it may prove desirable to employ them in the disposition of any surplus military plutonium that remains at the time, or in further reducing the risks from spent fuel or other waste forms containing both civilian and previously dispositioned military plutonium. But disposition, to the spent fuel standard, of the surplus military plutonium that exists today should proceed in the meantime, using the existing reactor technologies that can most quickly, safely, and inexpensively be adapted to this task.

## UTILIZATION OF PLUTONIUM IN REACTORS

This chapter briefly presents some reactor concepts, both supposing Pu usage and supplementing the nuclide balance in the whole structure of nuclear power sector. These concepts have been developed by RRC KI working closely in collaboration with other scientific and industrial organizations in Russia and abroad.

As can be seen from the evolution of the basic ideas of these reactor concepts, they were always aimed at the solution of the problem to use natural resources in the most effective for current situation way.

**Fast neutron reactors**

The criteria for choosing optimum fast reactor type cooled by have undergone essential evolution during NP development. At the earlier stages of NP development, the key point was to obtain the maximum breeding ratio, i.e. minimum fuel doubling time in the closed fuel cycle. This approach arisen due to high rates of NP growth expected in those times, which could lead to exhausting of cheap uranium ores.

Because of higher capital costs compared to LWR, the majority of liquid metal cooled fast breeder reactors fueled by plutonium (LMFBR) projects developed in RRC KI and other institutions (OKBM) was designed to have high unit power, 1000 MWe or more, and high breeding ratio (about 1.5-1.6). For the solution of fuel supply problems, in RRC KI also helium-cooled fast breeder reactors with doubling time from 3 to 5 years were considered.

As the rates of NP growth turned out to be not so high, by the mid-1980s the criteria for fast reactors began to be reevaluated. Breeding, safety and efficiency criteria got almost the same importance in expert analysis.

Alkaline metals (Na-K, then Na) were selected as a coolant for fast reactors 40 years ago and now its technology is well developed. Such characteristics as low price and compatibility with steel, real capabilities to reach high power density of fuel, decrease of loading and time of Pu doubling were very attractive for problems actual in that time. In current conditions, decrease of Pu loading and short times of its doubling are not still actual. On the other hand, the chemical activity of Na, moderate temperature margin up to boiling, fire danger and rather high activity hinder a full realization of fast reactor possibilities and reaching by them of the best safety and profitability levels.

By 1982, as a first step, in the RRC KI a concept for the core of a fast sodium-cooled reactor with shroudless fuel assemblies, low hydraulic resistance (<1bar), lower coolant heating-up, heterogeneous U-Pu core composition ensuring core breeding ratio 1.0, both in medium and large power output option, was developed. Its neutron economy and safety features are better than conventional sodium-cooled fast reactors.

The negative properties of Na coolant stimulate search for new coolant compositions for fast reactors to implement their positive qualities to a greater extent. It is obviously impossible to speak about inherent reactor safety without refusal from alkaline coolant. Liquid lead and its eutectics Pb-Bi, Pb-Mg, Pb-Li (possessing their advantages and shortages in comparison with Pb) are preferable by nuclear, thermal-physical, chemical and cost properties among liquid metals.

A lead-cooled fast reactor was proposed [3] by RRC KI (with EDO "Gidropress", IPPE, RDIPE) in the mid-1980s, in which all internal dangerous sources are excluded. Concept of fast reactor with lead-based coolant with implementation of design upgrading measures allows to create a facility with such inherent safety features as negative void reactivity coefficient and almost zero reactivity change during fuel burnup in regimes providing the equilibrium nuclide fuel composition.

**High-temperature gas-cooled reactors**

The high-temperature gas-cooled reactor (GT-MHR) concept [4] is a joint Russian-U.S.-French-Japanese development of all experience gained while designing graphite reactors, cooled by high-temperature gas.

The concept is based on the use of the core with graphite moderator and helium coolant as well as of the fuel in the form of microspheres with pyrocarbon and silicon carbide coatings. The GT-MHR consists of a reactor enclosed into a steel high pressure vessel incorporated with the power conversion system using gas turbine cycle. The GT-MHR is characterized by enhanced safety and high efficiency (up to 50%) which could make it economically more advantageous comparing with other reactor types.

In reactors of this type weapons-grade plutonium is used in the form of undiluted plutonium dioxide. The use of microspheres allows the high burnup of Pu : up to 90% of the initial $^{239}Pu$ charge, to be reached in a once-through cycle. Plutonium contained in the spent fuel is of no interest for weapons production. The ceramic structure of the spent fuel and the multilayer coating properties make possible its long-term disposal in geological formations without reprocessing.

As a new advanced-reactor system, a variant of GT-MHR with low enriched uranium-loaded core is now evaluated, to estimate its merits as energy option for certain energy market domains.

**Molten salt burners**

In Russia, a systematic research program on the MSR problem was launched at RRC KI in 1971. Today in RRC KI, a feasibility study on new fuel cycle development based on molten salt technology is carried out, and it is supported by MINATOM institutions (VNIITF, EDO "GP", IPPE), Ministry of Science and Academy of Science, and within international cooperation (Chech Republic, Japan).

The advantages of the MSR as a burner reactor [5] follow not only from its potential combination with the gas-fluoride technique of fuel reprocessing, which is low-cost and produces a small quantity of waste, but also from its capability to use fuel of any nuclide composition. The MSRs have the flexibility to utilize any fissile fuel in continuous operation with no special modification of the core, as demonstrated during MSR operation for $^{233}U$, $^{235}U$ and Pu. The MS-BRs require a minimum of special fuel preparation and can tolerate denaturing and dilution of the fuel. Moreover, the systems of this reactor could be simultaneously used as the components of the external fuel cycle.

Now the future fuel cycle of the MSR burner should be aimed at solving the following tasks:

- introduction of highly radioactive fissile materials (Pu, Np, Am, Cm) as well as some fission products into the fuel cycle;
- minimizing the amount of radwaste generated by fuel cycle as a whole and on individual stages;
- reprocessing of fuel and its recycling in nuclear power installations must be realized with as few operations as possible and a minimum loss of radionuclides to be incinerated outside the protective barriers of the closed fuel cycle;
- introduction of thorium into the MSR fuel cycle in small amount to increase plutonium content in molten salts in near-term applications and on a large scale for creation of a uranium-thorium fuel cycle for long-term applications.

**Innovative LWR-type reactors**

When the fuel supply of the expected high rate of NP growth was considered as the main problem (before 1986), the main directions in the development of light-water reactors, in particular, of VVER type, were concentrated on the improvement of their fuel consumption features by spectrum shift for the increase of conversion ratio from 0.55 to about 0.7-0.75.

Among them are concepts of high conversion LWR (HCLWR) with moderator-to-fuel ratio about 1.0 (tight lattices), and another one is spectrum shift by the use of supercritical water as a coolant (with EDO "GP"). The latter concept permits to obtain the mean fuel cycle hydrogen-to-fuel atom ratio similar to the value of VVER at EOC [6].

One of the ultimate examples of such an approach is Steam-Water Power Reactor (SWPR) concept suggested by RRC KI with EDO "GP" and VNIIAM [7]. The origin this concept is an attempt to combine the advantages of low-level capital costs due to succession of light water reactor technology with acceptable level of fuel breeding inherent for fast reactors. The idea of this concept is the cooling of fast reactor by steam mixture. Such cooling mode allows to provide low cladding temperatures, and, hence, the possibility to use steel as a structure material. Average core parameters like coolant density and operating pressure for different SWPR designs can vary in relatively wide ranges. Key points are the almost constant coolant temperature in the core and high thermal capacity of the core due to phase transition.

As the SWPR neutron spectrum in normal operation is essentially fast, the qualification of design and operation of LMFBR's fuel elements can be applied. The fast neutron spectrum provides breeding ratio of about 1.0 and advantages in safety compared to LWRs.

Judging SWPR, as an advanced reactor concept, by the criteria of safety, economy, ecology and fuel consumption, one can summarize that

* SWPR is quite competitive in safety with traditional LMFBRs and LWRs;
* SWPR is the same as PWR from the economical point of view, being much better than LMFBR;
* SWPR is capable to incinerate long-lived radwastes and transmute TRU with the rate typical for any fast reactor, and much better than any thermal reactor.

**Utilization of plutonium in operating VVER-1000 reactors - a realistic near-term option**

The calculational studies of the possibility to use plutonium in VVER-1000 reactors have been carried out in RRC KI for several years. In the moment, under consideration is the simplest way of involving Pu in the VVER-1000 fuel cycle - the direct substitution of a part of uranium fuel by MOX fuel without essential changes in the core design [4]. It was found, that physical peculiarities of a core with MOX fuel (reduction of the effective fraction of delayed neutrons, of the efficiency of absorbers, etc.) pose restriction on the number of MOX fuel assemblies in the VVER-1000 of existing design. Therefore, the fraction of about 1/3 is usually considered.

Nowadays, in Russia the intensive studies are carried out for the modernization of the VVER-1000 fuel cycles, which main features are the following [8]:

- use of the improved fuel assembly with zirconium spacer grids and guiding tubes;
- use of uranium-gadolinium fuel as a burnable absorber;
- core loading patterns with reduced neutron leakage.

Comparisons of the currently used design three-year fuel cycle with the modernized one showed the significant advantages of the latter in a number of important parameters. In particular, the control & protection system (CPS) efficiency is increased by about 25%. By 2000, the transition to the new VVER-1000 fuel cycles should be completed, and this fact is now taken into account in RRC KI while analyzing the parameters of VVER-1000 with MOX fuel.

In 1997, the comprehensive program aimed at the licensing and operation of the VVER-1000 with partial (1/3) core loading with MOX fuel made of weapon-grade plutonium was elaborated under the scientific leadership of RRC KI. This program suggests the participation of all responsible scientific and industrial institutions in Russia, and now approved by MINATOM of Russia.

The main directions of the work and, therefore, the main its results should be the following:

- qualification of the MOX fuel use in VVER-1000 reactors;
- development and fabrication of MOX fuel, fuel rods and assemblies for VVER-1000 reactors, and their licensing;
- development of facilities for fabrication of MOX fuel, fuel rods and assemblies for VVER-1000 reactors;
- qualification and pilot operation of the lead test assemblies in a VVER-1000 reactor;
- licensing of NPP units with VVER-1000 for the use of 1/3 MOX fuel assemblies;
- pilot operation of serial MOX fuel assemblies in VVER-1000 reactors.

Along with traditional pellet technology for fuel rod manufacturing, developed by VNIINM, also the vibropacked technology for VVER-1000 MOX fuel is considered.

## CONCLUSIONS

- There is a possibility to update the NP fuel cycle, which enables the NP safety, ecology, cost effectiveness and sufficient resources supply and nonproliferation to be ensured for the long term. A multi-component fuel cycle system can be incorporated into the nuclear power infrastructure.

  In such a multi-component system, plutonium is considered as a valuable neutron source for utilization of minor actinides and for incineration of dangerous long-life fission products. Weapons-grade Pu could be converted into a non weapons-grade form without degradation of its potential properties as a nuclear fuel, allowing delayed utilization without reduction of the economic efficiency of the nuclear energy system.

- The nuclear power sector of Russia apparently will not change until 2010, except for finishing of the construction and commissioning of several units. It is doubtful, that by this time MOX fuel can become competitive with the usual uranium one. But further delays in the beginning of works to include plutonium in the NP fuel cycle could lead to necessity to use expensive natural uranium, and, therefore, to increase in NP energy cost for the next 20-30 years.

  In the next ten-year period it is necessary to carry out all R&D works on qualification of all components of the 21st century nuclear power infrastructure. Inclusion of excess weapon-grade fission materials into the fuel cycle of nuclear power could permit to considerably reduce terms and investments required for the creation of the efficient structure, ensuring the possibility for the nuclear power sector to reach its goals in energy supply.

- Utilization of W-Pu plutonium in VVER-1000 reactors is a realistic near-term option which should be undertaken in collaboration with other countries, in particular, in the creation of the "International Data Base For Licensing of MOX Fuel in VVER-1000s".

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**Peaceful Use of Plutonium Also Necessary in Preventing Global Warming**

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Abstract

For Japan's energy security and for observing the Treaty for the Prevention of Global Warming, expansion of the peaceful use of nuclear energy, mainly used for electric power generation, is essential. However, there is a limit to uranium resources, which will inevitably be exhausted in the near future. Uranium prices will soar in such a situation, and worse yet, obtaining uranium will be difficult. In order to avoid this kind of situation, the best solution would be to use plutonium extracted by reprocessing spent nuclear fuel.

A Prime Minister of Japan once remarked that "Japan has the capability for nuclear development (in terms of developing nuclear weapons) but has no intention of doing so," this sparked controversy at the time. Although many politicians and journalists, including myself, interpreted this remark as stating, in an easy-to-understand way, "The Three Non-Nuclear Principles," which constitute Japan's national policy. Some people were ready to jump at and criticize such comments and people in neighboring countries were made wary of Japan, taking issue with the Prime Minister's remark by saying that "One may change intentions anytime."

It is true that in neighboring South Korea, reprocessing of spent nuclear fuel from nuclear plants is prohibited because of an agreement with the U.S., and there is a mounting sense of distrust about why Japan is permitted to reprocess spent nuclear fuel. My own experiences during informal talks with South Koreans involved with electric utilities and scientific journalists has given me the impression that they all believe, in earnest, that "Japan will someday arm itself with nuclear weapons."

Although it is very difficult to dispel such suspicions and concerns, Japanese people will have to steadfastly explain, in order to gain the understanding of these people, the following message: being the only country in the world that suffered from atomic bombs, and having learned a valuable lesson by seeing the actual example of how nearby North Korea attempted nuclear development and has had to face severe response from the international community as a result, and as a country which subsists on international trade for survival, Japan will never plan nuclear weapons development, and this is guaranteed by the existence of the Atomic Energy Basic Law.

Of the carbon dioxide ($CO_2$), which accounts for much of the greenhouse gases emitted in Japan, 29% comes from thermal power plants. This means that switching from thermal to nuclear power generation will contribute considerably to the prevention of global warming. In preparation for the Kyoto Convention for the Prevention of Global Warming held in late 1997, the Japanese Government calculated that it would be necessary to construct 20 more nuclear power plants in order to reduce $CO_2$ emissions by 2.5%, compared with the 1990 level. However, it was decided at the Convention that Japan's reduction target should instead be 6%, far exceeding the projected 2.5% figure. Because there has been a 10% increase in $CO_2$ emissions in Japan since 1990, a reduction of 16% in $CO_2$ emissions by 2010 will actually be necessary in order to meet the target. Even when taking into account such factors as solar power, wind power and other energy saving efforts, this would entail switching from thermal to nuclear power generation by building more than 40 new nuclear power plants, according to simple arithmetic.

Assuming for now that the difficulty of securing locations for nuclear plant construction is solved (which is quite unlikely), there is the fact that natural uranium resources are finite, just like oil and natural gas. When exhaustion becomes more imminent, Japan, which already imports 14-15% of the global production of uranium at present, will probably come under intense pressure from the international community. We would be lucky if prices just skyrocket; obtaining uranium in the first place will inevitably be very difficult. This will be a matter of life or death for Japan, an industrial nation that imports raw materials, processes them using electricity and exports manufactured products. Making good the promise Japan made to the world at the Kyoto Convention for the Prevention of Global Warming will also be impossible, which will seriously damage Japan's reputation in the international community.

The only way for avoiding such a scenario is to use the plutonium that is already stored in nuclear plants and then extracting the plutonium by reprocessing spent nuclear fuel, which continues to accumulate at nuclear plants. There are organizations in Japan opposed to plutonium which try to incite anti-plutonium sentiments by taking advantage of the mentality of the general public, for whom nuclear weapons are called to mind at the mention of plutonium. It is, however, only natural for Japan, which depends on imports for more than 80% of its primary energy, to utilize the plutonium which is regarded as an energy source obtained by quasi-domestic production, especially in this age of recycling.

Although an ideal solution would be to realize the fast breeder, which achieves 60 times as much utilization efficiency as a light water reactor that uses enriched uranium as fuel, the troubles at France's Superphenix and Japan's Monju prototype reactor have resulted in making the prospect of realizing fast breeders more remote than before. In the meanwhile, more and more spent nuclear fuel from light water reactors is accumulating. Japan also has the obligation of receiving from France extracted plutonium which was commissioned for reprocessing. A likely outcome would be that a large increase in the plutonium amount stored in Japan, which various countries of the world are so wary of, will become a reality; such a scenario will have to be avoided by all means.

The second best option, although not as high in utilization efficiency as fast breeders, may be in using mixed-oxide fuel (MOX), a mixture of uranium and plutonium, is burned in light water reactors, which is sometimes called as "the Pu-thermal technology." The advantages of adopting this plan are as follows: the amount of final high-level radioactive waste disposal will be very small, although such disposal will be necessary, regardless of which method is used; it would be possible to use current light water reactors for this plan with only simple modifications; and importantly, conserving uranium resources will be possible with the implementation of this plan.

Along with speeding up the development of the fast breeder reactor, the application of "the Pu-thermal technology" into actual use should be implemented as soon as possible, as these endeavors would make up a nuclear fuel cycle policy significant to Japan, both from the viewpoint of preventing global warming and of conserving finite resources. Regarding the fast breeder in particular, some people tend to ask the question, "Why does Japan carry on the development of the fast breeder while other countries have given up the effort?" We should try to gain the understanding of such people by actively sending a clear message to the world that Japan, with its advantages in development technology and cost, will try to play a pioneering role and make contributions by sharing the results of its research and development efforts and relevant information with the rest of the world as a common intellectual and technological property.

It is an undeniable fact that dispelling the doubts and concerns of various countries of the world about plutonium is a difficult task. It is desirable for Japan to constantly make public the current storage amount of plutonium and to come up with measures to move in the direction of international plutonium management in the near future.

If I may add a little more regarding the development of the fast breeder, the responsibility for which will be moved from PNC to a new organization to be established, I think it will be necessary to promote substantial participation of researchers from developed countries which should improve other countries' sense of trust in this research. We have already had the experience of many foreign researchers participating at nuclear fusion research facilities in the Tsukuba Research and Education City, and the transparency of information concerning plutonium research may be raised thanks to the word-of-mouth communication of these foreign researchers. Participating in this research in Japan, which regards fast breeder development as an important part of the peaceful use of nuclear energy that is Japan's national policy, while many countries have taken a step backward in fast breeder development would provide a unique opportunity to conduct extensive research with foreign researchers hoping to take part in the effort.

第3回核不拡散国際フォーラム・セッション1「プルトニウムの平和利用について」

地球温暖化防止の見地からも必要なプルトニウム平和利用

産経新聞論説委員長代行　　飯　田　浩　史

わが国のエネルギー安全保障及び地球温暖化防止条約履行のためには原子力平和利用（主として発電）の拡充は不可欠である。しかしウラン資源も無尽蔵ではなく、近い将来枯渇することは必定である。そういう事態になれば価格も暴騰し、というよりも入手自体困難になる。このような事態を避けるためには使用済み核燃料を再処理して取り出したプルトニウム利用は最善の策である。

・かつてわが国の総理大臣が「核開発（武器としての）能力はあるが、その意図はない」と発言し物議をかもしたことがある。政治家や私たちジャーナリズムは発言の趣旨は国是である「非核3原則」のことを分かりやすく表現したものと理解したが一部ためにする人たちや日本に警戒心をもつ周辺諸国の人たちは「意図はいつでもを変えられる」と首相の問題発言としてとらえた。

確かに隣国の韓国では、対米協定で原発の使用済み核燃料の再処理もできないことになっており、なぜ日本は許されているのかに不信をつのらせている。私自身の経験でも、韓国の発電事業者、科学ジャーナリストと懇談した際、異口同音に「日本はいずれ核武装するだろう」と本気で思っていることを実感させられた。

・こうした疑惑を払拭するのは極めて難しいことだが、世界で唯一の被爆国であるという地位、それに反面教師として近くに北朝鮮という国があり、核開発を目論んだあげく国際社会でどういう厳しい評価目にあっているかを実際にみれば、貿易で成り立っているわが国がどう転んでも核開発を目論むことはありえない、その担保として原子力基本法があるということを根気よく説明し理解を得るしかない。

・わが国で排出される地球温暖化ガス（温室効果ガス）の主力である二酸化炭素（ＣＯ２）のうち２９％は火力発電所からのものである。いいかえれば火力発電から原子力発電に転換すればかなり地球温暖化防止に貢献することになる。昨年暮れの温暖化防止京都会議に臨むにあたって政府はＣＯ２排出量を１９９０年レベルから２．５％削減するには原子力発電を２０基増設しなくてはならない、と試算した。しかし会議の結果わが国は削減目標は２．５％から大幅に上乗せした６％に決まった。１９９０年から現在までにＣＯ２排出量は１０％増加しており、目標通り達成するには２０１０年までに差し引き１６％ものＣＯ２を削減しなくてはならない。そうだとすれば火力から原子力発電への転換はソーラーや風力利用、省エネ努力なども考慮した上でも単純計算で４０基以上になる。

・ところが仮に立地難が解消しても（そういうことはありえないが）全量を輸入している天然ウランも石油や天然ガス同様有限の資源である。枯渇が目に見えてくれば現在でも世界の生産量の１４～１５％を輸入しているわが国に対する風当たりは強まるだろう。価格の暴騰ですめばよいが入手自体が困難になることは必定だ。原料を輸入、電気を動力として加工、製品を海外に輸出する工業国のわが国にとって死活問題になる。地球温暖化防止会議で世界に約束した公約もとうてい果たせなくなる。ひいては国際社会でのわが国の信用は失墜する。

・こうした状況から抜け出す唯一の手段がすでに保管されている、またこれからも溜まる一方の原発からの使用済み核燃料の再処理によって取り出したプルトニウム利用である。日本の国内でもプルトニウムといえば核兵器を想起する一般国民の心理を利用して煽る、反プルトニウム団体があるが、一次エネルギーの８０％以上を海外からの輸入に頼っているわが国が準国産エネルギーとして位置付けているプルトニウムを利用することはリサイクル時代として当然のことである。

・理想としては濃縮ウランを燃料とする軽水炉の６０倍もの利用効率がある高速増殖炉を実用化することだが、フランスのスーパーフェニックスに続いてわが国でもトラブルが起きた原型炉「もんじゅ」の影響で実用化は遠のいている。

この間にも軽水炉から排出された使用済み核燃料が蓄積され続けている。さらにフランスに再処理を委託して取り出されたプルトニウムも引き取ってこなければならない。結果として世界各国が警戒するわが国のプルトニウム蓄積量の増大がいやでも現実化する。このような事態はどうしても避けなければならない。

・次善の策として高速増殖炉ほど利用効率はよくないが、ウランとてプルトニウムの酸化混合燃料ＭＯＸを軽水炉で燃やすプルサーマルの利用が考えられる。この計画の利点はいずれはしなくてはならない最終的な高レベル放射性廃棄物の処分量が極めて少なくなること、現在の軽水炉を簡単な改修で使えること、それに大事なことはウラン資源の節約につながることである。

・地球温暖化防止の観点からも有限資源節約の観点からもわが国にとっては重要な核燃料サイクル政策であり、高速増殖炉の開発を急ぐとともに、プルサーマルの実用化も早急に実施に移さねばならない。特に高速増殖炉については「各国が開発を断念しているのになぜ日本が」との疑問を呈する人がいるが、開発技術、経費などで優れている日本が先鞭をつけ、その果実を世界的な知的技術的共有物として情報を公開、貢献するべきであることを世界に発信することで理解を得るようにしたい。

・とはいってもプルトニウムに対する世界各国の疑念は簡単には晴らすことが困難である。わが国としては常時プルトニウムの現在保有量を公開するとともに、将来は国際管理の方向へ進むような手だてを講じることが望ましい。

・さらに付け加えれば、高速増殖炉の開発は今後動燃の手を離れて新しく設ける組織によって進められるが日本国内だけでなく、海外の信用を高めるためには思い切った先進諸国の研究者を参加させることも必要だと思う。筑波研究学園都市ではすでに核融合研究施設で大勢の外国人研究者が参加している実績もあり、これら外国人研究者の口を通してプルトニウム研究の透明性を増すこともできる。高速増殖炉開発から一歩後退した国が多い中で国策としての原子力平和利用の主要な一端と位置付けている日本での研究開発は、参加を希望する研究者にとってはまたとない研究の場となるはずである。

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# Plutonium Utilization in Japan

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(Abstract)

Japan's nuclear policy is to reprocess spent fuel and recycle recovered plutonium and uranium. Fast Breeder Reactor (FBR) can utilize uranium with remarkable efficiency, so its commercialization is regarded as essential. However, considering of the present energy supply and demand situation, FBR development is expected to be delayed.

While under contracts with BNFL and COGEMA, we own about 10.5 tPu(f) overseas as of the end of March, 1997. It is necessary to steadily utilize recovered plutonium to avoid worldwide concerns, based on the principle that Japan should never own surplus plutonium.

At present, the utilization of MOX fuel in light water reactors (LWRs) is the most feasible method and will become primary means of plutonium utilization for the coming several decades. In Japan it is scheduled to start in 2 nuclear units from 1999. To start the utilization of MOX fuel in LWRs, it is important to obtain the understanding of the residents around the nuclear sites, and a nationwide consensus by assuring the transparency of plutonium utilization, showing necessity and safety .

## 1. Necessity of Nuclear Power

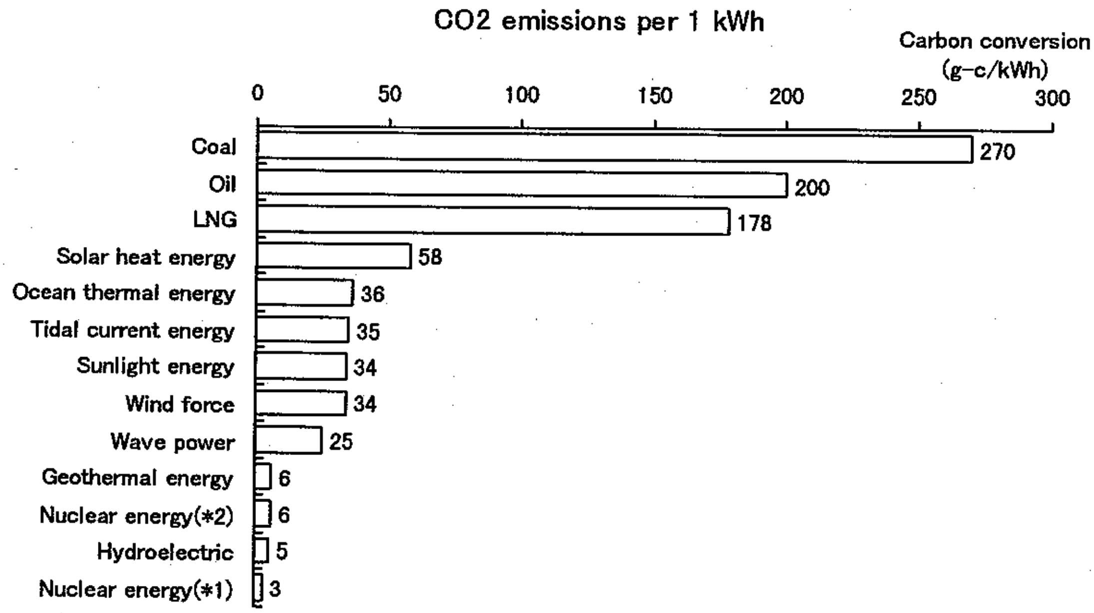
Japan has scarce natural energy resources and we depend on foreign resources for 80% of our primary energy supply. After experiencing two oil crises, the concept of energy efficiency has gained popularity in Japan. We have also tried hard to develop oil-alternative energy. Even so, the oil-dependent energy production of Japan remains as high as 56 % (in 1995), and 99.7 % of the oil is imported, which makes Japan's energy supply structure extremely fragile in comparison to other industrialized countries.

In the meantime, although energy efficiency is promoted, the energy demand in Japan is expected to continue to increase in the future , as the Japanese life style continues to become richer, more comfortable, and in general more information-oriented.

Under these circumstances, it is necessary for us to diversify our energy resources in order to ensure our future energy security. That is why Japan has promoted the utilization of nuclear power.

Currently, global environmental issues are of great international concern. Last December, the Third Session of the Conference of the Parties for the Framework Convention on Climate Change (COP 3) was held in Kyoto, to have worldwide discussions of these issues. In the conference, the targets for greenhouse-gas reductions of the industrialized countries were decided and agreed upon by the member countries. Japan's target is to reduce its emission of greenhouse gases to 6 % below 1990 levels by sometime between 2008 and 2012. Japan's reduction program was using the estimation that 20 more nuclear power plants of 1,000 MW each would be constructed by 2010. Therefore, nuclear power is expected to become one of the ideal means of relieving the negative impact on the environment. The amount of CO2 released by nuclear power is significantly less than other types of power generation, even considering all the processes involved, ranging from fuel mining to plant construction and operation. Consequently, there is every reason to believe that nuclear power can be the "ace" of all the power generation methods in terms of preventing global warming.

(Fig. 1) CO2 emissions according to Power Source




Note: CO2 emissions levels include emissions from material mining, construction, transportation, purification, operation(actual power generation), maintenance and all other processes

Nuclear energy(*1): centrifuge separation method, plutonium-recycle

Nuclear energy(*2): gaseous diffusion method, closed-cycle

Source: CENTRAL RESEARCH INSTITUTE OF ELECTRIC POWER INDUSTRY

2. Necessity of Nuclear Fuel Cycle

Japan's nuclear policy is to regard spent fuel as a valuable quasi-domestic energy resource, reprocess it domestically, and recycle recovered plutonium and uranium as nuclear fuel.
To establish the above system, Japan's first commercial reprocessing plant is now being constructed by Japan Nuclear Fuel Ltd., in Rokkasho-mura, Aomori prefecture. It is scheduled to start operation in 2003.

From the viewpoint of ensuring energy security, effective utilization of uranium resources, and waste reduction, establishment of the nuclear fuel cycle is important.
The 20th century civilization has been based on mass production, mass consumption and mass disposal. However, in the coming 21st century, we should aim to create a "recycling-oriented" civilization which utilizes natural resources effectively, minimizing waste generation as much as possible. In the field of nuclear power, it has become necessary to recycle plutonium and uranium, reduce radioactive waste to the minimum level. This concept follows naturally from the idea of a "recycling-oriented economy society", where resources are effectively used and waste generation is minimized. Typical examples of such a society is one which makes use of power generated by refuse incineration, and which uses recycled paper.
In January, 1997, the Atomic Energy Commission of Japan reaffirmed that it is essential to smoothly develop the nuclear fuel cycle, for the stable development of nuclear power in the long term, and suggested some measures which include plutonium utilization in LWRs. In February, 1997, those measures were approved by the cabinet and confirmed as the government's policy.

3. Plutonium Utilization

(1) Reprocessing of spent fuel
Since 1970, most spent fuel has been reprocessed at overseas reprocessing plants according to the contracts with BNFL and COGEMA. As a result, we own about 10.5 tPu(f) overseas as of the end of March, 1997. The amount of plutonium recovered from the overseas reprocessing contracts will become about 30 tPu(f) by around the year 2010. Fundamentally, the recovered plutonium is to be fabricated into MOX fuel overseas, and then shipped back to Japan to load in LWRs. It is highly important to use the recovered plutonium at a steady pace, so as to avoid worldwide concerns, based on the principle that Japan should never own surplus plutonium.

(Fig. 2) Present condition of Japan's plutonium stockpile (as of the end of March, 1997)

| | | |
|---|---|---|
| Recovered plutonium | Overseas reprocessing (BNFL, COGEMA) | 12.4 tPuf |
| | Domestic reprocessing (PNC) | 4.3 tPuf |
| | Total | 16.7 tPuf |
| Amount of plutonium to be used in FBR & ATR in Japan | | 5.1 tPuf |
| Stockpile of Plutonium | Overseas reprocessing (BNFL, COGEMA) | 10.5 tPuf |
| | Domestic reprocessing (PNC) | 1.1 t Puf |
| | Total | 11.6 tPuf |

(2) Plutonium utilization in Fast Breeder Reactor (FBR)

FBR system can remarkably upgrade the efficient use of our uranium resources. Therefore, it is one of the most promising non-fossil energy options for the future, and thus, it is necessary to develop FBR commercialization program.

However, to establish FBR commercialization emphasizing safety, we have to consider that FBR system should be economically competitive in comparison to other types of energy resources. Taking into account the present situation of the uranium market, the stability of the oil market, and also the current status of the research and development of FBR technology, it will take longer than originally expected to actually commercialize FBR.

(3) Plutonium utilization in LWRs (utilization of MOX fuel)

In Japan, since the Long-Term Program for Research, Development and Utilization of Nuclear Energy in the 1960's, the utilization of MOX fuel in LWRs has been consistently planned to be carried out as one of the plutonium utilization methods. In the 1982 version of the Long-Term Program, the small scale demonstration program of MOX fuel in LWRs was suggested. Based on that suggestion, the Kansai Electric and Japan Atomic Power performed it as well as the post-irradiation examination.

The utilization of MOX fuel in LWRs is the most feasible method of utilizing plutonium. This can be seen from the experiences in France and other European countries, and in Japan's Advanced Thermal Reactor (ATR) called "Fugen", and also from the results of the small scale demonstration. We believe that the utilization of MOX fuel in LWRs will become primary means of plutonium utilization in the coming several decades, judging from the present energy supply and demand balance, and the delayed progress of FBR commercialization.

In addition, the amount of plutonium recovered from the overseas reprocessing contracts will keep on increasing. Therefore, it is necessary for us to immediately start the utilization MOX fuel in LWRs, so as not to appear suspicions in the eyes of the international community with regards to nuclear proliferation.

Based on this information, we have announced the MOX utilization program as a common theme. In Japan, it is scheduled that 2 units will start using MOX fuel in 1999, expanding the use of MOX fuel LWRs for 16 to 18 by around 2010.

(Fig. 3) Japan's program of MOX fuel utilization in LWR

| | By 2000 | Beginning of the 2000's | By 2010 | Total number of units |
|---|---|---|---|---|
| Tokyo Electric | 1999 1 unit<br>2000 1 unit | 1 unit | 0 - 1 unit | 3 -4 units |
| Kansai Electric | 1999 1 unit<br>2000 1 unit | | 1 - 2 units | 3 - 4 units |
| Chubu Electric | | 1 unit | | 1 unit |
| Kyushu Electric | | 1 unit | | 1 unit |
| JAPCO | | 2 units | | 2 units |
| 5 other utilities | | | 1 unit per utility | 5 units |
| EPDC | | | 1 unit | 1 unit |
| Total | 4 units | 5 units | 7 - 9 units | 16-18 units |

4. Assuring the Transparency of Plutonium Utilization

In the process of promoting plutonium utilization in Japan, it is necessary to pay great attention to preventing worldwide concerns about the nuclear proliferation. Japan's development and utilization of nuclear power has always been strictly limited to peaceful purposes from the very beginning of its introduction to nuclear power, conforming with the Atomic Energy Fundamental Act of Japan. We have also signed the IAEA Safeguard Agreement, and have accepted the IAEA's full-scope safeguards relating to all types of nuclear materials.

Moreover, we have been trying our best to assure transparency in plutonium utilization by voluntarily disclosing our plutonium demand and supply perspectives, as well as data about our plutonium inventory, in accordance with the principle that Japan should never own surplus plutonium.

I believe it is necessary to make further efforts to assure the transparency of our plutonium utilization, and thus to obtain both domestic and international understanding and trust for the future. To achieve this goal, we intend to strictly observe the Nuclear Non-Proliferation Treaty and the Convention on the Physical Protection of Nuclear Material, to accept IAEA program 93+2, and to continue our effort to disclose information about our plutonium inventory.

5. Conclusion

Unfortunately, anxiety and distrust of nuclear power are increasing among the general public in Japan. To counteract this, Japanese utilities must keep on giving safety their highest priority, and try to disclose information to the public. We intend to spare no effort to obtain the understanding of the necessity and the safety of MOX fuel utilization from the residents around the nuclear sites as well as the general public, so as to be able to carry out the MOX fuel program in a steady and successful manner.

核不拡散国際フォーラム
１９９８．２．２３－２５

# 日本のプルトニウム利用について

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＜概　要＞
わが国は、ウラン資源の有効利用の観点から、使用済燃料を再処理し回収されたプルトニウムやウランをリサイクルすることとしている。高速増殖炉（ＦＢＲ）は、ウランの利用効率が飛躍的に高く、その実用化は是非必要であると考える。
しかし、石油、ウランなどのエネルギー資源の需給が緩和状況にあり、また経済性の観点からも、その開発計画の長期化が予想される。
一方わが国は、１９７０年から海外再処理を実施しており、その結果１９９７年３月末現在で約１０．５ｔの核分裂性プルトニウムを海外に保有している。国際的な疑念が生じないよう余剰プルトニウムを持たないとの原則のもと、これを着実に利用していくことが必要である。
現時点で最も確実なプルトニウム利用方法は、軽水炉でのプルトニウム利用であり、今後数十年にわたりプルトニウム利用の柱となる。そのためわが国は、１９９９年から２基の軽水炉でＭＯＸ燃料の利用を開始する計画である。軽水炉でのＭＯＸ燃料利用にあたっては、プルトニウム利用に関する透明性の確保に努めていくとともに、その必要性、安全性に関し、立地地域をはじめ広く皆様からのご理解が得られるよう最大限の努力を行っていく。

## １．原子力の必要性

わが国は、エネルギー資源に乏しく、一次エネルギーの８０％を海外に依存している。また、二度にわたる石油ショック以降、省エネルギーに努めるとともに、石油代替エネルギーの開発に取り組んできたが、依然として石油依存度が５６％（1995年度）と高く、その内９９．７％は輸入に頼っており、わが国のエネルギー供給構造は他の先進諸国と比べて極めて脆弱である。

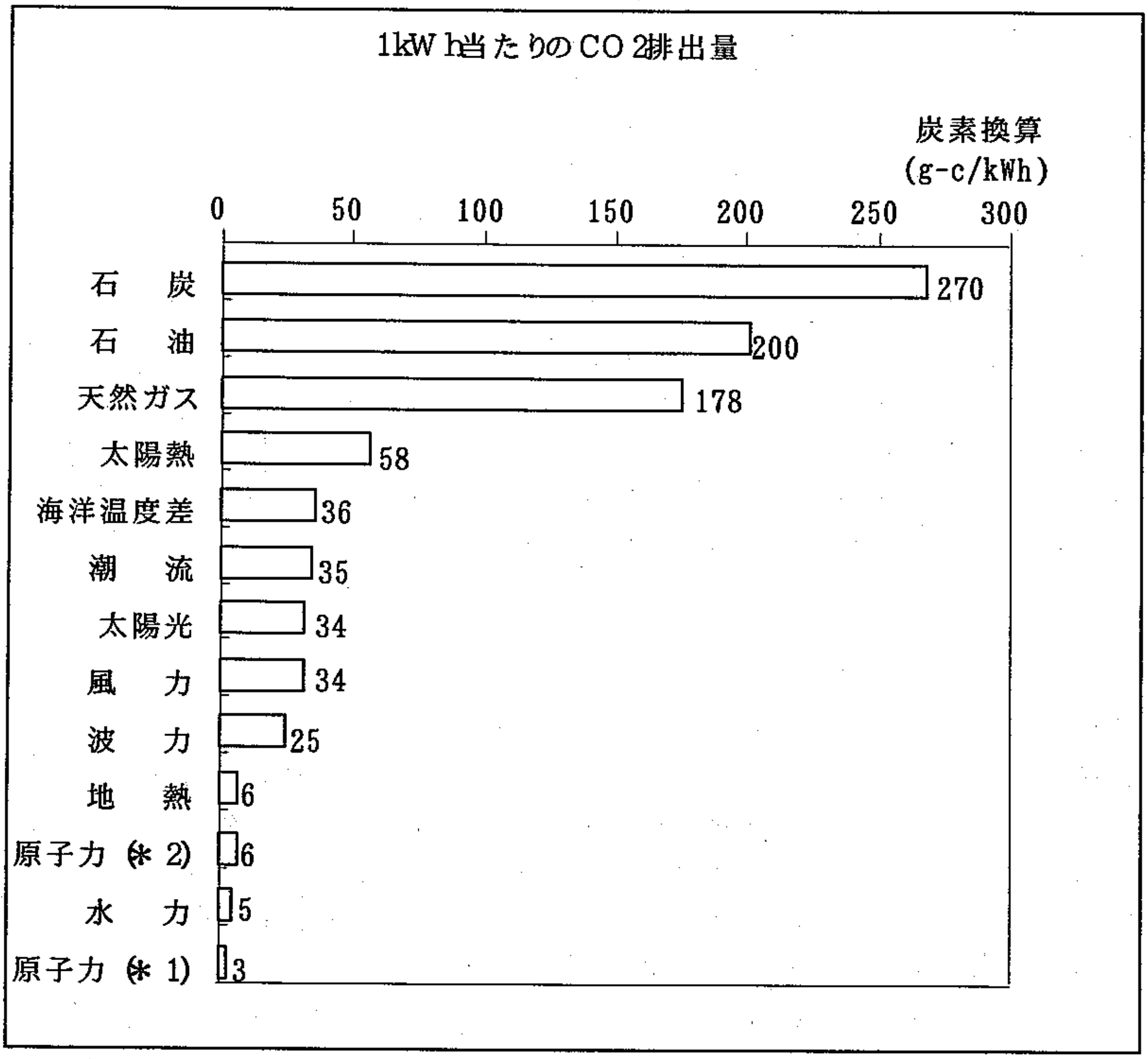
一方わが国のエネルギー需要は、省エネルギーの推進が図られている中、国民のライフスタイルの変化によるアメニティ志向の高まり、情報化社会の進展などにより、今後も着実に伸びていくことが予想される。

このような状況のもと、将来にわたるエネルギー・セキュリティの確保のため、エネルギー源の多様化を図る必要があり、原子力の利用を推進していく必要がある。

また世界的に地球環境問題がクローズアップされる中、昨年１２月京都で気候変動枠組み条約第３回締約国会議（ＣＯＰ３）が開催され、先進国の温室効果ガスの排出削減目標が採択された。わが国の温室効果ガスの排出削減の数値目標は、２００８年～２０１２年時点で、１９９０年に対して６％削減することになっている。わが国の計画では、１００万ｋＷクラスの原子力発電所を２０１０年までに、あと２０基つくることが織り込み済みであるなど原子力発電の環境影響緩和方策としての期待は高い。

原子力発電によるＣＯ２発生量は、建設、運転、燃料の採鉱などの各工程を考慮しても、他の発電形態と比較して圧倒的に少ないため、地球温暖化防止策の切り札になることが期待できる。

（図１）各種電源のＣＯ２排出量




（注）原料の採掘から建設・輸送・精製・運用（実際の発電）・保守などのために消費されるすべてのエネルギーを対象として$CO_2$排出量を算定。

原子力（＊１）：遠心分離法、プルトニウムリサイクル

原子力（＊２）：ガス拡散法、ワンススルー

出　典：電力中央研究所「発電システムのライフサイクル分析　平成７年３月」

## ２．原子燃料サイクルの必要性

わが国は、使用済燃料をプルトニウムやウランを含む、準国産の有用なエネルギー資源として位置づけ、これを国内で再処理し回収されたプルトニウムやウランをリサイクルする「原子燃料サイクル」を原子力政策の基本としている。

このため現在、日本原燃株式会社が、青森県六ヶ所村に国内初の商業用再処理工場の建設を進めており、２００３年に操業が開始される計画である。

原子燃料サイクルを確立することは、限りあるウラン資源の有効利用、エネルギー・セキュリティの確保の観点から重要であるばかりでなく、廃棄物の観点からも重要である。２０世紀の大量生産、大量消費、大量廃棄の文明から、２１世紀は資源を有効に利用し、廃棄物はできるだけ出さないリサイクル型の文明を目指すべきであり、原子力においてもリサイクルにより、有用なウラン、プルトニウムは利用し、放射性廃棄物は極小化することが必要となっている。これは、ゴミ発電や再生紙の利用などに代表される、資源を有効利用し廃棄物を最小限化する「リサイクル型経済社会」という目標に沿ったものである。

昨年１月、原子力委員会は、原子力発電を長期的、安定的に進めていく上で、原子燃料サイクルを円滑に展開していくことが不可欠であることを改めて確認するとともに、軽水炉でのプルトニウム利用などの施策を示した。同年２月には、これを政府として確認する閣議了解がなされた。

## ３．プルトニウムの利用

### （１）使用済燃料の再処理

わが国は、１９７０年から海外再処理を実施しており、その結果１９９７年３月末現在で約１０．５ｔの核分裂性プルトニウムを海外に保有している。海外再処理により回収される核分裂性プルトニウムは、２０１０年頃には累計で約３０ｔになると見込んでおり、これらは基本的に海外においてＭＯＸ燃料に加工した後、わが国に持ち帰り軽水炉で利用する計画である。回収されたプルトニウムについては、核拡散に対する国際的な疑念が生じないよう余剰プルトニウムを持たないとの原則のもと、着実に利用していくことが重要である。

（図２）わが国のプルトニウム保有状況（1997.3末現在）

| | | |
|---|---|---|
| 回収量 | 海外再処理（BNFL、COGEMA） | １２．４tPuf |
| | 国内再処理（PNC） | ４．３tPuf |
| | 小　計 | １６．７tPuf |
| 使　用　量（FBR、ATR） | | ５．１tPuf |
| 保有量 | 海外再処理（BNFL、COGEMA） | １０．５tPuf |
| | 国内再処理（PNC） | １．１tPuf |
| | 小　計 | １１．６tPuf |

（２）高速増殖炉（ＦＢＲ）でのプルトニウム利用

ＦＢＲは、ウラン資源の利用効率を飛躍的高めることができるため、将来の非化石エネルギー源の有力な選択肢の一つであり、その実用化を進める必要がある。

しかしＦＢＲの実用化は、安全の確保を前提に他のエネルギーに対して経済的競争力を持っていることが必要であり、昨今のウラン市場、石油市場の安定化や、ＦＢＲの研究開発状況を考慮すると、ＦＢＲの実用化は長期化する傾向にあると考える。

（３）軽水炉でのプルトニウム利用（ＭＯＸ燃料利用）

わが国では１９６０年代の原子力長期計画以来、一貫してプルトニウム利用方策の一つとして軽水炉でＭＯＸ燃料を利用することが計画されている。また１９８２年の同計画において、ＭＯＸ燃料利用の実証の必要性が示され、関西電力と日本原子力発電は少数体のＭＯＸ燃料の使用とその後の照射後試験を実施した。

軽水炉でのＭＯＸ燃料の利用は、フランスをはじめとするヨーロッパや新型転換炉原型炉「ふげん」での利用実績並びに少数体実証から、現時点で最も確実なプルトニウム利用方法であり、ＦＢＲの実用化状況を見通すと、今後数十年にわたりプルトニウム利用の柱になると考える。

また海外再処理によりプルトニウム回収が進んでいることを踏まえると、核拡散に対する国際的な疑念が生じないよう、これを早急に開始する必要がある。

このため、わが国では、軽水炉でのＭＯＸ燃料利用を、原子力発電を有する全ての電気事業者の共通の課題として位置づけ、１９９９年から２基の発電所で利用を開始し、２０１０年までには全ての電気事業者が合計１６～１８基で実施することを計画している。

（図３）わが国の軽水炉でのＭＯＸ燃料利用計画

| | ２０００年まで | ２０００年代初頭 | ２０１０年まで | 累　計 |
|---|---|---|---|---|
| 東京電力 | 1999年　１基<br>2000年　１基 | １基 | ０～１基 | ３～４基 |
| 関西電力 | 1999年　１基<br>2000年　１基 | | １～２基 | ３～４基 |
| 中部電力 | | １基 | | １基 |
| 九州電力 | | １基 | | １基 |
| 日本原電 | | ２基 | | ２基 |
| その他<br>電力５社 | | | 各社１基 | １基 |
| 電源開発 | | | １基 | １基 |
| 合　計 | ４基 | ５基 | ７～９基 | 16～18基 |

４．プルトニウム利用に関する透明性の確保

プルトニウム利用を推進していくには、核拡散について国際的な疑念が生じないよう十分配慮する必要がある。そのためわが国は、当初から原子力基本法により、平和目的に限り原子力開発利用を推進してきているとともに、ＩＡＥＡとの間で保障措置協定を締結し、国内原子力活動に係る全ての核物質についてフルスコープ保障措置を受け入れている。

さらに余剰プルトニウムを持たないとの原則の下、プルトニウムの需給見通しや保有プルトニウム量の積極的な公表を通じ、プルトニウム利用に関する透明性の確保に努めている。

今後も、核不拡散条約、核物質防護条約の厳守、ＩＡＥＡ保障措置強化・効率化への取組み及び保有プルトニウム量の積極的な公表などを通じ、プルトニウム利用に関する透明性の確保に努め、広く国内外の皆様のご理解と信頼を得ていくことが必要であると考える。

５．おわりに

昨今原子力に対する不安感、不信感が高まっているが、電気事業者としては、今後とも安全を全てに優先し、情報公開に努めることによりＭＯＸ燃料利用の必要性、安全性に関して、立地地域をはじめ国民の皆様からのご理解を得て、着実に計画が進められるよう最大限の努力を行っていきたいと考えている。

以　上

# PEACEFUL USE OF PLUTONIUM: ISSUES AND TRENDS

*Philippe Savelli, Deputy Director, Nuclear Energy Agency of OECD*

***Abstract***

*Energy and especially electricity demand will grow, in spite of efficiency improvement. Nuclear power is one of the proven technologies that can contribute significantly to sustainable energy supply in the 21st century. Large scale deployment of light water reactors could exhaust known uranium resources around the middle of the next century. While recycling uranium and plutonium in those reactors is a more efficient use of uranium resources, fast reactors are the only demonstrated technology that allows to exploit fully the energy content of natural uranium and to monitor plutonium inventories. The technical feasibility of fast reactors has been demonstrated but further research and development is needed to enhance their performance and economics. To keep the fast reactor option open and to reduce the financial burden in each country it is necessary for interested countries to exchange information and experience. International organisations such as NEA could play a key role in this regard.*

## Introduction

Plutonium offers opportunities and challenges for the nuclear community world-wide. Potentially, the use of plutonium can extend significantly the resources of nuclear fuels. Some technical options are available already for managing, using or disposing of plutonium, and R&D in this field is pursued by a number of countries. The management and peaceful use of plutonium do not raise major technical difficulties. However, plutonium handling require specific safety and radiation protection measures. Also, beyond technical, economic and safety issues, plutonium management has wider political and social aspects that have to be recognised.

The Nuclear Energy Agency (NEA) has carried out several studies covering scientific, technical and economic aspects of plutonium management. Those studies include analyses of the physics[1] and safety[2] issues associated with plutonium recycling, economics of plutonium recycling in light water reactors[3], and assessments of plutonium management[4] and use as a nuclear fuel[5]. Also, the work of NEA covers analyses of nuclear power development and fuel cycle strategies in the medium and long term, that provide a framework for assessing and comparing alternative plutonium management options.

The present paper is based essentially upon the findings and conclusions from those studies, reflecting scientific knowledge, technical know-how and consensus views of experts from NEA Member countries. It covers an outlook of world energy and electricity demand to 2050 and projections of nuclear power development that serve as a framework to discuss alternative reactor and fuel cycle strategies.

## Energy, Electricity and Nuclear Power Outlook

Energy demand growth will depend on many factors, including technological progress, lifestyle changes and national energy policies. However, there is no doubt that world energy demand will continue to grow, at least for several decades, and that electricity demand will grow at a higher rate than energy demand. Even if technology progress, efficiency improvement and the success of policies aiming towards sustainability would meet the most optimistic expectations, population growth as well as social and industrial development are likely to outweigh gains on energy intensities of the world economies.

One of the most authoritative organisations in the field of energy analysis, the World Energy Council (WEC), in its 1995 report entitled "Global Energy Perspectives to 2050 and Beyond"[6], presents energy scenarios leading to a world primary energy demand ranging between 14 and 25 Gtoe in 2050, as compared with 9 Gtoe in 1990. It should be pointed out that those scenarios are assuming that sizeable efficiency improvements are achieved world-wide. Over the period to 2050, the energy intensity of the world economy is assumed to decrease by 0.8 to 1.4 per cent per annum, depending on the scenario considered. Other international and national studies give similar ranges for energy demand in 2050 and beyond.

Today, electricity accounts for some 20 per cent of final energy consumption in the world. Electricity consumption has grown consistently at a higher rate than energy demand, and this trend is expected to continue for a number of reasons. Electricity is an efficient and flexible energy carrier that provides energy services without harmful environmental impacts at the point of end-use. Also, a significant share of the population in developing countries has no access to electricity. The average per capita consumption is roughly ten times lower in developing countries than in OECD countries, reflecting the limited access to electricity supply in the most populated regions of the world. In those regions, consumption is likely to grow very rapidly as soon as supply is available. Therefore, world electricity consumption is expected to more than double by 2050, reaching between 25 000 and 40 000 TWh as compared with some 12 800 TWh at present.

On the supply side, although there are many options available for providing the energy services that people need, the choice is in fact limited when constraints related to natural resources, technical development, economics and environmental protection are taken into account. Nuclear power is one of the proven technologies that can contribute significantly to sustainable energy supply in the 21st century. Recent studies on long-term nuclear power development provide a range of scenarios covering a range of possible nuclear capacity evolutions in the world to 2050. For example, Key Issues Paper No. 1 of the International Symposium on Reactor and Fuel Cycle Strategies: Adjusting to New Realities[7] presents nuclear capacities in the world ranging in 2050 from 333 GWe (in case of nuclear power phase out) to 1 800 GWe. Other studies, such as the Global Vision Project being carried out by the Los Alamos National Laboratory in the United States, suggest similar ranges of nuclear power projections by 2050. In the reference scenario developed by the NEA, within its programme of work on nuclear power and sustainable development, for investigating alternative fuel cycle strategies, it is assumed that world nuclear capacity will be around 1 100 GWe[8] by 2050.

**Nuclear Fuel Cycle Strategies for Plutonium Management and Use**

The scenarios discussed above are illustrative of possible futures and not predictive, but they constitute a relevant framework to investigate fuel cycle strategies that would provide adequate uranium and fuel cycle service supply capabilities to support nuclear power world-wide. For each step of the fuel cycle, different processes, either technically proven and commercially available or under development, may be considered in order to adapt nuclear fuel supply to demand. In each country, fuel cycle strategy choices will depend on national policy goals, economics, domestic energy resources and industrial capabilities, and a number of other factors. Also the growth rate of nuclear power, in each country and world-wide, will have an impact on fuel cycle strategy choices.

High or medium nuclear capacity growth, in a given country and/or world-wide, is likely to provide incentives to reprocess spent fuel in order to recover and recycle fissile materials as a means to reduce uranium requirement. Reprocessing and recycling, including recycling in fast neutron reactors, could be considered also, in some countries, even in the case of low nuclear capacity growth, as a means to reduce plutonium stocks and high level radioactive waste. Although safe technical solutions are available for the disposal of plutonium contained in spent fuel, its recycle, and especially its use in fast reactors, enhance the sustainability of nuclear power in the long term.

Also, fuel cycle strategies have to take into account the plutonium stockpiles already existing. For several decades, the production of nuclear electricity has generated fission products and actinides, including plutonium. By the end of 1995, about 970 tonnes of plutonium (tPu) had been generated; about 185 tPu had been separated; and about 50 tPu had been recycled in reactors[9]. Taking into account the nuclear programmes being implemented and the fuel cycle strategies in place, it is estimated that, by 2000, separated plutonium inventories will increase to about 175 tPu and that cumulative amounts of plutonium contained in spent fuel will reach around 1 000 tPu. After the turn of the century, the quantities of plutonium separated and contained in spent fuels will depend upon nuclear power growth and fuel cycle strategies adopted in different countries.

Technologies for reprocessing light water reactor (LWR) spent fuel and recycling plutonium in those reactors have been developed and are commercially used in some countries. Several reprocessing plants and facilities manufacturing mixed oxide (MOX) fuel elements for LWRs are in operation. Reprocessing, and production and use of MOX in LWRs have reached industrial maturity during the last ten years and considerable experience has been accumulated already in the field. Currently, 32 LWRs are licensed to use MOX fuel and this number is expected to increase. The MOX fuel fabrication capacity exceeds 200 tonnes of heavy metal per year (tHM/year) at present and will rise to about 400 tHM/year before 2005. The experience with recycling plutonium in fast neutron reactors although more limited, is significant also.

The risks and hazards associated with separated plutonium handling, storage, transport and use have been recognised since the early development of nuclear industries and are well understood. Because of its radioactivity and toxicity, plutonium presents potential hazards to workers. In OECD countries, civil plutonium handling facilities have very good operational and safety records, provide high standards of protection for public health and the environment[2]. The design and operation of civil plutonium handling facilities meet international safety and radiation protection standards and norms[4], and follow well established practices and international guidelines.

Because of its potential non-civil uses, plutonium must be guarded against diversion. A number of international, regional and bilateral agreements are in place for ensuring that plutonium and plutonium handling facilities are subject to safeguards and, in most countries with civil nuclear programmes, national safeguards systems are in place. Therefore, plutonium separation, transport, storage and use are under strict government control and international surveillance. Over many years, the international organisations in charge of safeguards have gained significant experience in controlling the steps of the fuel cycle involving plutonium handling.

Although the fast neutron reactor history is as old as that of thermal reactors, the accumulated experience on their operation is not very extensive. World-wide, ten countries developed fast neutron reactor technology at different times and to a certain extent, but few countries are currently pursuing fast neutron reactor programmes. The rationale for developing fast reactors was, and remains, the recognition that they are by far more efficient than thermal reactors in utilising natural uranium. Consequently, the slowing down of nuclear power growth, that in turn has alleviated concerns on uranium supply, led to delays in fast neutron reactor development and implementation. Only two industrial-scale fast reactors have been built and operated. On the one hand, these reactors have demonstrated the technical validity of the concept. On the other hand, the feed-back from the experience acquired with the construction and operation of test, prototype and industrial-scale fast reactors calls for additional research and development aiming at enhancing their technical and economic performance. In this context, it is expected that only a few fast reactors may be built before 2025.

Different fuel cycle strategies, based upon existing technologies and/or concepts under development, may be considered for the long term. The following discussion illustrates how alternative strategies would impact on uranium consumption, cumulated non-reprocessed spent fuel arisings and plutonium inventories. Those indicators, among other factors, are of relevance to assess the sustainability of nuclear power and its fuel cycle.

With regard to natural resource management, if the world nuclear capacity would be around 1 100 GWe by 2050, as mentioned above, with once-through operated reactors, cumulative uranium requirements would exceed uranium reserves by 2025 and known uranium resources by 2040. Past experience shows that, over years, exploration efforts and science and technology progress have led to an increase in amounts of known uranium resources in spite of continuing production[10]. However, delineating and exploiting additional conventional and unconventional uranium resources, that could complement uranium supply by 2050, would require costly exploration and development activities. Therefore, with the progressive exhaustion of known resources recoverable at low costs, uranium prices are likely to increase. In this connection, fast reactors could be part of a strategy aimed at ensuring long term security of nuclear fuel supply irrespective of the rate of discovery of economically recoverable uranium resources.

Finally, once-through strategies do not utilise the energy that can be extracted from plutonium contained in spent fuel. Reprocessing spent fuel and recycling fissile materials in thermal reactors can reduce significantly the amounts of plutonium remaining in non-reprocessed spent fuel. Within the illustrative medium nuclear growth scenario mentioned above, the use of MOX in LWRs could reduce by some 60 per cent the cumulative amounts of plutonium contained in non-reprocessed spent fuel by 2050. However, recycling plutonium in LWRs only does not allow a full utilisation of the plutonium contained in spent fuel arising from LWRs. Therefore, the amounts of plutonium contained in non-reprocessed spent fuel that have to be disposed of continue to increase, although at a lower rate than in once-through strategies. Fast reactors, as they can use plutonium from all types of spent fuel including MOX fuel discharged from LWRs and fast neutron reactors, could in the long term reduce drastically plutonium stockpiles other than the hold-up inventories in reactors and fuel cycle facilities.

With the development of fast reactors, other fuel cycle strategies might be considered in the long term. Options such as partitioning and transmutation of actinides could address concerns related to waste minimisation and global sustainability. It should be pointed out, however, that extensive research and development remains to be done for demonstrating the technical feasibility of those options.

**Concluding Remarks**

There are a number of options available or under development for peaceful uses of plutonium, including its recycling in thermal and fast reactors as well as its final disposal in spent fuel or in separated form. Among those options, decision makers in each country are likely to base their choices upon a wide range of criteria reflecting national policy objectives and goals.

Fuel cycle strategies aiming at reducing uranium requirements and radioactive waste arisings are likely to become increasingly attractive from sustainability as well as economic viewpoints. Fast reactors offer advantages both in terms of natural resource management and in terms of plutonium amount and radioactive waste minimisation. However, alternative options, already available or that would emerge from on-going research and development, might prove to be equally attractive.

The technical feasibility of fast reactors has been demonstrated but further research and development is needed to enhance their performance and economics. Intergovernmental organisations such as the NEA could play a role in facilitating information exchange and experience sharing between interested countries and, thereby, reducing the efforts and financial burdens in each country aiming at keeping the fast reactor option open.

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# KEYNOTE SPEECH

# Jayantha Dhanapala

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# SESSION 2

# Strengthening Nuclear Nonproliferation; Japanese Perspective

Position Paper by Ambassador Nobuyasu Abe

*In spite of the significant progress in nuclear disarmament in the last decade, the risk of nuclear proliferation is still real and growing. To achieve a world free from the dangers of nuclear weapons, the world has to further strengthen the nuclear non-proliferation efforts. Japan fully embraces the NPT as the essential bulwark against nuclear proliferation. Japan is trying hard to bring the CTBT into force and to start negotiation for a fissile material cutoff treaty as soon as possible. Japan is also committed to work for the containment of proliferation risks in the existing and newly emerged areas through such export control regimes as NSG and MTCR and new ways and means for this purpose.*

## 1. Opportunity and new challenges

### Gathering momentum for nuclear disarmament

**The end of the Cold War provided a golden opportunity for the efforts towards nuclear disarmament. The achievement so far, including those leading up to the end of the Cold War, include the 1987 Intermediate-Range Nuclear Forces Treaty and the U.S.-Soviet or Russia START I and START II Treaties. We also welcome the bilateral understanding reached last year to start working on START III. We can now look forwards to their strategic warheads to be reduced to the range between 2,000 and 2,500 each by the year 2007. We have also succeeded in extending the NPT and adopting the CTBT. If there are those who may say that is not good enough or is too slow, I would say this is a significant progress and we should try to consolidate the progress so far achieved and to build further on it.**

### New challenges; imminent threat posed by the proliferation of weapons of mass destruction

**By consolidation I mean, for example, tackling the question of the management of the fissile material produced by the arms reduction so that we may prevent the material and the technology and experts from falling into the wrong hands. Our continued concern is the efforts by the countries mainly in the Middle East, South Asia and Northeast Asia to acquire nuclear weapons. The occasional news that efforts to smuggle fissile material were foiled combined with the experience here in Japan of the religious cult that tried to obtain WMD and succeeded, at least, in producing chemical weapons confirms our new concern that not only the countries of concern but now also small fanatic or terrorist groups can put hands on the means to produce nuclear weapons.**

**By building on the progress I mean, for example, to work to bring the NPT Review Conference to a success in the year 2000 and to secure further adherents to the NPT and bring CTBT into force.**

## 2. Japan's commitment towards a nuclear weapon-free world

Building practical steps towards the ultimate elimination of nuclear weapons free from the world

It may be superfluous to say but as the only nation that experienced the scourge of atomic bombs Japan is unswervingly committed to work towards a world free from nuclear weapons. It is against this background that Japan has been promoting the U.N. General Assembly resolution entitled "Nuclear Disarmament with a view to the Ultimate Elimination of Nuclear Weapons." We are grateful for the almost universal and overwhelming support offered to the resolution. In order not to make such a resolution a mere slogan, our belief is that we need to build concrete and realistic measures of nuclear disarmament step by step so that we may nurture more favorable security environment that enables further progress towards the ultimate goal of total elimination of nuclear weapons.

Indeed the non-nuclear commitment starts from Japan. To those non-believers who may still suspect Japan may one day go nuclear let me reiterate our commitment that Japan has no intention to acquire nuclear weapons and will continue to abide strictly by the IAEA safeguard inspections.

## 3. Securing nuclear nonproliferation; NPT the cornerstone

In fact among the arms control negotiators the recent debate about nuclear disarmament centers around the question of whether we should or should not start negotiation on any nonproliferation agreement until there is a firm commitment from nuclear weapon states to definite nuclear disarmament. In our view this goes against our thinking of step by step approach to the ultimate goal and as a practical result stifles any further progress towards nuclear nonproliferation while the two nuclear superpowers proceed towards rapid reduction of their strategic weapons.

In our view the NPT is the cornerstone of nuclear nonproliferation. Without this bulwark against nuclear proliferation, there would have been many more nuclear-weapon states today. The world would have been more dangerous and more destabilized. Japan firmly supported the indefinite extension of the Treaty and is working hard to win more adherents to achieve the universal application of the treaty. Brazil's adherence left only a handful of states as non-adherants. I know that they have many reasons to explain why they cannot accept the NPT but on this score Japan will remain tenacious in its efforts to persuade them to join the NPT.

Strengthened NPT review process

We also need to work on the strengthening of the NPT regime based on the two key decisions made at the time of the Treaty extension in 1995. They are the "Principles and Objectives for Nuclear Non-Proliferation and Disarmament" and the decision regarding the "Strengthening (of) the Review Process for the Treaty." We are working with other countries in this strengthened review -

process running up to the Review Conference in the year 2000. It is an important process to maintain the Treaty's credibility and viability.

Strengthened and more efficient IAEA safeguards system

For the international nonproliferation system to have real teeth it is also important to strengthen and make more efficient the IAEA safeguards system in line with the latest IAEA Program "93+2." This is especially so in view of our experiences in Iraq and North Korea where persistent inspection efforts still have not cleared the air. The program must be implemented without delay by all countries including nuclear-weapon states.

## 4. CTBT: historic achievement

The latest achievement in nuclear disarmament was the historic signing of the CTBT in 1996. It was the culmination of the step-by-step efforts to curve nuclear weapons competition and proliferation, following the partial ban, the outerspace ban and the threshold ban. Banning all nuclear explosions it is not only a strong measure to curve the efforts by the non-nuclear weapon states to acquire nuclear weapons but also serves as a strong brake against the escalation of nuclear weapons competition among the nuclear weapon states.

Bring CTBT into force as soon as possible

The overwhelming support in the U.N. General Assembly in adopting the CTBT was a clear pronunciation of support by the international community. Japan took the lead last July becoming the first to ratify the Treaty among those countries that are required for the enactment of the Treaty. Japan urges the other signatories to ratify the Treaty as early as possible. I would also urge the signing of the Treaty by India, Pakistan and North Korea whose participation is required under the Treaty for its entry into force.

I have recently been to some of those countries to have discussions on this and other questions of arms control. I heard many arguments justifying their position of not signing the Treaty. But Japan, together with other countries, will have to continue the efforts to persuade them to reconsider their positions so that we can bring the Treaty into force before it becomes too late.

In the meantime Japan and other members of the Preparatory Commission for the CTBT Organization have already started their preparations to implement the verification regime of the Treaty. Japan not only picks up nearly 16% of the bill for the organization but also offers practical help by transferring its seismological monitoring technology for nuclear test detection and by providing training for the experts from developing country members.

## 5. Cutoff treaty: next step in nuclear nonproliferation

Beyond the CTBT the next step forward to strengthen nuclear nonproliferation is a treaty to cutoff the production of fissile material for nuclear weapons. The U.N. General Assembly in 1993 adopted a resolution calling for such a treaty. The concept was also endorsed in the document adopted at the time of the indefinite extension of the NPT in 1996. The document titled the "Principles and Objectives for Nuclear Non-Proliferation and Disarmament" expressed the agreement that "the immediate commencement and early conclusion of negotiations on a FMCT as the next step after the CTBT, is important in the full realization of nuclear disarmament.

Cutoff Treaty can greatly contribute to nonproliferation

A fissile material cutoff treaty can greatly contribute to nuclear nonproliferation by literally cutting off supply of the essential ingredient of nuclear weapons to those countries trying to acquire nuclear weapons. The treaty can also nail down the commitments of those nuclear weapon states who have declared their voluntary cutoff and help non-proliferation by extending verification measures to fissile material production facilities such as those for enrichment and reprocessing that are currently not subjected to international monitoring.

Despite the wide international support for the cutoff treaty, however, negotiation at the Conference on Disarmament in Geneva has not yet started, partly due to the insistence of some countries who argue that it should only be started in parallel with negotiation on nuclear disarmament with a prescribed timeframe. This in fact created a serious deadlock in Geneva. In our view such a linkage policy has now become an effective roadblock against the cutoff negotiation.

Japan's practical options to break the deadlock

Japan has proposed a number of options to break the deadlock. Last February Japan proposed to appoint a Special Coordinator to conduct consultations with the CD members in Geneva in order to identify the issues in the field of nuclear disarmament which could be negotiated in the Conference on Disarmament in Geneva. Since we detected still some reluctance to go along with this option, Japan further proposed late last year to start discussions on the technical aspects of a cutoff treaty as a means to pave the way for treaty negotiation. Indeed our preference still is to start the negotiation of the treaty itself immediately. We can go along with either the appointment of a special coordinator or the establishment of an ad hoc working group for this purpose. South Africa made a proposal to establish a committee on nuclear disarmament at the outset of this year's CD session. Japan welcomes the proposal and is prepared to explore.

## 6. Containing proliferation risks in the specific areas of concern

Beyond these international instruments of nuclear nonproliferation, Japan is also acting in the field of specific areas of proliferation concern and the less formal international nonproliferation regimes. For example, Japan joins the efforts to help Russia and other former Soviet republics to dismantle their nuclear arsenals, to stave off the drain of expertise related to nuclear weapons from those republics, to manage the plutonium derived from dismantled nuclear weapons and to prevent illicit trafficking of nuclear materials out of those republics.

Efforts to help Russia and the other FSU republics

Such endeavors related to the former Soviet Union are all new kind of non-proliferation challenges that the world has never faced with. Japan has so far pledged equivalent of US$100 million for the dismantlement projects including construction of storage and disposal facilities for fluid radioactive material, provision of fissile material containers and equipment for emergency preparedness and establishment of state accounting and control systems for nuclear materials. The International Science and Technology Center in Moscow and its twin in Kiev are a part of efforts to stave the flow of sensitive scientists and engineers out of former Soviet Union for which Japan has pledged US$25.9 million or roughly 20% of the total project fund. The center in Moscow has already made a significant headway. Japan offered $6.1 million for 20 projects in 1997. Here in Japan we are intensifying our efforts to encourage Japanese industries to take advantage of the opportunity offered by the center.

Other measures in the process of formation are, first, international efforts to help manage surplus weapon plutonium and, second, to tackle illicit trafficking of nuclear materials. The U.S. and a few other countries have already started working on plutonium question. In our view, while the primary responsibility for the management rests with the states that possess the plutonium, the international community has its own role to play to avert proliferation risks and promote the reduction of nuclear weapons. In this context, Japan has been urging nuclear weapon states to place their surplus material under the IAEA safeguard as early as possible. Japan on its part is prepared to contribute to the efforts making use of the experience and technology that Japan has acquired through the peaceful use of nuclear energy.

On illicit trafficking of nuclear material the P8, i.e. Japan and the G7 industrial countries plus the Russian Federation, have started to make progress, for example, through encouraging the undertaking of more enhanced information-sharing and greater cooperation among law enforcement, intelligence and customs authorities. A Point of Contact system was established for better communication. The P8 is soliciting expanded participation in the program.

Strong commitment to KEDO

Closest to Japan a very specific threat of nuclear proliferation exists in North Korea. Japan is firmly committed to play a significant role in the construction of light water reactors under KEDO to implement the Framework Agreement. Following the groundbreaking ceremony last summer, groundwork for the project are progressing in Kumho. In the meantime Japan continues to support IAEA to have North Korea adhere strictly to that Agreed Framework and implement fully its safeguards agreement with the IAEA so that it can dispel

**the concern about its nuclear development.**

**Export control regimes complement legally binding instruments for nuclear non-proliferation**

**The Nuclear Suppliers Group(NSG) and the Missile Technology Control Regime(MTCR) are two important export control groups for nuclear nonproliferation purpose. By adhering to their common export control policy of restraint they supplement the legal constraints imposed by the international legal instruments. Japan has no problem in controlling the exports of any weapon or any of its component because it has been maintaining a very strict policy to ban exports of weapons from Japan. In fact, the policy was applied so strictly that the Cabinet recently had to take a special action to allow export of demining equipment for humanitarian purposes. Japan applies strict policy of restraint as to the dual-use technology and material to ensure that trade of such items do not inadvertently contribute to the manufacture of nuclear weapons or their delivery means. Japan is committed to promote the purposes of these nonproliferation regimes which so far have had a reasonable degree of success but have a lot more to be done as the threat of proliferation persists and the technology they have to control advance day by day.**

**Japan currently performs the role of Point of Contact for the NSG in Vienna and chairs the MTCR for the current year until the next annual meeting scheduled to be held in Budapest coming October. In order to further the objective of the regimes we are seeking to win cooperation of non-members in pursuit of our common nonproliferation objectives by organizing seminars and other activities for non-members including what we call the transshipment points. In my capacity as the chair of the MTCR I am working to organize dialogue sessions with India, Pakistan and China this year. Japan will also be taking up this issue in such a regional forum as the ASEAN Regional Forum.**

## Conclusion

**As I have reviewed the various avenues of nuclear nonproliferation, there are a lot of agenda and homework that we need to work on the question of nuclear nonproliferation and disarmament. I pledge today that Japan is prepared to do its utmost to make as much progress as possible and I myself will devote myself to those works. So wish me a good luck so that there can be a good progress to be made this year. Thank you.**

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# GETTING THE CUT-OFF CONVENTION NEGOTIATIONS STARTED

By George Bunn

**Abstract:** Negotiation of a cut-off convention has long been stalled at the Geneva Conference on Disarmament, just as a treaty to ban anti-personnel land mines was stalled there. If that Conference does not begin negotiations for a cut-off this year, Japan should do for the cut-off what Canada did for land mines: Invite governments to a conference it would host at its capital to negotiate such a treaty without insisting upon the rule of unanimity that has blocked progress at Geneva.

**Full text:** With the end of the Cold War, Russia and the United States are dismantling thousands of nuclear weapons. These have come from cuts agreed between the two in the first treaty reducing long-range strategic missiles (START I), from the treaty eliminating intermediate-range missiles (the INF Treaty), from the Bush-Gorbachev-Yeltsin reciprocal unilateral withdrawals to Russia and the United States of shorter range nuclear weapons, and, of course, from obsolescence. As a result, hundreds of tons of plutonium (Pu) and highly enriched uranium (HEU) are no longer needed for defense purposes in Russia and the United States.[1] Other nuclear-weapon states have also announced cuts.

An expert committee of the U.S. National Academy of Sciences has concluded that the existence of this surplus Pu and HEU "constitutes a clear and present danger to national and international security" because "these two materials are the essential ingredients of nuclear weapons and limits on access to them are the primary technical barrier to acquisition of nuclear weapons capability in the world today."[2] U.S.-Russian negotiations have sought bilateral agreement to cut-off further production of Pu and HEU for weapons, to dispose of the excess Pu and HEU safely and

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[1] U.S. Department of Energy, Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives DOE/NN-0007 (Washington, DC: Office of Arms Control and Nonproliferation, 1997) (hereafter DOE,"NP Assessment"), p.1, 26; U.S. National Academy of Sciences, Committee on International Security and Arms Control, Management and Disposition of Excess Weapons Plutonium, (Washington, DC: National Academy Press, 1994) (hereafter "NAS, Management of Pu"), pp.1, 19.

[2] NAS, Pu Management, above, pp.1, 19.

to guard it from theft or diversion.[3]

Among the five declared nuclear-weapon states (Britain, China, France, Russia and the United States -- hereafter the "Five"), there appears to be a near moratorium (without explicit agreement) on producing more Pu and HEU for weapons. Yet there are no pending negotiations even among the Five for a cut-off convention, a treaty to prevent further production of Pu and HEU for weapons.

The long-standing proposal for such a convention is an essential next step toward strengthening international barriers to nuclear proliferation and toward achieving nuclear disarmament. Yet the cut-off is stalled at the Geneva Conference on Disarmament because of differences over what it should cover and because of the insistence of members of the Conference on a rule of complete unanimity.[4] If that Conference fails again in 1988 to begin negotiating a cut-off, I propose that Japan invite governments to send representatives to Tokyo to negotiate a cut-off convention just as Canada invited those interested in banning anti-personnel land mines to come to Ottawa to negotiate a treaty to do so.

Why is Japan an appropriate state to issue such invitations? Japan has more knowledge of the terrible consequences of nuclear war than any other country in the world. At the same time, Japan is one of the most advanced in nuclear technology. Given the rate at which Japan is acquiring Pu for peaceful purposes, it will one day have a very large stockpile. While some experts in Japan maintain that this stockpile could not, technically, be used for making nuclear weapons, the nuclear experts of the U.S. National Academy of Sciences and of the U.S. government agency responsible for making such weapons disagree. While not the best Pu for making bombs, the American experts say that what Japan is stockpiling will work.[5]

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[3] DOE, NP Assessment, above, pp.13-14, 23-24, 42; Bruce McDonald and Nikolai Yegorov, Chairmen, Joint U.S.-Russian Plutonium Disposition Steering Committee, Joint United States/Russian Plutonium Disposition Study (Washington, DC: GPO, Sept. 1996); G. Bunn and J.B. Rhinelander, "The DUMA-Senate Logjam on Arms Control: What Can be Done?" The Nonproliferation Review (Fall, 1997), pp.77-81.

[4] R. Johnson, "Geneva Update No.37, Conference on Disarmament," Disarmament Diplomacy (July/Aug.1997), pp.17-18; R. Johnson, "First Committee Report," Disarmament Diplomacy (Nov. 1997), pp.18, 21.

[5] See DOE, "NP Assessment,"above, pp. 37-39; NAS, Management of Pu, above, pp. 32-33.

Acquiring Pu or HEU is the most important hurdle today to terrorists or governments seeking to make weapons of the kind dropped on Hiroshima and Nagasaki. How to design such weapons is a 50-year old technology that has been disclosed publicly. As U.S. Department of Energy experts have said:

> Several kilograms of plutonium, or several times that amount of HEU, is enough to make a nuclear bomb. With access to sufficient quantities of these materials, most nations and even some subnational groups would be technically capable of producing a nuclear weapon....[6]

Instead of making bombs itself, Japan has chosen to join the nuclear Non-Proliferation Treaty (NPT) which prohibits it from manufacturing them. It has a clear interest in reassuring the rest of the world that it will not withdraw from the NPT in order to make nuclear weapons if it one day faces a more threatening world than that of today. It has an interest in demonstrating that its support for nuclear disarmament for all states is sincere.

At the same time, Japan should have an interest in seeing that the Five declared nuclear-weapon states and the Three undeclared "threshold" states (India, Israel and Pakistan) choose the path that it has chosen -- giving up nuclear weapons. It also should have an interest in strengthening the nuclear-non-proliferation regime in a way that will reduce the NPT's discrimination between nuclear-weapon and non-nuclear-weapon states in the inspections that it requires.

Giving a major boost to the negotiation of a cut-off convention would serve all of these interests. Japan would be taking a strong leadership role in helping to negotiate a long-overdue treaty that is an essential next step both toward nuclear disarmament and toward strengthening the non-proliferation regime in a way that should make it more equitable. Japan is well qualified to help lead the way toward a cut-off convention.

Why is the cut-off urgent? With the end of the Cold War, the public in many countries including my own seem to have stopped worrying about nuclear war between Russia and the United States. In my view, there is another nuclear threat that is in fact greater today -- that from attack by terrorists or rogue states with nuclear weapons like the weapons first designed more than 50 years ago.

We in the United States awoke to this danger when the World Trade Center in New York City was bombed. That bombing could have killed 10,000 people in the twin towers of the building that were

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[6] See DOE, "NP Assessment," above, p.vii. See also p.13.

both supposed to fall pursuant to the terrorists' plan. We were lucky that they did not. Later, the terrorist bombing of a federal government building in Oklahoma City did kill 168 and injure some 600.[7]

People in Japan probably also thought they were safe from mass killings by terrorists. But the release of the chemical-weapon nerve gas by the Aum Shinrikyo terrorists in the Tokyo subway was meant to kill far more than 12; it did injure some 5000. Before using nerve gas, the Aum Shinrikyo had tried to buy a nuclear weapon in Russia and had experimented with anthrax, a deadly biological weapon. We can no longer assume that terrorists do not want to kill thousands of people and would not choose to use nuclear weapons if they could acquire them.

There are far more nuclear weapons, Pu and HEU in Russia and the United States today than elsewhere in the world. Preventing theft of that material by terrorists or others is of concern to every country where it might be used. Yet other countries do not yet even know accurately how many tons of Pu and HEU Russia and the United States have and how well it is guarded. These are matters of international concern today. A cut-off convention would not only prohibit making more Pu and HEU for weapons, but could begin the process of letting the rest of the world know what the remaining quantities are, where they are located, and how well they are protected. It could begin to require the nuclear-weapon states to permit inspection of Pu and HEU materials not just to provide a numerical accounting but also to satisfy international standards for guarding the material.

<u>What sort of a cut-off convention should Japan's invitation to other governments to Tokyo negotiations propose?</u> There are two opposing positions to be avoided.[8] One is the original U.S. cut-off proposal which would simply agree not to produce Pu and HEU for weapons and would provide for inspection only at the plants that have produced it in the past. Russia and the United States have both agreed in principle to go beyond that in their bilateral talks, in their trilateral discussions with the Internataional Atomic Energy Agency (IAEA) on safeguarding excess weapons materials, and in recent nine-power negotiations described below.

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[7] See, e.g., G. Bunn, "Physical Protection of Nuclear Materials: Strengthening Global Norms," <u>IAEA Bulletin</u> (v.39, no.4, 1997 forthcoming).

[8] For an excellent analysis of the cut-off options, see Annette Schaper, <u>A Treaty on the Cutoff of Fissile Material for Nuclear Weapons --What to Cover? How to Verify?</u> (Frankfurt: Peace Research Instituts Frankfurt, 1997)(hereafter, Schaper, <u>Cutoff</u>),chap.3.

Both have agreed in principle to dedicate excess Pu and HEU from weapons to peaceful purposes subject to IAEA verification. Details such as the amounts to be declared excess and the methods of verification necessary to prevent disclosure of weapons secrets remain to be worked out. Thus, Russia and the United States have, in other negotiations, already proposed going beyond a simple prohibition on future production of Pu and HEU for weapons.[9]

The opposing position to be avoided is the Indian proposal that agreement on the cut-off must be conditioned upon an agreement to achieve total nuclear disarmament by date to be specified now. The cut-off has long been thought of as a step toward nuclear disarmament but not as the final treaty requiring nuclear disarmament.[10] There are other steps along the way that must first be taken -- difficult technical and political problems that need to be resolved -- before the right path toward nuclear disarmament can be seen clearly and a date certain for achieving it be predicted with accuracy. To insist upon resolving all these problems before taking the next step is unrealistic; it only blocks negotiation of a cut-off convention.

In between these opposing positions is an approach that would dedicate to peaceful purposes Pu and HEU from weapons dismantled as a result of START agreements, the INF Treaty, reciprocal-unilateral withdrawals or obsolescence -- dismantlements agreed or announced by the Five. START I and II and the INF Treaty deal with missiles and do not require dismantling warheads from the missiles destroyed. The Bush-Gorbachev-Yeltsin reciprocal unilateral withdrawals of weapons to Russia and the United States do not require warhead dismantlement either. Nor do the announcements of reductions in nuclear weapons by any of the Five. But to assure the rest of the world that warheads have in fact been dismantled irreversibly and that the process of nuclear disarmament has begun, a cut-off convention could provide for inspection by the IAEA of Pu and HEU from dismantled weapons declared excess to defense needs.

<u>Who should be invited to Tokyo negotiations for a cut-off treaty?</u> All non-nuclear-weapon states party to the NPT are already subject to a cut-off obligation in the NPT: They are prohibited by Article II from manufacturing nuclear weapons from any Pu or HEU

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[9] See DOE, <u>NP Assessment</u>, above, pp.13-17; McDonald and Yegorov, above, pp.Sum-1--Sum.-35; Bunn and Rhinelander, above, pp.75-80; G. Seneviratne, "New IAEA Head Orders Expert Panel to Evaluate Programs, Performance," <u>Nucleonics Week</u> (1 Jan. 1998), p.15.

[10] See, e.g, Address by UN Secretary General Kofi Annan to Geneva Conference on Disarmament, 30 January 1997, UN Press Release SG/SM/97/12, pp. 2-3.

that they may have and they are subject to Article III's requirement of comprehensive IAEA safeguards to verify that they do not do so.

The key states not subject to such obligations are first the Five. They have all joined the NPT but they are subject to different obligations. Until the negotiation of a cut-off or other nuclear disarmament agreement pursuant to NPT's Article VI, they are permitted to manufacture Pu and HEU for nuclear weapons. Their facilities for doing so and for storing Pu and HEU from weapons are not required by the NPT to be subject to IAEA inspection.

Three other key states not subject to NPT or other cut-off obligations are the "threshold" states, India, Israel and Pakistan (referred to here as the "Three"), none of which has joined the NPT but all of which have the capability to make nuclear weapons.

India, as already indicated, has taken a position at Geneva that appears totally non-negotiable. Pakistan has refused to agree to cut-off negotiations unless India does so. Israel is preoccupied by the Middle East peace process and demands a further accord there before it negotiates restrictions on its nuclear facilities. Thus, none of the Three is likely to join a cut-off negotiation except as observers at the beginning -- though they should all be invited to Tokyo along with the Five.[11]

If, in its invitation, Japan outlines what is to be negotiated and refuses to require unanimity for decisions, it can prevent India or any other country from blocking all negotiations. As a result, the disagreements at Geneva should not prevent negotiation of a cut-off convention at Tokyo for the Five, a convention that could be joined by the Three when they are ready to do so. Since the negotiations are likely to take several years, there may be time to persuade the Three to join the negotiations before they are completed.

Should the negotiations be left to the Five if the Three do not come? I believe not. There are many non-nuclear-weapon states with the ability to make nuclear explosives who have, like Japan, chosen to join the NPT instead. They are the states most discriminated against by the inherent differences in the NPT's obligations for nuclear-weapon as compared with non-nuclear-weapon states -- until nuclear disarmament is achieved. They are also the states most discriminated against by the refusal of the Three to join the NPT. They have a clear interest in a cut-off convention applicable to both the Five and the Three.

A cut-off convention should be verified by the IAEA which already verifies the cut-off related NPT obligations of non-

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[11] Schaper, above, pp.6-9, 26-29, 53-55.

nuclear-weapon NPT parties. The IAEA is now engaged in trilateral negotiations with Russia and the United States on safeguards for Pu and HEU that they declare excess to military needs. The IAEA has an interest in cut-off negotiations and has assigned expert staff to work on how a cut-off convention should be verified.[12] The IAEA and its members, at least those subject to IAEA safeguards because they have nuclear power or research reactors, should be invited. Members of the IAEA Board would likely be asked to approve a verification role for the IAEA if a cut-off convention were negotiated.

The IAEA has played a key role in negotiations to create international guidelines for management of Pu. Multi-party negotiations failed to achieve agreement on that subject in the late 1970s and the early 1980s. But, during that period, the Convention on Physical Protection of Nuclear Materials of 1980 was negotiated with IAEA help. In 1992, as a result of a Japanese initiative assisted by the IAEA, negotiations resumed on Pu management guidelines. Nine powers participated in these negotiations, the Five plus Belgium, Germany, Japan and Switzerland -- all advanced in nuclear technology and concerned one way or the other with Pu fuel cycles. In December of 1997, the Nine announced their agreement to the IAEA.[13]

The original Pu management idea was to provide effective protection for stored or transported materials not in use in regularly safeguarded reactors, to place it under IAEA safeguards, and to release it only for immediate civilian use. Another important goal was to increase transparency concerning the amounts of civilian Pu in storage in each participating country. The new agreement would make Pu in storage subject to agreed international Pu management guidelines.

Protection against diversion by the owner of the Pu as well as theft by terrorists or others seeking nuclear weapons were goals of the Nine-power negotiations just as they should be for a cut-off convention. Given those goals, the participation in the Nine-power negotiations of four non-nuclear-weapon states concerned with Pu fuel cycles was important.

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[12] See Seneviratne, above, p.15; T.E. Shea, "Verifying a Fissile Material Production Cut-Off: Safeguarding Reprocessing and Enrichment Plants: Current and Future Practices," Paper presented at Seminar on Safeguards and Non-Proliferation, IAEA Headquarters, Nov. 16-17, 1995.

[13] See DOE, <u>NP Assessment</u>, p.31; Schaper, <u>Cutoff</u>, pp. 13-15; Martin Kalinowski, e-mail <dh3m@hrzpub.tu-darmstadt.DE>, 16 Dec. 1997 (notes by governments to IAEA not made public as of this writing).

Since the cut-off would deal with HEU as well as Pu, more states should be included in the invitation than the Nine that negotiated the guidelines for international management of Pu. Certainly those non-weapon states that are IAEA members and have nuclear-power or research reactors should be invited even though all their signatures might not be needed to create a useful agreement.

<u>Who would come?</u> Each of the Five has supported the initiation of cut-off negotiations at the Geneva Disarmament Conference. They have each manufactured nuclear weapons and together have the most Pu and HEU. They are clearly important to a cut-off negotiation. Bilateral discussionw with them would be useful to find out whether, if the Geneva Conference fails to begin cut-off negotiations this year, they would come to Tokyo to begin such negotiations there -- without the rule of unanimity for decisions that has prevented progress at Geneva. Without all or most of them participating, the negotiations would probably not succeed.

The Three would be important to the negotiation also. But, if they do not choose to come to Tokyo in 1999, they should be told that they would be welcome at a later time.

Many other IAEA members would probably come if the Five agreed to come. While the cut-off does not have the kind of public support that an anti-personnel land-mine ban had when Canada invited states to its conference in Ottawa, it is an essential next step toward nuclear disarmament and it should help provide a stronger, more equitable, non-proliferation regime. It should be of interest to many states with nuclear capability.

<u>What rules of decision?</u> Japan's invitation should outline the kind of cut-off convention it hopes to achieve -- within broad limits. I suggested earlier that my goal would be to reject two opposing views which are both unlikely to produce agreement, but to leave options open in between.

Under the Ottawa process, unanimous agreement was of course sought but the rules permitted decisions by a two-thirds majority vote. No vote of this kind was necessary because the Chair and designated representatives of the Chair found out informally through discussions and caucuses what was wanted by two-thirds or more of the participants. The Chair announced these results and participants could challenge them and seek a vote. But no formal votes were necessary.[14]

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[14] J.Velin, "Landmines, Special Report: Stage Three of the Ottawa Process, The Oslo Diplomatic Conference," <u>Disarmament Diplomacy</u>, (Sept. 1997), pp. 6, 8.

Such a process might be called "consensus with an emergency brake" -- a brake which is rarely used to stop progress, but is there for real emergencies. Why not try such a process for cut-off negotiations?

Conclusion. Japan should invite the Five nuclear-weapon states, the Three threshold states and the members of the IAEA with nuclear power or research reactors to come to Tokyo in 1999 to begin negotiation of a cut-off convention if the Geneva Conference on Disarmament does not begin negotiation of a cut-off in 1998. The conference should use the Ottawa rules for decisionmaking.

You may ask who I am to ask Japan to take the lead in cut-off negotiations. I first came to believe in the value of the cut-off while working for the U.S. Arms Control and Disarmament Agency in the Kennedy administraion in 1961. I helped get the cut-off into a proposal President Johnson made in 1964 to the predecessor to the present Geneva Disarmament Conference.[15] In 1968, as the U.S. representative to the earlier conference, I agreed to place the cut-off on its provisional agenda.[16]

Despite many efforts since then, the cut-off has gotten nowhere at the Geneva Conference. Its time for a country as knowledgeable as Japan about the meaning of a cut-off -- having as strong interests in achieving one as Japan does -- to take the lead in trying to move the negotiations elsewhere. If my country did it, other states might be suspicious of our motives. Moreover, given President Clinton's current conflicts with the U.S. Senate concerning arms control treaties, he might cause more difficulties for Senate consideration of other treaties if he issued such an invitation.[17]

I am an old man who would like to see a cut-off negotiated before he dies. States are losing interest in it because of their frustrations at Geneva. I fear it will again be put aside if Japan does not take action.

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[15] L.B. Johnson, Message to Eighteen-Nation Disarmament Conference, ENDC/120, Jan.21, 1964.

[16] Report to the UN General Assembly and Disarmament Commission on behalf of the Eighteen-Nation Disarmament Conference, ENDC/236, 28 Aug. 1968.

[17] See Bunn and Rhinelander, above, pp. 73-76, and appendix.

# Reinforcement of the Nuclear Non-proliferation System and a Treaty Banning Nuclear Weapons

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## I. Reinforcement of the Non-Proliferation System after the Cold War

Right after the end of the Cold War, the role of nuclear weapons dramatically diminished. The nuclear deterrence strategy during the Cold War was so formulated as to limit the role of nuclear force to deterring the opponent from using nuclear weapons in the unusual context of the two-party game between the U.S. and the Soviet Union. This was a confirmation of the military stalemate that the two superpowers had come to in the mid 1950s with the completion of the hydrogen bomb and ballistic missiles as a delivery system. Nuclear deterrence is often cited as one of the main contributing factors in turning the Cold War into "the Long Peace." It is not so evident, however, that nuclear deterrence really prevented a major war. For, in WW II, before the nuclear age, the leading powers had become deeply aware that a "defense dilemma" ---excess of war damage over any political purpose of war--- had gone too far to permit another major war. Therefore the potential for nuclear war simply made the dilemma clearer. Nuclear force had become not so much a weapon for actual use as a "political" one by the 1960s, to keep the credibility of nuclear deterrence by showing the willingness to fight even a third world war.

As a matter of course, the utility of nuclear weapons in this context shrank at once with the demise of the Soviet Union. This strategic change has been reflected in a series of agreements on substantial disarmament such as the INF Treaty of 1987, START I of 1991, and START II of1993, the latest of which will reduce the strategic nuclear warheads of the U.S. and Russia to 1/3 of their peak levels.

Guided by this rather bright course of disarmament, the nuclear non-proliferation regime has also been strenghthened in terms of the number of adherents to the Nuclear Nonproliferation Treaty (NPT). It should be noted, however, that substantial disarmament and reinforcement of the nuclear non-proliferation system were not necessarily linked by a simple causal relationship, nor will they be hereafter. For example, South Africa abandoned its nuclear development program, including some finished weapons, because adversarial forces in neighbouring countries, who were obviously supported by Cuba, the Soviet Union and other communist nations, had disappeared with the end of the Cold War. Argentina joined the NPT (and perhaps Brazil will follow) as the nuclear option it has long kept became an obstacle on its way to democratization and economic reform based on international financial support. France and China became members of the NPT because their resistance to the "Pax Russo-Americana" system became meaningless once the bipolar structure had dissolved. Thus nuclear disarmament and nuclear non-proliferation will have to be dealt with separately in the future too.

The NPT was extended indefinitely in 1995. Along with this, negotiation of the CTBT was completed in 1996, as mentioned in the "Objectives and Principles of Nuclear Non-proliferation and Disarmament" which was adopted on the occasion of the NPT's indefinite extension. (However the CTBT does not come into effect as long as India refuses to sign it). The CTBT, though not yet effective, will have moral and political influence in preventing the increase of nuclear-weapon-states (NWSs). Thus, the nuclear proliferation problem that had been seen in almost every region of the world has now become an isolated problem in the Middle East (Israel) and South Asia (India and Pakistan).

But we have seen new nuclear proliferation issues arise during the same period. Secret nuclear activities have been brought to light in some countries which had joined the NPT as non-nuclear weapon states (NNWSs). Nuclear development in Iraq was uncovered by the UN inspection mission after the Gulf War and the alleged nuclear development in North Korea was shelved by the U.S.-North Korea Framework Agreement in October 1994. To cope with these new problems, the IAEA has worked hard to reinforce its verification system, resulting in a new model protocol, which empowers the IAEA to extend its inspection to undeclared facilities and areas where nuclear materials are not handled directly.

Another distinctive feature in the post-Cold War reinforcement of the non-proliferation system lies in stricter and wider export controls on materials, equipment and facilities relating to nuclear development. The Nuclear Suppliers Group (NSG, 1977) agreed to extend its export regulations to nuclear related but general-purpose items. Regional approaches to the issue have also produced excellent results. Two treaties on the nuclear-weapon-free zone (NWFZ) in South East Asia and Africa were signed in 1995. The NWFZ covers most of the southern hemisphere, including the Antarctic, Latin America and the South Pacific.

Thus, the international community has established a more solid nuclear non-proliferation system on its way out of the post-Cold War chaos.

## 2. the Role of the Remaining Nuclear Stockpiles

How to reinforce the nuclear non-proliferation system hereafter depends on the role of the remaining nuclear arsenals. The bigger the expected utility of nuclear weapons is, the higher the probability of nuclear proliferation becomes. To that extent, the system must be firm.

First of all, the NWSs do not believe that the role of nuclear force will soon be over, though the major threats are gone. However loose and rough it may be, a nuclear balance is still assumed to provide major support for international order as long as the anarchical structure of the international system remains unchanged. Equations of calculating the balance of power contain elements which are hard to analyze objectively, such as the prestige and status of a great power. The United States regards its nuclear deterrent as an indispensable hedge against two nuclear powers, Russia, due to its uncertain domestic politics, and China, due to its rapid economic and military rise. Moreover, the U.S. fears at bottom that, if the U.S. nuclear umbrella were withdrawn, Germany and Japan would switch to arm themselves with nuclear weapons against Russia and China respectively. Russia has made it clear in its "Concept of National Security," issued on December 24, 1997, that it considers the maintenance of a nuclear deterrent as an important task. The more Russia's status declines, the higher its nuclear deterrent will be revalued. China is also making efforts to improve its nuclear arsenal qualitatively, pursuing smaller and more accurate warheads, solid-fuel, long range missiles, and multiple-warhead missiles. Nor will the United Kingdom or France dispose of their nuclear force.

Therefore, the prospect of nuclear disarmament negotiations beyond the coming START III is very uncertain, largely depending on the development of strategic relations among the major powers. It is not highly conceivable that NWSs could work out a new shared nuclear doctrine that would enable them to guide further disarmament. Though the basis of past nuclear doctrine has long disappeared, no new doctrine is in evidence. There are always some countries who may be induced to get nuclear weapons, as long as their utility is believed in, however eclipsed such a philosophy may be.

Secondly, there remains the problem of the opaque nuclear weapon states, namely Israel, India and Pakistan. They are believed to have virtually completed construction of a nuclear device outside the NPT regime. Whether they can keep their nuclear option open is, they claim, a matter of life and death in terms of national security. These countries will abandon the nuclear option only after they feel themselves sufficiently secure in a full-blown regime of peace in their respective regions. The question is who will create such conditions in those regions. No other nation besides the United States is making effective efforts or is competent to do so for the time being. In this respect, the U.S. nuclear force is supposed to play some role in the effort to lead a regional peace, soothing India's fear of China and providing Israel with security reassuarance. Taking into account the Iraqi nuclear development and missile attacks against Israel during the Gulf War, the U.S. retaliatory nuclear force seems to be necessary to keep Israel from becoming a declared nuclear weapon state.

Thirdly, another emerging problem is that some NPT members allegedly engage in secret nuclear development. Americans call them "rogue states". Iraq was found to have been about to complete a nuclear device by the UNSCOM's inspections after the Gulf War. Later North Korea was, too. The United States suspects Iran and Libya. There is a controversy, however, over whether nuclear force is really necessary to counter these micronuclear powers, because their nuclear capability will long remain poor under the current tight international export controls and the major powers have high-tech conventional weapons like PGM or TMD as a passive part of their "counter-proliferation" measures, which would be more effective in coping with these minor threats. This line of argument must be right and rational. Nevertheless, it would be unwise, or at least incautious, to declare in advance the exclusion of any nuclear options from possible countermeasures. Those countries might be less reckless, when impressed strongly with the possibility of suffering a devastating blow should they use their weapons of mass destruction.

Finally, another new threat, that terrorist might acquire nuclear weapons, should be added. This seems to be one of the most serious concerns in the United States at present. In the case of nuclear terrorism by a nonstate actor, nuclear weapons have no relevance as a deterrent. But in President Clinton's directive to review the nuclear strategy set forth in December 1997, preparation for nuclear retaliation against terrorists was mentioned as one of the roles of the remaining U.S. nuclear arsenals, particularly in the case of an attack on the U.S. mainland by terrorists with weapons of mass destruction. This seems less unlikely when one takes into account growing fears of nuclear smuggling. On the one hand, there are tons of fissile material released from scrapped warheads under inadequate control in Russia and, on the other hand, Islamic fundamentalist groups in the ethno-religious conflicts, which have increasingly taken place in former Soviet republics and other countries adjacent to Russia, are often hostile to the United States.

As stated above, nuclear weapons remain part of the global and regional security equation. But what is noteworthy here is that the roles listed are no longer as essential as they used to be during the Cold War. Now nuclear powers appear to be searching for excuses for maintaining their nuclear stokcpiles and have come up with these "roles" out of bureaucratic inertia. The main approach to non-proliferation in the Cold War era was to deny suspected nations accsess to the materials, technology and equipment relevant to nuclear development, while admitting the value of nuclear weapons as a deterrent. It appears highly questionable to reinforce this approache as was done in the post-Cold War situation, for the nuclear proliferation problem has become an issue only relevant to a limited number of states and the utility of nuclear force as a deterrent has greatly decreased.

3. The Nature of Nuclear Weapons Reconsidered

I do not intend to deny the importance of the current nuclear non-proliferation regime as a valuable institutional asset of the international community. It surely deters wavering countries from going nuclear and helps confidence-building efforts in conflict-ridden regions.

The often cited prediction, made in the NPT negotiation process, that more than twenty nations might acquire nuclear weapons in ten to fifteen years, turned out wrong thirty five years later. Now most nations are forswearing membership of the nuclear club. Now that the law of diminishing returns is working within the NPT regime, we have to examine seriously whether the further reinforcement of the present NPT/IAEA safeguard system really pays. Would pushing India and Israel to join the NPT for the sake of its universality result in real reinforcement of the system? Could the IAEA's new tough measures, such as special inspections of undeclared facilities and materials as well as environmental sampling, deter countries who are firmly determined to develop nuclear weapons? Would it not just force extra costs on most NNWSs? The reinforcement of export controls may seem nothing but an increase of trade discrimination to the majority of nations who have no intention of acquiring nuclear weapons.

We need a change of approach regarding the non-proliferation issue. It is necessary to draw close attention to the fact that, apart from the lenient deterrence relations between the United States, Russia and China, the role of the nuclear weapons mentioned above is no longer "political." Certainly, it is only a technicality to differentiate the "political" from the "actual" use of nuclear weapons, because the "political" use is effective only when nuclear weapons are believed to be actually usable. But sometimes the role assigned to the remaining nuclear arsenals seems to assume much more strongly their actual use in an asymmetrical power equation than in bipolar circumstances of the Cold War. The United States appears to see it as highly probable that Iraq or North Korea would resort to nuclear weapons, once they acquired them, and the United States would retaliate with theirs. The function of nuclear weapons now tends to be similar to that in the example of Hiroshima and Nagasaki, where atomic bombs were believed usable and actually dropped to force early surrender on Japan.

Here we can remember the distinct effects of nuclear weapons when actually used. The most important is that, in addition to the enormous destructive force of the blast, heat and radiation make no distinction between combatants and non-combatants, one of the essential principles of the law of warfare (humanitarian law). It was on the grounds of legal principle that the admissability of nuclear weapons has been questioned from the beginning of the atomic age. In fact, the Soviet Union insisted on the immediate ban of atomic weapons in the first session of the UN Atomic Energy Commission right after WWII. Nuclear weapons could be regulated along with other weapons of mass destruction like biological, toxic, and chemical weapons, which are all banned under respective treaties. The reason why nuclear weapons are not banned is that their deterrent effect was recognized and placed in the center of the successive military strategies of both superpowers. The priority has been the avoidance of major war by the balance of terror, not the regulation of inhumane weapons.

Now that the utility of nuclear arsenals as an effective deterrent has rapidly receded, we may have an historic opportunity to regulate nuclear weapons in terms of the law of warfare. It will be almost impossible, however, to go back to the pre-nuclear era. The fear of diverting fissile material produced in power plants will persist, for neither will the peaceful use of nuclear energy be abolished, nor are the blueprints and manufacturing technology of nuclear weapons be eradicated in the forseeable future. Should nuclear weapons be totally abolished at once, every country would be oversensitive towards the weapon-producing capacity of other countries, and doubts beget doubts, destabilizing international relations. As suggested earlier, the non-proliferation problem and that of controling the remaining nuclear stockpiles have to be dealt with in a closely linked, but separate manner.

4. A Treaty Banning Nuclear Weapons

It might be useful to refer once again to the discussion at the first UN Atomic Energy Commission in 1946. As mentioned before, the Soviet Union claimed that nuclear weapons should be banned immediately. As opposed to this, the United States proposed to build a strict and comprehensive international control system of atomic energy. Although they failed to compromise fifty years ago, there seems to be a growing possiblity of integrating these two approaches for deeper cuts and stricter regulation of nuclear weapons. A new regulatory mechanism would comprise three parts.

Firstly, the illegality of nuclear weapons would have to be established, as a final goal, by a treaty banning them in terms of the law of warfare. The treaty would apply to both NWSs and NNWSs. Secondly, another agreement should be worked out that all parties take on the obligations they accepted under the past treaties such as the NPT, CTBT and NWFZ treaties and their protocoles. Thirdly, there would be a final agreement to construct a strict international control system of the remaining nuclear stockpiles. The current five NWSs would have to take special responsibility for securing the implementation of all three agreements, the third one in particular. To fullfil their obligations, they would have to be allowed to have a minimum nuclear force and decisions on its use would have to be left to their discretion. But the purpose of such use would be strictly limited to carrying out the treaty obligations and would, in principle, exclude self-defense.

Special obligations that NWSs would have to assume are as follows:

---to pledge no-first use in general and non-use against non nuclear weapon states,

---to complete a treaty governing the cut-off of the production of fissile material as soon as possible and to sbject all nuclear activities to a mutual inspection system set up by the five NWSs or the IAEA's safeguard system,

---to hold a multilateral nuclear disarmament conference of the five NWSs and to work out an anual program to reduce nuclear force to the minimum level and make stockpiles transparent. In the first stage, the U.S. and Russia could propose to make deeper cuts, if China would make public its inventory of arsenals and be willing to freeze its force at current levels.

Some political benefits could be expected from such a mechanism.

First of all, the significance of the international community confirming the illegality of nuclear weapons would be immeasurable, and would provide the non-proliferation system with a new basis. The ICJ's advisory opinion concerning the legality of threat or use of nuclear weapons announced in July 1996 was, in rough outline, that the threat and use of nuclear weapons generally violates the rule and principle of humanitarian law. However, it stated in the latter part of the same clause that they could not conclude clearly whether it is illegal in the extreme contingency of self-defense of a nation. If the illegality of nuclear weapons were generally confirmed, the role of the remaining nuclear force would be confined to securing the implementation of treaties and ensuring that the non-first use pledge by the NWSs was strictly carried out. The latter part of the clause would eventually become unnecessary.

Discriminatory, though such a regulatory mechanism might be, it would be no more so than the NPT. The privileges of the NWS would be limited and discrimination would be minimized as a result of new constraints on their activities and an obligation to achieve a radical reduction in the number of nuclear weapons. NNWSs could also ease the possible nuclear "security dilemma" through renewed anti-nuclear commitment. Once the new mechanism was firmly established, it would make it easier even for non-signatory states to participate in the new mechanism, providing they were not accused of past nuclear development activities.

In the suggestions so far made there are many political, legal and technological problems to be examined in detail hereafter. It is, however, worth examining them as a step towards strengthening an anti-nuclear stance ( " nuclear taboo" ) based on the new conditions of the post Cold War era.

# The Fissile Material Cutoff Treaty as a Policy Driver for Promoting Universal Full Scope Safeguards

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## Abstract

Several initiatives on fissile materials have been started during the last years which all aim at strengthening the non-proliferation regime: the safeguards reform 93+2, the International Plutonium Guidelines, disarmament and material control cooperation with the Newly Independent States (NIS), and attempts to start negotiations on a Fissile Material Cutoff Treaty (FMCT). They all show that there is a growing tendency towards universalization of transparency and control measures. Today, major proliferation and rearmament dangers result from the lack of safeguards and irreversability of disarmament in nuclear weapon states. The FMCT could act as a policy driver to promote new principles. But so far, not much progress has occurred in starting negotiations. The reason is an unfortunate perception that there is a contradiction between disarmament and nonproliferation. The paper will explain the current situation and the role an FMCT can play for a new universal fissile materials regime.

## Introduction

Until only a short time ago, everybody was confident that negotiations on a treaty to end the production of fissile material for nuclear weapons, the so-called *cutoff*, would start soon.[1] But meanwhile, the Conference on Disarmament (CD) is deadlocked, and the confidence in soon negotiations is replaced by stupefaction. The underlying conflict of the Comprehensive Test Ban Treaty (CTBT) negotiations can be summarized as *nuclear disarmament versus nuclear nonproliferation.* The same conflict is now blocking progress with negotiations in the CD on the Fissile Material Cutoff Treaty (FMCT). But the cutoff would be the major policy driver to insert transparency and irreversibility in the disarmament process,[2] and all efforts should be taken to find a way for progress. The CTBT can be regarded as a tool to cap the *qualitative* nuclear arms race, e.g. to hinder the future development of qualitatively new nuclear explosives, and an FMCT can be seen as its *quantitative* counterpart, capping the amount of material available for new nuclear weapons. It would also have the benefit to promote a universalisation process of verification of fissile materials that could lead towards universal full-scope safeguards.

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1 The topic of this paper is discussed in detail in: A. Schaper, A Treaty on the Cutoff of Fissile Material for Nuclear Weapons – What to Cover? How to Verify?, PRIF Reports No. 48, July 1997.

2 W. Walker, Reflections on Nuclear Transparency and Irreversibility: the Re-regulation of partially disarmend states, Background paper for the Conference on the Fissile Material Cutoff, Schlangenbad (Germany), 25-27 July 1997.

## The need for universal full-scope safeguards

The current system controls mainly those states which have complied with the NPT for many decades and which do not pose any proliferation danger. The goal is to detect noncomplicance as early as possible. But it has been learned from the history of nuclear proliferation that it is also important not only to detect the receiving end of sensitive technologies but also the supplying end, and the latest safeguards reforms have taken this lesson into account. The major sources of proliferation relevant materials and technologies can be found in the NWS who control them only nationally without obligation to adhere to international standards and without obligation to have the security of their nuclear materials be checked by an international agency. The proliferation dangers have increased since the end of the Cold War: huge quantities of weapon materials are becoming excess, and the processes of warhead dismantlement, material transport, storage, and disposition create additional diversion risks. The risks are especially high in Russia which is in the process of transforming its nuclear control system. The security of the Russian nuclear production complex is estimated to be far below Western standards and in danger of deteriorating even further; thus, proliferation is likely to increase.[3] The time is ripe to consider additional measures. The international safeguards in the NNWS have greatly reduced the danger of nuclear proliferation. They have triggered discipline and high standards of physical protection, material accountancy and control of nuclear materials and installations. The major dangers now result from the lack of similar standards in NWS. Universal international safeguards would promote a security culture and similarly high standards everywhere.

Apart from nonproliferation, nuclear arms control has another pillar which is nuclear disarmament. Both are complements that reinforce each other. Also the goal of nuclear disarmament would be best served if universal full scope safeguards would be implemented. During the next decades, the international community must deal with increasing amounts of insufficiently secured fissile materials, resulting from nuclear arms reductions, while upgrading security of civilian and military nuclear installations in the Newly Independent States (NIS)[4] and other countries that have rapidly developed their nuclear industries, e.g. East Asia. Further nuclear reduction agreements beyond START II are likely, and more weapons-grade nuclear material will be declared excess.[5] So far, many of these activities are highly intransparent for the international community, and they would be reversable, in case international politics would develop in an unfortunate rearmament direction. In case excess nuclear materials would be irreversably submitted under international verification or even IAEA safeguards, such a reversal would become far less likely.

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3 W. C. Potter, "Before the Deluge? Assessing the Threat Of Nuclear Leakage From the Post-Soviet States", *Arms Control Today*, October 1995, S. 9-16; A. Schaper, "Nuclear Smuggling in Europe – Real Dangers and Enigmatic Deceptions", Paper presented at the Forum on Illegal Nuclear Traffic: Risks, Safeguards and Countermeasures, Como, Villa Olmo, sponsored by the UE Joint Research Center, June 11-13, 1997, proceedings forthcoming 1997; V. A. Orlov, "Accounting, Control, and Physical Protection of Fissile Materials and Nuclear Weapons in The Russian Federation: Current Situation and Main Concerns", Paper presented at the International Seminar on MPC&A in Russia and NIS, Bonn, sponsored by the Deutsche Gesellschaft für Auswärtige Politik, April 7-8, 1997.

4 O. Bukharin, "Upgrading Security at Nuclear Power Plants in the Newly Independent States", *The Nonproliferation Review* 4 (Winter 1997), p. 28; for an overview on the security of the Russian nuclear complex see: O. Bukharin, "Security of Fissile Materials in Russia", *Ann. Rev. Energy Environ.* 21 (1996), p. 467-496.

5 The problem of excess Pu and its disposition options have been studied in detail by: National Academy of Sciences (NAS), Committee on International Security and Arms Control (CISAC), *Management and Disposition of Excess Weapons Plutonium* (Washington 1994);, NAS, CISAC, *Management and Disposition of Excess Weapons Plutonium: Reactor Related Options* (Washington 1995).

Indeed, the time is ripe for the introduction of regulatory measures also in the NWS, and for the creation of a fundamental, new concept of how to deal with fissile materials.[6] More principles are needed as a base for new regulations and agreements: These principles should include transparency of fissile materials, in contrast to the former secrecy in NWS during the Cold War, irreversibility of transfers of fissile materials from the military into the civilian use, and universality of international measures. It is now widely understood that nuclear activities are not only national concerns. However, while transparency is accepted and practiced in non-nuclear weapon states, it is still new to the NWS and the states outside the NPT. The degree to which the NWS are ready to endorse IAEA safeguards for themselves varies. While the United States shows an increasing openness, Moscow has yet to seriously consider transparency: V. N. Misharin, a former diplomat who served two tours of duty at the IAEA said in an interview on IAEA Safeguards in the Former USSR: "The IAEA also should keep in mind that large segments of Russia's nuclear industry will remain outside IAEA control."[7] Ambassador Sha Zhukang presented China's position on verification of a cut-off treaty as: "The verification measures should be least intrusive in nature and sufficient care been taken to avoid abuse".[8]

But some processes that lead into this direction have already started: Several bilateral and international collaboration projects are designed to reduce proliferation dangers in the NIS, notably the Nunn-Lugar Cooperative Threat Reduction (CTR) Program.[9] These initiatives aim at implementation of material accountancy,[10] reforms of export controls[11] and border controls, conversion of jobs in the military nuclear complex,[12] the dismantling of warheads, the conversion of military reactors,[13] the construction of a storage facility at Mayak for fissionable materials,[14] and technical solutions for the disposition of fissile materials.[15]

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6 D. Albright, F. Berkhout, W. Walker, *Plutonium and Highly Enriched Uranium 1996 – World Inventories, Capabilites and Policies*, (SIPRI, Oxford University Press, 1997), see Chapter 15: "The control and disposition of fissile materials: the new policy agenda"

7 V. N. Misharin, "IAEA Safeguards in the Former USSR", *The Monitor* 1 (Spring 1995), p. 4.

8 Amabassador Sha Zhukang, "China's Position on the Cutoff Convention", Paper presented at the Workshop on "Fissile Material and Tritium – How to Verify a Comprehensive Production Cutoff and Safeguard all Stocks", sponsored by UNIDIR and INESAP, Geneva, Switzerland, 29-30 June 1995.

9 Department of Defense, *1997 Annual Defense Report*, Chapter 7: "Cooperative Threat Reduction" (Washington 1997); U.S. General Accounting Office (GAO), *Weapons of Mass Destruction: Status of the Cooperative Threat Reduction Program*, (Letter Report, GAO/NSIAD-96-222, 09/27/96); for assessments see: J. E. Stern, "U.S. Assistance Programs for Improving MPC&A in the Former Soviet Union", *The Nonproliferation Review* 3 (Winter 1996), p. 17; and O. Bukharin, "U.S. Cooperation in the Area of Nuclear Safeguards", *The Nonproliferation Review* 2 (Fall 1994), p. 30.

10 A. Rumyantsev, "The Accounting and Control of Nuclear Material and Radioactive Substances in Russia", *Yaderny Kontrol English Digest* 1 (Spring 1996), pp. 5-8.

11 E. Kirichenko, "Evolution of the Russian Nonproliferation Export Controls", *The Monitor* 2 (Summer 1996), p. 8.

12 For this purpose, the International Science and Technology Center has been implemented that aims at funding civilian projects with international collaboration involving scientists from the Russian nuclear weapons complex. See: The International Science and Technology Center, *January – December 1995 – Second Annual Report*, (Moscow 1996); for the activities of the IAEA see: Sven Thorstensen, "Nuclear Material Accounting and Control: Coordinating Assistance to Newly Independent States – An Overview of IAEA-Supported Activities to Help Former Soviet Republics Establish State Systems Of Accounting and Control", *IAEA Bulletin* (January 1995), p. 29; for the activities of the Europeans see: European Commission, *Communication from the Commission to the Parliament and the Council. Illicit Trafficking in Nuclear Materials and Radioactive Substances – Implementation of the guidelines laid down in the communication from the Commission of 7 September 1994*, (COM(94)383) *and in the Conclusions of the Essen European Council*, COM (96) 171 (Brussels, 19 April 1996); and Commission of the European Communities, DG XVII, *Euratom-Russian Cooperation in Nuclear Materials Accountancy and Control*, (Luxembourg, 31 March 1997).

In addition to these practical initiatives, political reforms are underway: A remarkable endeavor towards more international transparency is the trilateral U.S.-Russian-International Atomic Energy Agency (IAEA) talks on IAEA verification of declared excess materials.[16] Substantial reforms of the IAEA's safeguard systems — the 93+2 program — were triggered by the Iraq proliferation case and are now being implemented. They are aimed at detecting clandestine nuclear material production at an earlier stage. Export control reforms have introduced the principle of full-scope safeguards in the recipient country as a condition for nuclear exports.[17] New transparency measures on plutonium, the so-called „plutonium management guidelines" (GPM) have been negotiated in Vienna, spurred by concerns about Japanese plutonium shipments. They are perceived as a beginning for even more universal reforms. The FMCT is one of the most important next steps in nuclear disarmament, and all efforts should be made to overcome the current difficulties in its designated negotiation forum, the Conference on Disarmament (CD).

All these activities are motivated by an interest in more transparency of fissile materials and the desire to make the disarmament process irreversible. The interest of many actors in universal measures and safeguards is rising. For example, any German participation and collaboration in disposition projects is only possible under international safeguards.[18] To date, however, the United States is the only nuclear weapon state that has already put some declared excess material under IAEA safeguards. The Moscow P8 nuclear summit in spring 1996 did agree that IAEA safeguards should be applied to such material "as soon as practicable"[19]. But this wording weakens the potential commitment substantially because the "practicable" allows wide interpretations and has the potential to change the meaning into "never." Neverthless, if vigorously pursued, the objectives outlined in this official statement by the P8 can mark a historic turn in the traditional structure of the global nonproliferation regime.

## The stalemate at the CD

Lessons have been learned from the CTBT negotiations that will strongly influence any future FMCT negotiations. They are the major reason for the current deadlock, because in contrast to the start of the CTBT

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13 T. Perry, "Stemming Russia's Plutonium Tide: Cooperative Efforts to Convert Military Reactors", *The Nonproliferation Review* 4 (Winter 1997), p. 104

14 GAO Report, note. 9.

15 The disposition efforts are still in their infancy. The still most advanced disposition project is the proposed French-German-Russian cooperation on the fabrication of MOX from disarmament material whose technical feasibility has been demonstrated by several studies and whose acceptance has been endorsed by a meeting of the P8 Nonproliferation Experts Group in November 1996. See: A. MacLachlan, "French, Germans and Russians aim for 1998 decision on MOX plant"; *Nuclear Fuel*, Dec. 2, 1996; National Academy of Science and German-American Academic Council (GAAC), *U.S.-German Cooperation in the Elimination of Excess Weapons Plutonium*, (Washington July 1995). The idea of making use of the abandoned German MOX facility at Hanau which would have secured maximum transparency was not pursued because of lacking public acceptance. See: A. Schaper, "Using Existing European MOX Fabrication Plants for the Disposal of Plutonium from Dismantled Warheads", in: W.G. Sutcliffe, ed., *Selected Papers from Global '95*, (UCRL-ID-124105, Livermore, June 1996), p. 197

16 Department of Energy, *Trilateral Initiative on Verifying Excess Weapon Origin Fissile Materials*, (Press Statement, November 8, 1996); B. Pellaud, "International Verification of US and Russian Materials Released for Storage and Disposition", Paper presented at the International Policy Forum: Management & Disposition of Nuclear Weapons Materials, Landsdowne, Virginia, 12 February, 1997.

17 H. Müller (ed.), *Nuclear Export Controls in Europe*, (European Interuniversity Press, Brussels 1995)

18 See GAAC study, note 15.

19 Moscow Nuclear Safety and Security Summit Declaration, April 20, 1996

negotiations, now the conflicts lay on the table. They can be summarized as *nuclear disarmament versus nuclear nonproliferation*, although the majority of the negotiation partners wanted both.[20] The nuclear weapon states (NWS) were mainly motivated by the prospect of nonproliferation, e.g. the curbing of any future nuclear weapon developments by the states outside the NPT (SON), including the development of thermonuclear designs in the cases of India, Israel, and Pakistan. At the same time, they were interested in minimizing their own restrictions as much as possible.

India, a major target of the efforts by the NNWS, had the perspective that the NWS demanded far more from the SON than they were willing to give in return. Throughout the negotiations, it stressed the disarmament component, in a way that during the two and a half years became more and more radical. It culminated in the demand for a timetable for comprehensive nuclear disarmament. This goes far beyond any traditional perception of what constitutes a test ban, and was unacceptable to the other participants, mainly because it was unacceptable for the NWS and everybody knew that insisting would deadlock the negotiations.[21]

The value of the FMCT as an arms control and disarmament measure, beyond its value as a non-proliferation measure, has been underestimated in the NWS – partly deliberately. An FMCT would involve considerable administrative effort to implement, and would require changes in attitudes and behaviour, especially regarding multilateral verification within the NWS. Originally, when it was proposed by Clinton in 1993, it was probably perceived in the U.S. as an easy arms control success, just cementing the end of production of military plutonium (Pu) and highly enriched uranium (HEU) that has taken place anyway, and with verification only on former production facilities. It is likely that the consequences of which verification would be necessary and how many undissolved questions might cause trouble was studied only later. The emphasis on non-proliferation and the refusal to address the topic of disarmament has thus been a useful means, for some constituencies, of lessening the likelihood that an FMCT will ever be negotiated.[22]

## What could be the scope of an FMCT?

At the center of disputes already during negotiations for the FMCT mandate was its potential scope. There is a wide variation of possibilities covering bans or production bans on a range of different material categories. The following Pu and HEU categories of utilisation can be distinguished:

1. military direct use material in operational nuclear weapons and their logistics pipeline,
2. military direct use material held in reserve for military purposes, in assembled weapons or in other forms,
3. military direct use material withdrawn from dismantled weapons,
4. military direct use material considered excess and designated for transfer into civilian use,
5. military direct use material considered excess and declared for transfer into civilian use,
6. direct use material currently in reactors or their logistics pipelines and storages, and
7. irradiated Pu and HEU in spent fuel from reactors, or in vitrified form for final disposal.

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[20] On the interests and results of the CTBT negotiations see: A. Schaper, "Der Umfassende Teststoppvertrag: kurz vor dem Ziel – oder gescheitert?", HSFK-Standpunkte, Nr. 7, August 1996; An English version is: A. Schaper, "The Comprehensive Test Ban Treaty From a Global Perspective", in: M. McKinzie (Ed.), The Comprehensive Test Ban Treaty: Issues and Answers, Occasional Paper #21, Cornell University, Peace Studies Program, June 1997.

[21] See P. Bidway, A. Vanaik, "After the CTB... – India's intentions", *The Bulletin of the Atomic Scientists*, p. 49, March/April 1997.

[22] I owe this point to W. Walker.

Large quantities of materials are neither inside weapons nor declared excess. So far, there are no legal obligations for NWS for limitations, declarations, or international controls of any of the military categories beyond national legislations. The following table gives an overview on how much material is in categories 1-5:

| | *USA* | *FSU* | *France* | *China* | *UK* | ***average total*** |
|---|---|---|---|---|---|---|
| Inside weapons | | | | | | |
| Pu | 28 – 37 | 38 ± uncertainty | 1.5 – 2 | ? | 1.5 ± uncertainty | **75** |
| HEU | 140 – 280 | 165 – 330 | 7.4 – 14.8 | 9.0 – 13.5 | 3 – 6 | **485** |
| Unknown destination | | | | | | |
| Pu | 10 – 20 | 0 – 76 | 1.5 – 5 | 0 – 6 | 0 – 2.? | **77** |
| HEU | 126 – 395 | 0 – 667 | 2 – 23.8 | 1.5 – 16 | 0 – 7 | **553** |
| Declared excess | | | | | | |
| Pu | 38.2 | 50 – 100 [a] | 0 | 0 | 0 | **74** |
| HEU | 174.3 | 500 [b] | 0 | 0 | 0 | **674** |
| Under safeguards | | | | | | |
| Pu | 2 [c] | 0 | 0 | 0 | 0 | **2** |
| HEU | 10 [c] | 0 | 0 | 0 | 0 | **10** |
| **Total** | | | | | | |
| Pu | 85 ±2% | 131 ± 25 % | 5.0 ± 30 % | 4.0 ± 50 % | 3.1 ± 20% | **228** |
| HEU | 645 ± 10% | 1025 ± 30% | 24 ± 30% | 20 ± 25% | 8 ±25% | **1722** |

Numbers for total, inside weapons, and U.S. declared excess from Albright/Berkhout/Walker[23].
[a] Not officially declared, but working figures used in disposition studies of Russian Pu, e.g. the Joint U.S./Russian study[24].
[b] Russia has agreed to sell 500 t weapon grade HEU to the USA over 20 years.
[c] from F. v. Hippel[25].

*Table: Inventories of Pu and HEU inside and outside operational nuclear weapons (illustrative estimates).*[23] *The units are tons.*

The potential variations of an FMCT scope with different degrees of obligations are:

***The original approach*** which bans just future production without measures on existing materials: This was the original U.S. proposal. It would cement what is already almost reality but it would leave huge quantities of already existing material untouched, thereby still allowing rearmament to the levels of the Cold War.

***The good-will-approach*** which strives for reductions of the amount of military material: It would also ban the transfer of material back to military uses, once it has become civilian, and it would register upper limits that are allowed for undeclared material. In addition to the original approach this approach would include the following:

a) the ban of future production,

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[23] D. Albright, F. Berkhout, W. Walker, *Plutonium and Highly Enriched Uranium 1996 – World Inventories, Capabilites and Policies*, SIPRI, Oxford Univeristy Press, 1997

[24] Joint U.S./Russian Plutonium Disposition Study, prepared by the Joint U.S.-Russian Plutonium disposition Steering Committee, September 1996

[25] F. v. Hippel, "A Program for Deep Cuts and De-Alerting of the Nuclear Arsenals", Paper prepared for the 5th ISODARCO-Beijing Seminar on Arms Control, Cheng-Du, China, 12 - 15 November, 1996

b) the ban to transfer material back to military uses, once it has become civilian,

c) the register of upper limits that are allowed for undeclared material, e.g. material above this limit must be declared excess, e.g. it must be put into category 5 of the above list. A variant or complement could be an International Nuclear Weapons Register.[26]

***The one-way-approach*** which would make sure that the amount of military material is not increased and more obstacles against a reversal would be inserted: This could be accomplished by the following additional obligations:

d) the ban to withdraw material from international safeguarding. This goes beyond what is currently legal under the voluntary safeguards agreements with the IAEA which allow the withdrawal of materials from safeguarding "in exceptional circumstances".[27]

e) the obligation to put declared excess material (category 5) under international safeguards within a defined timetable.[28] The definition of the timetable should be more explicit than the wording of the Moscow P8 nuclear summit declaration "as soon as it is practicable to do so". A timetable will probably be necessary because there might be specific problems at former military sites that must first be solved.

The advantage would be that the control over fissile materials would be steadily increased and would thereby better serve disarmament and nonproliferation. Also related activities would be confirmed and strengthened, especially the already ongoing efforts to submit Russian and U.S. declared excess materials under IAEA safeguards.

***The disarmament approach*** which would create mechanisms for reduction: Instead of building in only some political pressure not to keep military stocks too large, some more binding disarmament obligations would be created when the scope would also cover the following item:

f) the obligation to adjust the upper limits of undeclared material to future nuclear disarmament treaties, e.g. a START-III treaty and others that might come. This implies that these limits must be justified in negotiations on their quantities and made plausible with rough estimates of how much is averagely needed for one warhead, as soon as the next nuclear reduction treaty is concluded. This will create pressure to keep them low. As a consequence, the limits will not be much larger than the actual need, e.g. in weapons and in reserve for military purposes (categories 1 and 2). Large ambiguous stocks considered excess but not declared so (categories 3 and 4) will be delegitimized as a consequence.

***The Indian approach*** which would be a time-bound framework for comprehensive nuclear disarmament: This is what India now asks as a condition for its cooperation. In the logic of the above list of scope elements, another element would be added:

g) The obligation to reduce all military material in a defined time down to zero.

This has been unacceptable for the NWS and presumably also for Israel during the CTBT negotiations and is equally now. This demand is the reason for the current deadlock in the CD. In fact, an FMCT has always been understood as a step towards nuclear disarmament and as a disarmament symbol, but not as the final nuclear disarmament treaty. Time-bound proposals are always problematic where substantial problems have to be

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[26] K. Kinkel, "German 10-point initiative for nuclear nonproliferation", Bonn, 15 December 1993. For the significance of this proposal and the reaction of the NWS see: H. Müller, "Transparency in Nuclear Arms: Toward a Nuclear Weapon Register", *Arms Control Today*, October 1994.

[27] T. Shea, "On the Application of IAEA Safeguards to Plutonium and Highly Enriched Uranium from Military Inventories", *Science & Global Security*, Vol. 3, p. 223, 1993.

[28] This corresponds to the proposal of an International Register of Plutonium and HEU: D. Albright, F. Berkhout, W. Walker, *World Inventoy of Plutonium and Highly Enriched Uranium 1992*, SIPRI, Oxford University Press, 1993.

solved. They neglect the obstacles and problems that have hitherto resisted nuclear disarmament. Proponents of timetables for nuclear disarmament refuse to first approach solutions for these problems.[29]

## Verification and nondiscrimination

Although many verification scenarios are possible, reaching from just a fence around former military production facilities to complete new global concepts, even the minimum requirements are high: Even in case the scope is only the ***original approach***, e.g. only a ban on future production (e.g. only item *a)* of the above list), it still has to be ensured that material produced later is not simply declared as earlier production. The consequence is that all civilian and military materials being produced after entry into force must be put under safeguards. If the civilian material would be left out, it could later be declared as earlier production and diverted into military use. Verification must cover not only nonproduction but also nondiversion at least of civilian materials produced later. This is the same as what is already being verified in NNWS under full scope safeguards, with the only exception that NNWS are not allowed the possession of unsafeguarded materials from earlier production. In other words, no material must be diverted to nuclear weapon use, equally for all members of a *nondiscriminatory* FMCT, except that the NWS and states outside the NPT (SON) are allowed a "black box".

The logical conclusion can be drawn that a similar verification system, e.g. full-scope safeguards, would also be appropriate and necessary for an effective FMCT verification. They do not only cover direct use materials and their major production facilities which are reprocessing and enrichment plants, but also the next category, special fissionable materials which also include low enriched uranium and spent fuel. Even source material is controlled, though to a less intrusive extent.

The question arises why different standards for the NPT or for the FMCT should be set, although the verification task is the same. Why should a lower standard in the one case be satisfactory while it is not in the other? It can be argued that as long as a NWS has not disarmed down to zero, some warheads more or less do not make much difference, and secondly, as long as a NWS's black box of unsafeguarded materials is not empty, it makes less a difference if small diversions remain undetected. However, the goal of verification is the deterrence of noncompliance by creating a sufficiently high detection risk. In case of the NPT, the trust into the NNWS is not high enough to renounce full scope safeguards. Why should NWS be more trusted not to divert fissile materials for nuclear explosive purposes than NNWS? A provocative variant of this question is: who can be more trusted, those who have renounced nuclear weapons, or those who still maintain nuclear arsenals and huge quantities of unsafeguarded weapon materials? At stake is not just a question of technical feasibility but more principally, the question of the importance of treaty compliance. It would be discriminatory if there were two different classes of state parties who are granted two different degrees of trust. But so far, full scope safeguards are still difficult to accept for NWS.

It is concluded here that the time is ripe. Although the current reality is the contrary of a consensus, the topic can hardly be removed from the agenda any more. An FMCT would put this complex of universal fissile material control reforms into the arms control context. The major benefit would be reinforcement of all other efforts, and the general strengthening of the nonproliferation regime. The FMCT would act as policy driver to ensure that verification measures are developed and applied in NWS.

The FMCT is a major next step on the nuclear arms control agenda, explicitly mentioned in the Principles and Objectives. It is a key element of nuclear nonproliferation and disarmament policy. In principle, its verification is possible, and far less contested than was once the verification of a testban. It would constitute the policy driver for more transparency and irreversability that are desired and necessary anyway. There are no technical,

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[29] W. Walker, "Evolutionary Versus Planned Approaches to Nuclear Disarmament", *Disarmament Diplomacy*, p. 2, May 1997; H. Müller, "Far Reaching Nuclear Disarmament", in *UNIDIR Newsletter*, Nr. 31/1995, p. 31-38.

but only political obstacles that can be overcome if the political will is there. It is important that the idea of the FMCT is not lost, even if short time progress is unlikely.

3rd International Forum on Nuclear Non-Proliferation
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# TAKING STOCK: PROLIFERATION AND PLUTONIUM

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For the purpose of my remarks, I wish to distinguish three faces of proliferation in order to focus on existing international preventative mechanisms and additional steps that might be undertaken:

1. Use of forcible seizure, theft by stealth, bribery or extortion to acquire nuclear weapons, components or fissile material from a State possessing such commodities. Preventing this form of proliferation is first and foremost the responsibility of the State itself, effected through stringent laws coupled with protective measures and strict enforcement. Regional and international cooperation is essential to ensure that no nation or sub-national group is able to acquire such commodities, nor is able to find refuge.

2. Creation of an indigenous clandestine nuclear weapon development program, perhaps in violation of treaty commitments, perhaps not. Preventing this form of proliferation is accomplished by restricting access to materials, goods and services that could assist a State with such an intention, and of efforts to discover such programs before they reach fruition.

3. Diversion of indigenous or imported materials, goods or services from declared peaceful use to the development or manufacturing of nuclear weapons. Diversion would complement clandestine activities in such a case. The involvement of the "peaceful" industrial activities could range from providing a basis for training specialists in related technologies to providing a cover for bypassing supplier restrictions to providing the actual fissile materials to be used in nuclear weapons. The "peaceful" activities might be conceived and created as a cover for the weapons work, or may already exist when a State decides to acquire nuclear weapons. Preventing this form of proliferation is accomplished by restricting access to sensitive materials, goods and services, and through regional and/or international verification to ensure that peaceful nuclear activities serve no malevolent purpose.

Coping successfully with the general "threat" of nuclear weapons proliferation requires universal recognition of the fact that real threats regarding the use of existing nuclear arms, and real threats of proliferation – when they are known – endanger peace and demand corrective steps.

Nuclear weapons were invented during World War II, and used against this country, in which we are today privileged to revisit the past and to contemplate the future. We come at a time of promise. We might marvel at the remarkable accomplishments over the past ten years in controlling nuclear proliferation and in stopping and reversing the nuclear arms race. With the end of the Cold War, the threat of global nuclear warfare has receded and nascent but significant steps have been taken towards the ultimate elimination of nuclear weapons. Progress has been most evident in the step-wise reductions of nuclear arms agreed between the Russian Federation and the United States and in the Comprehensive Test Ban Treaty.

Closer to the topic of this Forum, over the past ten years, clandestine nuclear weapon development programs were stopped in a number of States. In some cases, the States concluded independently that their security would not be enhanced by acquiring nuclear weapons and so they stopped their programs – unilaterally or in concert with neighboring States (e.g., South Africa, Argentina, Brazil). Other States were compelled to stop through outside influence (e.g., Iraq and the Democratic People's Republic of Korea). Some of those programs involved the production of plutonium, others highly enriched uranium. In some cases, peaceful nuclear activities served as a means to conceal their true intention.

Until the extent of Iraq's clandestine nuclear weapons program became clear, IAEA safeguards had focused on declared facilities and material. Iraq and later experience in the Democratic People's Republic of Korea compelled States to conclude that the safeguards system needed to confront more directly the threat of clandestine operations, in facilities where inspections were routinely carried out and in undeclared facilities which may be far away from locations where IAEA inspectors were allowed. At the time, the Chemical Warfare Convention was being concluded and provisions incorporated in that Treaty went substantially beyond the rights embodied in comprehensive IAEA safeguards agreements.

Reacting to Iraq and the DPRK, a project (initially known as Project 93+2) was undertaken to strengthen the effectiveness and efficiency of the IAEA safeguards system. The first series of improvements fall within the legal provisions of existing safeguards agreements, while a second series require expanded legal authority to be secured through a protocol additional to the comprehensive IAEA safeguards agreements.

The first series of improvements in the Strengthened Safeguards System includes requirements for earlier notifications and information on the construction of new facilities and modifications to existing facilities, the application of environmental sampling within facilities where inspections are carried out, access to and use of additional information regarding the nuclear activities within a State, and the adoption of advanced technologies including unattended assay systems which are integrated into the material transport systems in several Japanese plutonium facilities.

The second series of improvements address limitations on access and requires States to submit expanded declarations on nuclear-related activities and to accept controls on equipment and certain materials which could be used in the manufacture of nuclear weapons. It also provides for expanded use of environmental sampling, and opens possibilities for the use of modern telecommunications as a means to enhance the effectiveness and efficiency of IAEA safeguards. It is also foreseen in the additional protocol that wide area monitoring systems may be adopted in the future to increase the sensitivity of detecting clandestine reprocessing plants, and perhaps enrichment facilities.

The second stage improvements require additional legal rights, as noted above. Last May, the IAEA Board of Governors approved a model for the protocols additional to comprehensive IAEA safeguards agreements, and in September, States began signing the protocols. At present, seven States have signed and ratification proceedings are underway. In the Pacific basin, Australia has signed and inspections under that Protocol are expected to begin this year.

When these measures are adopted, the Strengthened Safeguards System, as it is called, will be fully implemented. The IAEA safeguards system will be more effective at being able to detect steps underway by States in relation to the development of nuclear weapons, should such steps be taken. Moreover, the control mechanisms restricting access to sensitive nuclear technology will continue to tighten, making it increasingly difficult to obtain outside assistance in developing nuclear weapons. As a result, international capabilities in relation to the second and third threats of proliferation will have been substantially improved.

International measures to stop the spread of nuclear weapons will be aided further as progress continues in related arms control measures. As the Russian Federation and the United States ratify and implement START II and begin negotiations on START III, and as other nuclear weapon States begin to take comparable steps towards the reduction of their respective arsenals, the commitment to the promise of Article VI of the NPT will become tangible. Such progress can only bind the community of NPT Parties more closely to the shared goal of the full and final elimination of nuclear weapons. Talks are now underway between the United States, the Russian Federation and the IAEA under a "Trilateral Initiative" to establish a verification system for weapon origin fissile materials, with the understanding that the measures applied in those States may also find acceptance in the remaining nuclear weapon States.

Progress towards the implementation of the provisions of the Comprehensive Test Ban Treaty will also help to solidify international support for the eventual elimination of nuclear weapons. States party to comprehensive IAEA safeguards agreements have always been subject to a complete ban on testing nuclear weapons, and in fact, non-nuclear weapon States party to NPT or the Tlatelolco Treaty or the Rarotonga Treaty or the Pelindaba Treaty or the Asean Treaty, are already banned from any activities in relation to the development or acquisition of nuclear weapons. The CTBT was intended to serve several purposes, to stop further development in nuclear weapon States, to block threshold States from avenues to produce sophisticated weapons, and to make explicit the express bans on testing that all Parties accept. At the present time, the CTBT provisions for entry into force are blocked: the Treaty's provisions require that the five acknowledged nuclear powers (America, Britain, China, France and Russia) sign, together with the three threshold States (India, Israel, Pakistan). Not all of the required States are unwilling to sign, and hence, the Treaty's provisions for entry into force cannot be met. Even without entry into force, however, the CTBT will constrain such ambitions. Concluding the Treaty carried with it the moral commitment of States to observe its precepts, and global opinion would be outraged by any further testing, whether by a State that has signed the Treaty, or a hold-out. Moreover, the verification system for the CTBT is being established by the newly created Comprehensive Test Ban Treaty Organization which shares headquarters accommodations with the IAEA in the Vienna International Centre. The verification system will include four global networks to detect evidence of nuclear testing, and that capability, while inhibited somewhat by the refusal of the threshold States to participate, will make it very difficult to hide weapons testing. While the legal powers granted through the Treaty may be frustrated, especially those in relation to challenge inspections, the CTBT will be substantial force serving to frustrate the expansion of existing arsenals and the development of new ones.

Are these proliferation control measures enough? If not, what more is needed?? Will further measures gain international support both in terms of the added assurance they provide and the funding required for their implementation???

Of all of the tendentious issues that might motivate further steps, there are two that merit special consideration. The first is the peaceful use of plutonium, and the second are steps that could accelerate progress towards nuclear disarmament, specifically, a fissile material production ban.

In the early years of nuclear power, closing the fuel cycle was accepted as part of a strategy to generate electricity that, in the words used at the time, would be "too cheap to meter." Under Presidents Ford and Carter, the idea of using plutonium came to be viewed in relation to concerns that widespread access to plutonium would exacerbate the challenge of curtailing proliferation. Over the intervening years, the nuclear world divided itself into two camps: those that favor reprocessing and plutonium usage and those favoring forgoing such a route. Technical problems slowed the development of breeder reactors and the costs of reprocessing, mixed oxide fuel fabrication and waste management grew to provide economic advantages to once-through fuel strategies. Several States determined that the benefits of plutonium use, especially recycling in light water reactors, was not essential at present and deferring such programs would not a have a substantive impact on meeting national energy requirements. Other States continued to pursue the plutonium option, for diverse reasons. Japan asserts that its lack of natural energy resources and difficulties in finding suitable arrangements for disposing of nuclear waste compel Japan to embrace the plutonium option. States pursuing the peaceful use of plutonium may believe that the risk of proliferation may be overstated and that energy resource management arguments and the waste disposal advantages justify the peaceful use of plutonium.

The peaceful use of plutonium is clouded by the fact that the difference between peaceful and military plutonium is relative, not absolute, and thus any non-nuclear weapon State embracing the peaceful plutonium option invites the concern of other States and non-governmental organizations, especially in the absence of compelling need or economic advantage. The plutonium produced as a natural byproduct of the production of electricity through nuclear energy is certainly a potent energy source. When extracted from spent fuel, its use as a replacement reactor fuel reduces the demands on natural resources and decreases the volume of hazardous waste resulting from nuclear power. By contrast, plutonium produced for use in nuclear weapons consists predominantly of the isotope Pu-239, generally in excess of 90%. Similar plutonium might be created in the production of electricity[1], but for the most part, the fraction of Pu-239 is substantially less in peaceful plutonium than in military plutonium. It is known that the physical properties of all plutonium isotopes are such that virtually any plutonium with any mixture of isotopes might be used to create a nuclear explosive, but as the fraction of Pu-239 decreases, the engineering demands become increasingly complicated by the spontaneous emission of neutrons and heat. There is no way to denature plutonium, and hence no way to rule out the use of "peaceful plutonium" in nuclear weapons. If a State were to decide to divert plutonium from peaceful nuclear activities to a weapons program, the intensified IAEA safeguards should deter such steps, and if the State persists, provide an early warning before they succeed. The CTBT, too, in spite of the fact that it may not enter into force for some time, carries a very broad international commitment against testing, and the verification system, while it will not provide the full sensitivity until all monitoring stations are up and operating, will provide a capability to detect and pinpoint the most likely nuclear explosions that might be carried out.

What can be done beyond that? I would like you to picture in your minds two States engaging in the peaceful use of plutonium. One is innocent, with no aspirations other than legitimate activities intended to meet its national energy needs in a conscientious manner. The other State is intent on acquiring nuclear weapons, using "peaceful" nuclear programs to avoid detection as long as possible. I believe that many of the outward indications from the two States would be difficult to distinguish. It seems to me, then, that with this duality in mind, a State pursuing a strictly legitimate program must seek to distinguish its indicators from a State following a malevolent course. If the State considers that with all factors considered, peaceful use of plutonium is still preferred, what practical means are possible to mitigate the suspicions that might otherwise arise?

Three thoughts come to mind:

First, sign and ratify the Protocols Additional to Safeguards Agreements. Non-nuclear weapon States will demonstrate that they are prepared to make the additional commitments and allow expanded inspection access, and more than any other step, this should provide the assurance that only a more effective verification system can offer. Nuclear weapon States will demonstrate their willingness to accept more extensive commitments to non-proliferation and to create a climate which could lead to nuclear arms reductions.

Second, take steps to make the programs transparent to the world. IAEA safeguards are carried out under agreements that provide that information submitted by States or gained in the course of inspections is confidential. Recent progress has made by a number of States pursuing peaceful plutonium programs towards releasing information and that information should help. Each State – especially each non-nuclear weapon State – pursuing a program that is prudent and legitimate needs to find ways to make its activities and intentions open, if it wishes to mitigate suspicions.

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[1] The plutonium produced in blanket assemblies in breeder reactors and in on-load power reactors permitting refueling during normal power production more closely resembles "weapon-grade" than "reactor grade" plutonium.

Third, minimize the accumulation of stocks of separated plutonium as might arise when utilization gets out of sync with production. In situations where such accumulations arise, steps should be taken to defer reprocessing and to continue to produce mixed oxide fuel elements as a means of making the plutonium less immediately usable.

Let me turn lastly to the prospects for a fissile material production cut-off treaty (FMCT)[2] and what its impact might be on proliferation and the peaceful use of plutonium. I cannot imagine that nuclear weapons can be eliminated without eliminating existing stocks of fissile materials and banning the production of future stocks. I believe that the FMCT is thus essential as a step towards limiting the ability of the nuclear weapon States and the threshold States to produce nuclear weapons. Together with a verification systems for weapon-origin fissile materials, the foundations of a comprehensive scheme would be set in place for international verification of progress towards nuclear disarmament. It may be possible to go beyond that later on, to negotiate proportionate reductions in the fissile material stocks remaining available for use in nuclear weapons, for example, but the FMCT is necessary and probably essential as the next step, and probably the only step that might gain universal support.

Negotiating the FMCT will require thorny issues to be resolved. Some of those issues will affect all parties, while others would affect only the nuclear weapon States and threshold States. Provisions for non-explosive military uses of fissile material will be a problem, as will existing stocks non subject to IAEA verification (stocks set aside for military use and fissile materials intended for, or arising from peaceful nuclear programs). In addition to imposing controls on facilities used in the past for the production of fissile materials for military use, at the least, controls should extend under an FMCT to all enrichment and reprocessing facilities, and to all facilities that would store, process, use or dispose of fissile materials.

What impact an FMCT would have in non-nuclear weapon States is not at all clear, since there is no such treaty nor even suggested texts in circulation. There might be impacts, for example, if challenge inspections were to be adopted, or specific linkages to the CTBT verification system, or if the conditions on the confidentiality of reporting findings were to differ. There might also be confidence building measures incorporated in the FMCT that could influence judgments on the prudence of proposed peaceful uses of plutonium, and transparency measures that might be adopted. The FMCT might also serve the purpose of strengthening the protection of plutonium, and the controls on exports of sensitive materials and technology, thereby addressing the first two proliferation threats.

All of these steps could contribute to preventing the proliferation of nuclear weapons – especially the third threat – while assuring that the peaceful use of plutonium does not raise unacceptable risks. It is rather simple to conjure up notions of proliferation and the means that might be taken against them. The world picture today is rather promising, and in such times, there may be a reluctance to accept new obligations or to create costly verification arrangements. While the ideas I indicated would contribute to preventing proliferation, encourage further nuclear arms reductions, limit nuclear weapons production capabilities, and would create conditions under which legitimate and prudent peaceful uses of plutonium could proceed than at present, at the end of the day, it would be anyone's guess whether or not the steps suggested were in fact necessary, or whether they go far enough. I am convinced that the costs will continue to be modest in comparison with the immense consequences proliferation might bring about, and of the benefits to be realized through the prudent and legitimate peaceful utilization of plutonium.

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[2] Fissile materials include highly enriched uranium and uranium-233, for example. I have limited my considerations to plutonium in these remarks.

# Dingli Shen

**(China)**

# SESSION 3

Seongwhun Cheon

(Korea)

**KEDO, its achievements and current issues**
by Dr. Young-Jin Choi, KEDO


Abstract

Without KEDO, the nuclear non-proliferation regime might have suffered a serious, if not fatal, blow. During its two and a half years existence, KEDO has proved itself to be a successful mechanism thwarting a nuclear arms race among Northeast Asian countries and its spread beyond. The provision of heavy fuel oil to North Korea, costing about $60 million a year, is the key element sustaining this scheme.
The other mandate of KEDO, i.e., the provision of two nuclear reactors to North Korea, is the centerpiece of the deal. The construction of reactors is serving, it has been revealed in the course of implementation, a larger scheme. This is confidence building among Northeast Asian countries, a rare experience for them. A $5.2 billion project, involving thousands of workers and millions of tons of material, cannot succeed without a *modus vivendi* between North Korea and the KEDO countries. No wonder that the project has proven to be much more challenging than anyone has imagined.
The challenges are two-fold: dealing with North Korea and cooperation among KEDO countries. Solutions have been found to seemingly intractable situations, but at the same time many unexpected new problems are constantly emerging. It is a fascinating process and the stakes are enormous. But there is no guarantee that it will succeed. As the construction of reactors begins in earnest, KEDO needs more care and attention. Its ultimate success or failure depends upon the evolution of the inter-Korean relationship externally, and internally upon the complex leadership emanating from triangular cooperation among Seoul-Tokyo-Washington.

**The North Korean nuclear question and Geneva Agreed Framework**

When both China and Russia established diplomatic relations with the Republic of Korea, the DPRK found itself suddenly abandoned by its former allies and thus completely isolated. Pyongyang, at the same time, was faced with an economic failure. Moreover, it became evident that North Korea could not live on its militarist unification slogan: its *idée fixe* had become obsolete because it lacked the means to achieve it. To its horror, Pyongyang had seen its world reversed: instead of hoping to unify the South on its terms, North Korea had to fear unification by South. It wanted to become a North Vietnam but instead became more like East Germany-- the gravest crisis since its foundation half a century ago. The regime's very survival was at stake. North Korea responded to this crisis with a failing strategy, opting for nuclear weapons. In March 1993, Pyongyang declared that it would withdraw from the NPT regime.

It is a failing strategy because Northeast Asia, arguably the most dangerous flashpoint in the world, cannot allow intra-regional nuclear competition. Reasoning with Pyongyang proved very taxing. Amid frustration, the North Korean nuclear problem almost provoked a war in the Summer of 1994. The nuclear option could not be tolerated, even at the risk of a war. The rationale was proliferation, regional and global. North Korea's going nuclear would force South Korea to embark on the same path and eventually Japan also. And this trend will spread beyond Northeast Asia, dealing a fatal blow to the NPT regime. North Korea had to opt out. But North Korea had been a hostile country to the West. A deal, more than persuasion, was necessary.

After much ado, the Geneva Agreement was reached in October 1994. "Freeze and conversion" were the main themes and a *quid pro quo* concept was introduced:
-North Korea would receive annually 500,000 metric tons of heavy fuel oil (HFO) in exchange for a freeze of 5 MW, 50 MW and 200 MW graphite-moderated reactors (with related facilities) in operation or in construction; and
-North Korea would receive two 1000 MW light water reactors (LWR) in exchange for the dismantlement of the above-mentioned three reactors and related facilities. In other words, a conversion from proliferation-prone reactors to proliferation-resistant ones.

The Geneva Agreement thus successfully thwarted the unacceptable North Korean nuclear option. Regrettably, however, its achievement and contribution to the NPT regime and to the peace and stability of Northeast Asia has not been fully appreciated. Why? Perhaps because it was a *deal*, that is, a compromise solution rather than a complete victory. Perhaps because a *quid pro quo* concept was introduced. But vague complaints and criticism should not obscure the essential achievement and contribution of the Agreed Framework. The proof is that nobody has come up with a better alternative, barring a surgical strike, in other words, a second Korean war.

Why was a surgical strike, or rather the threat of it, out of question? Why was no better alternative to the Geneva Agreement possible? This was because of the very specific and complex nature of the North Korean problem of which the North Korean nuclear question is only a part. Without addressing the former, it was not possible to properly address the latter. More than one and a half years were necessary for the protagonists of the Agreed Framework to realize it. The problem they were dealing with exceeded the nuclear domain. This was also the road to be taken from the Agreed Framework to the creation of KEDO in July 1995. Legally, KEDO's mandate is limited to the North Korean nuclear question. Yet, KEDO is bound to deal with the very essence of the North Korean problem and contribute to the solution of it, without which KEDO's mandate can never succeed. KEDO has become an interim mechanism, *par excellence,* for dealing with the North Korean problem.

**KEDO as an interim mechanism for North Korean problem**

At the heart of the KEDO's mechanism lies North Korean problem: to survive, North Korea must deal with South Korea but it fears the consequences of the deal. No country other than South Korea and no companies other than South Korean companies are willing to take the high risks accompanying massive investment in North Korea. But Pyongyang is very fearful of the destabilizing effect these investment and reform measures would bring to its population. Hence North Korea's continued refusal to deal directly with the South. As long as Pyongyang harbors instinctive fear of Seoul, the only practical solution is indirect contacts, i.e., a camouflaged inter-Korean dialogue.

In fact, as KEDO assumed the immediate responsibility to negotiate the LWR Supply Agreement with DPRK, KEDO proved to be a very useful mechanism for inter-Korean dialogue, albeit with the U.S. as a third party interposed. The three-month long negotiation between September and December 1995 in New York was successfully concluded on three premises: 1) South Korea's central role in the LWR project and North Korea's acceptance of it; 2) America's valuable leadership/intermediary role and Japan's significant role especially in the form of its magnanimous financial contribution; and 3) that the LWR project could proceed only with a favorable inter-Korean atmosphere.

Such premises were natural outcomes because of several factors: 1) South Korea would bear the bulk of financing and the reactors to be built would be a South Korean model with KEPCO (Korea Electric Power Corporation) as the prime contractor; 2) yet, as long as North Korea harbors an instinctive fear of direct contacts with the South, an intermediary/leadership would be necessary; and 3) the reactors would be constructed by South Koreans with the help of North Koreans.

KEDO and DPRK have been following up the LWR Supply Agreement with negotiations on a dozen implementing Protocols. Conclusion of six crucial Protocols enabled KEDO to break ground in August 1997 at Kumho, the nuclear site on the northeast coast of DPRK. In the process, the LWR project, quite naturally, has increasingly become inter-Korean in nature. The project takes place on Korean soil, with mostly South Korean money and by almost exclusively South and North Korean people. How could it be otherwise?

Like it or not, intended or not, KEDO's business will be directly affected by the inter-Korean relationship. And KEDO's success or failure, in turn, will favorably or adversely affect the inter-Korean relationship. The submarine incident of September 1996 was a case in point: the incident completely froze KEDO activities for three months but the KEDO project was instrumental for the solution of the incident.

Thus to understand KEDO and to fathom KEDO's future, it is necessary to understand the inter-Korean relationship, which is marred by dilemmas and replete with myths.

*Pyongyang's dilemma.* Why was North Korea refusing to deal directly with the South? North Korean avoidance of direct contact with the South or its refusal to enter into an inter-Korean dialogue or its confrontational attitude was nothing new. It had been Pyongyang's consistent policy line. Most dialogues, both proposed and real, between the two Koreas on various levels in 1970s and 1980s served propaganda purposes. As long as Pyongyang maintained its irredentist unification policy, it could not be otherwise.

If there were exceptions, one can count two: the first one occurred in 1972 in the wake of the Sino-American rapprochement; the second took place in 1991 in the wake of the demise of the Soviet Union. In 1972, Pyongyang agreed to a dialogue to enhance its position on a par with Seoul. No sooner had Pyongyang seen its position enhanced than it retreated from the dialogue table. Having seen Hanoi triumph, it also saw continuing dialogue as an impediment to its irredentist reunification policy line. In 1991, Pyongyang sought an assurance that it was still on a par with Seoul. But soon, Pyongyang saw an ongoing dialogue as a threat to its regime. The apparent refusal to engage in dialogue is the same but the contents are reversed: from offensive to defensive. There is the rub.

On the defensive, Pyongyang's aggressive unification posture had become a fiction. But the entire regime, political structure, ideological orientation had been built on the premises of militarist unification. Making an aboutface, if any, would not come easy. By design or by inertia, Pyongyang would maintain for a considerable time its confrontational attitude towards Seoul. At the same time, as eloquently demonstrated by the KEDO project, Pyongyang had to engage with Seoul. This ambiguous situation created a dilemma for Pyongyang: between decades-old confrontation and newly required engagement.

When Pyongyang was on the offensive, engagement towards Seoul was a public relations matter at best or simple duplicity at worst. But now that Pyongyang is on the defensive, its engagement towards Seoul has become as genuine as its confrontational attitude. As long as Pyongyang remains a prisoner of this dilemma, ambiguity, confusion, vascilation and duality will mark Pyongyang's attitude towards the Seoul, presenting formidable challenges for the latter.

*Seoul's dilemma.* This ambiguity in turn causes serious problems for Seoul, because it would be as if the goal posts are moving constantly. It is not easy for politicians to maintain an engagement policy in the face of provocative actions and virulent verbal attacks. The end result can easily be inconsistency. Only true leadership can see that such actions and verbal attacks demonstrate weakness rather than strength on the part of Pyongyang. Only true leadership can maintain a consistent policy line.

Even before this challenge, South Korea already has its own difficulty due to its inherent dual attitudes towards the North; North Korea is both a brother country and its deadly enemy as it experienced during the Korean War. To make the situation more complicated, Pyongyang is pursuing an unequivocal engagement policy towards Washington while shunning/fearing Seoul. Thus, Seoul also is faced with its own dilemma: whether to engage or contain North Korea. If Pyongyang's dilemma is much more serious with its very survival at risk, Seoul's dilemma is much more complex.

In dilemmas, emotions mix with cool reasoning, wishful thinking with realistic goals and popular sentiment with actual policy lines. All these help create hazy myths. These myths constitute stumbling blocks for KEDO's work by fueling suspicion and distrust. The clarification of them, and acceptance by both Seoul and Pyongyang of the clarification, will greatly facilitate KEDO's work.

*Myth of unification policy.* Emotion is as powerful as reason, if not more. This is true for an individual as much as for a nation's public matters. The emotional importance of unification for the Korean people can never be underestimated. But unification as an external policy line has become a myth. Neither Pyongyang nor Seoul can will unification through a war. A Vietnam type of reunification, which North Korea persistently pursued for four decades until the demise of the Soviet Union, is no longer feasible. This is true both for North Korea because of its overall weakness, and for South Korea because of its ideological orientation as well as strategic vulnerability. Neither can unification be achieved through negotiation. This is in the realm of fantasy. No country or regime voluntarily has ever chosen to disappear. There is no case of negotiated unification in history. So, much-talked-about peaceful reunification as a public relations matter should be distinguished from real policy options. The only realistic unification is the demise of one party, currently North Korea according to widely accepted international opinion. But the essential character of this theory is that the demise of North Korea cannot be provoked. If it happens, it will happen only through North Korean failure, as was the case with East Germany. Thus the so-called unification by absorption can come only by a North Korean default, not by South Korean design.

Will North Korea collapse by default? After the demise of the East Germany, it had been widely predicted that the matter is not whether Pyongyang would collapse but when. Yet, North Korea so far has proven to be much more resilient than thought. The conventional wisdom has been that because its economy has already collapsed, the regime should follow suite. But the regime has yet to show signs of collapse. What went wrong in the assumption? The North Korean economy collapsed, yes, but what economy? Only its industrialization has failed. Its century-old rudimentary agricultural economy is still there, albeit with drought and flood damage. And the regime is the most secluded in the world: for most North Koreans, unlike the East Germans, their situation is nothing new, and thus, from their view, nothing fixable. Deprived the possibility of horizontal comparison, one can only have vertical comparison. Historically, North Koreans repeatedly experienced famine, flood and draught. This combination of agriculture and seclusion is the secret which explains why North Korea has not collapsed despite widely accepted predictions. This does not mean, however, that North Korea has no problems surviving. This means only that it has more resiliency than it appears, especially for Westerners. No regime can ensure its long term survival with an ever-aggravating political, economic and social situation. In order to remedy to this, it has to engage with the outside world.

*Myth of confrontation/containment.* In engaging with outside world, Pyongyang's plight is how to get rid of its anachronistic militant unification policy and its legacy. While its people are starving, North Korea still maintains the fifth largest army in the world and possesses a large stockpile of biological and chemical weapons. It also has developed a missile delivery system capable of reaching as far as Tokyo, not to mention the entire Korean peninsula. It still maintains aggressive operations towards the South, as indicated by the submarine incident in 1996. It can be argued that all these may be a disappearing legacy or the unfortunate inertia of North Korean's militant unification policy. But without the reduction in its offensive military capability, Pyongyang will have difficulty convincing the world that it is pursuing an engagement policy. The stern reality is that the post-Cold War order rendered Pyongyang's militant unification policy archaic and anachronistic. Engagement with Seoul, not confrontation, will serve Pyongyang's best interest. Pyongyang may fear the consequences but the bottom line for Pyongyang is: *is the medicine worse than the disease?*

For South Korea, the crucial question is whether containment (isolation, or strangulation) of North Korea will further a solution, be it the demise of North Korea or its engagement. Pyongyang, until it opts for reform and opening, will only use, for its survival, external pressure or threats to tighten its grip on its cadre and population. The more the South talks about forcing reform and opening, the more it will alarm the North. This will certainly make its reform and opening less likely. If reform comes, it will come from Pyongyang's own choice. If it is meant to be genuine, it should come from Pyongyang's own choice. Containment of a Pyongyang, which is already on the defensive, is counterproductive. Thus, the obvious choice for both Pyongyang and Seoul is engagement, not confrontation/containment. Although Seoul holds all the cards for the future, the chief burden seems to be on Pyongyang to shed its ambiguous posture. Because unless Pyongyang commits itself for engagement, it's futile for Seoul to try to engage Pyongyang.

*Myth of zero-sum game.* Clearly, engagement is a win-win stragegy. But there are qualms about engagement both in Pyongyang and Seoul. Pyongyang would see engagement as a

Trojan horse. For Seoul the misgivings are: what if engagement diplomacy results in the survival of North Korea, which was otherwise doomed to die? The answer to this question is that a confrontation/containment policy will increase the probability and the magnitude of North Korea's implosion (because of the lack of safety valve) or explosion (because of the regime's resentment, be it self-generated or imposed, against the outside world) of North Korea. An implosion serves neither Pyongyang's interest nor Seoul's best interest. War means extinction for North Korea, but can Seoul risk a second war on the peninsula in the name of unification?

An engagement policy may or may not increase the probability of North Korean survival. In spite of engagement, or perhaps because of it, North Korea may perish. In such a scenario, it will perish more peacefully than confronted with containment or strangulation. In case engagement diplomacy does increase the probability of survival of North Korea, it will also increase inevitably interdependence between two Koreas. The net result will still be beneficial for Seoul because to survive, the price North Korea should pay is to become similar to the South by emulating it. Thus, misgivings and qualms take its root from a zero-sum concept. Inter-Korean relations can and should be made non zero-sum.

**Challenge and current issues facing KEDO**

In the end, inter-Korean dialogue will follow. But until a certain measure of confidence has been established, the two Koreas need an interim mechanism to overcome deep-rooted suspicion and mistrust. KEDO is one and the Four-Party Talks is the other, these two embodying the same mechanism. KEDO and the Four-Party Talks will benefit from the dissipation of the triads of myths. And conversely, perhaps more importantly, the work of the KEDO and the Four-Party Talks themselves may constitute the very process of dissipating the myths. These are the fundamental challenges facing KEDO.

To successfully meet the challenge, KEDO deserves more attention for its unique valuable role. But attention and assistance to KEDO, far from being reinforced, appear to be dwindling. Why is that so? Principally because, after the creation of KEDO and more importantly after the ground breaking, the protagonists assume that *now that the ground breaking is done, the progress will be automatic.* Nothing can be more erroneous than this. The truth is exactly the contrary: KEDO is accumulating problems which undermines its proven usefulness. KEDO and the LWR project need more attention than before from both KEDO executive board member countries and the DPRK. What are the problems and issues KEDO and DPRK are facing?

Conceptually, the current issues are two fold:
-how to harmonize North Korean security concerns with KEDO's practical needs; and
-how to manage internal coordination of KEDO, especially in terms of financing the LWR project.

Both KEDO and DPRK have been delivering faithfully their respective commitments. Moreover, contrary to much speculation, the DPRK has been taking a practical and business-like attitude. But one central theme remains. Ever since the creation of KEDO, the recurring central theme in dealing with DPRK has been the latter's security concern. North Korea has been living virtually without contact with the Western world. Now with all its friendly socialist countries gone, its has only Western countries to deal with, countries which were its enemies. Thus, KEDO's every position and every move is viewed first through the prism of potential threats to its regime. This is the single most important impediment to KEDO's work.

The question of transportation routes for the LWR project is good example illustrating how difficult it is to harmonize security concerns with practical needs. At the peak of KEDO's construction of the nuclear reactors, there will be thousands of South Korean and North Korean working together. In the meantime, millions of tons of equipment and material will be transported to the nuclear site. What route should the people and equipment take? Land? Sea? Air? Because almost all the people, equipment and material will be transported from the South to the North, the most efficient and economic means of transportation is by land and sea. But Pyongyang refused to even mention the words 'land transportation' in the Supply Agreement and subsequent Protocols and agreed only to partial sea routes. The upshot is that a very inconvenient air route, via Beijing, is the most frequently used.

As the project has progressed, more people and material have been transported back and forth. Already, KEDO has reached a point where it can no longer proceed with current transportation means. KEDO's practical needs are obscured by Pyongyang's security concern. Several missions have been delayed and canceled and even those taking place have suffered from unnecessary hardships and a waste of time and money. For example, about one extra week is needed just for travel to and from the site. KEDO has urgent practical needs to improve transportation means, especially sea routes, but the DPRK so far is not responding, probably thinking that with the ground breaking, the essentials have been taken care of. Exactly the reverse is the case. KEDO's work needs the DPRK's continuous political attention. In doing so, the DPRK should be able to somehow overcome its excessive security concerns.

Matching the North Korean issues, KEDO has its own internal issues. The most critical is the financing of the LWR project. Last October KEDO members were able to agree on the total cost of the LWR project. It will be $5.2 billion. The coded language for cost-sharing is that the ROK will play a *central* role, Japan will play a *significant* role, and the U.S. will play an *important* role. This is all KEDO has inherited from the negotiators of the Agreed Framework. But can the sum of *central, significant and important* equal $5.2 billion? Is this a workable formula? The current provisional funding provided by South Korea will dry up before August this year. KEDO has only several months to resolve this important issue. Compounded by financial and/or political difficulties facing Seoul, Tokyo and Washington, it will not be an easy task to reach an agreement. KEDO is far from being on track. KEDO can only operate with a long term funding plan, which cannot be delayed further.

Another financial problem KEDO faces is financing the annual shipment to the DPRK of 500,000 tons of HFO. In actual dollar terms, it will cost around $60 million per year. It is no secret that KEDO has accumulated debts in supplier and bank credits. This year will be telling as KEDO will need an extra $50 million for HFO. Will KEDO be able to find it? Should yearly funding prove to be difficult, a creative mind might still see a solution-- KEDO is incurring a substantial amount of demurrage charges due to the insufficient absorption capacity on the part of North Korea. The human mind rejects new ideas the same way the body rejects foreign proteins. A crisis may be need to overcome the threshold. Will KEDO be able to resolve this grave financial situation without a crisis?

It is not fair to end this paper on a gloomy note because despite a couple of above-mentioned urgent problems, KEDO has been remarkably successful. Beyond its original design, KEDO has been fulfilling a larger mission as well: KEDO is a unique and very valuable mechanism not only for the North Korean nuclear question but for the larger North Korean problem. The stakes are enormous-- just imagine the negative impact that KEDO's failure would bring to the NPT regime, peace and stability in the Korean peninsula, Northeast Asia and beyond. KEDO must not fail. For this, KEDO needs continuous nurturing by its member countries and the international community. It also needs more political attention from DPRK. This year will be crucial for KEDO's continuing success, if not its survival.
END

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# Problems Concerning Nuclear Power Development in Asia

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An international joint project "The Long-Term Future for Nuclear Power in Asia," created last year and promoted by The Committee for Energy Policy Promotion of Japan and The Atlantic Council of the U.S., is being made by a group of international experts to study various problems concerning nuclear power development in Asia and the world to identify and clarify key points for the commercial use of nuclear power generation with the mid-21st century in mind and to prepare policy suggestions covering these areas.

Of the total planned working time set at two and a half years, the first part focusing on work in the Asian region has now been completed and a policy paper titled "An Appropriate Role for Nuclear Energy in Asia's Power Sector" was prepared. Nearly 60 experts from Japan, the U.S. and countries in Europe and Asia have participated in this research work and after a conference held for three days in Seoul, South Korea in June, 1997 work was started on the actual preparation of the report, which was completed after mutually exchanging opinions for a period of six months.
I would like to use this opportunity today to introduce the contents of this paper as my presentation.

I was involved in this work as a moderator at the conference in South Korea and as the chief organizer among the Japanese for the preparation of the report. Although the report is not necessarily based on the complete agreement among the participating experts and many items requiring further study remain, we can say that it identifies the main problems concerning nuclear power generation in Asia in the current situation and the directions for solving these problems. We have prepared an "Executive Summary" of the report, a "Conclusions and Recommendations" and a "Highlights of Recommendations." I will explain the outline of these sections and then present some of my own opinions regarding this matter.

## EXECUTIVE SUMMARY

Over the next 20 to 30 years Asian economies are expected to grow more rapidly than economies in the rest of the world. Despite economic difficulties in the latter part of 1997, the fundamentals for long-term growth for the region are exceptionally strong and should result in substantial growth in energy demand. The International Energy Agency (IEA), for example, assumes that roughly 75-80 percent of the energy needs of Asia will be met by an approximate doubling of coal and oil use. It is expected that gas use will also double, but will nevertheless meet only about ten percent of overall energy needs. Electricity use is projected to grow by a factor of two to three, with nuclear energy making a significant contribution to meeting the needs for power in a number of Asian countries.* Providing this power without worsening the region's already serious environmental problems represents a major challenge for the countries of Asia.

Historically, the major additions to nuclear power capacity have occurred in North America, Japan, and the countries of Europe. In the future, based on present planning, over three quarters of the increase in global nuclear power capacity is projected to come from Asian countries. Asia could therefore become the new center of civilian nuclear power development.

The Asian commitment to nuclear power is motivated by a number of considerations: keeping nuclear power on the list of options available to meet the rapidly rising demand for electricity; reducing energy import dependence; improving air quality; reducing greenhouse gas emissions; benefiting from the technological spin-offs of high technology; and easing energy supply logistics.

The planned rapid development of nuclear power in Asia presents challenges both to the countries concerned and to the rest of the world. This Atlantic Council paper discusses the nature of these challenges and presents recommendations on how such challenges might be met. These include:

- Adhering to strict safety standards in nuclear plants and strengthening the "safety culture".
- Ensuring the independence and competence of the agencies that regulate nuclear power.
- Improving the effectiveness of management and disposal of nuclear wastes and spent fuels.
- Determining the cost competitiveness of nuclear power.
- Establishing the financial integrity of national power sectors.
- Understanding and responding to public attitudes towards nuclear power.
- Strengthening the role of the International Atomic Energy Agency (IAEA) in preventing proliferation of nuclear weapons.

The Atlantic Council's goal in this project was to develop a credible paper which would be useful to: policy makers having responsibility for nuclear energy issues; owners and managers of nuclear power facilities; others interested in nuclear power issues; and the general public. The working group convened to develop this paper therefore includes individuals with broad knowledge of

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* Takehiko Sakairi notes that the word "country" or "countries" is used here with the meaning of "country or area" or "countries or areas" respectively only for the purpose of convenience.

energy issues, nuclear energy experts, economists and social scientists. About half of the working group has particular expertise and interest in nuclear energy. As noted, the nuclear community is also a key audience for the recommendations presented in the paper. The other participants with expertise on overall energy, economics and the social sciences have contributed significantly to broadening the perspective of the group as it discussed an appropriate role for nuclear power relative to other energy sources in meeting the electricity needs of Asia as we enter the next century.

The working group recognizes that nuclear power issues must be addressed in parallel, placing a heavy responsibility on the many actors in this field. These include operators of nuclear power plants, regulators, suppliers of associated equipment and services, national governments, and intergovernmental organizations such as the IAEA. Given the growing role of nuclear power in Asia, it is imperative in the view of the working group that policies of all interested parties in the private and public sectors be compatible and responsible.

Recommendations deserving particular attention at this time are:

- Re-emphasis of the critical importance of a safety culture if nuclear power use is to be maintained and/or expanded.
- Consideration of an Asian association of nuclear institutions and experts to enhance the effective management of nuclear power operations in the region.
- Increased efforts by nuclear plant operators and governments to strengthen the role of the IAEA in helping prevent actions contributing to the proliferation of nuclear weapons.
- Increased participation by non-Asian countries in Asian regional efforts to develop the peaceful use of nuclear power.

Highlights of recommendations are presented on the following page.**

** The order in which the items appear follows the order in which each item is discussed in the text.

## HIGHLIGHTS OF RECOMMENDATIONS

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|---|---|
| Reactor Safety | Intensify efforts to ensure strict standards of safety in plant design, construction and performance, and increase regional sharing of information and data. |
| Regulation | Strengthen the independence, predictability and competence of regulatory bodies. |
| Spent Fuels Handling and Waste Management | Foster acceptance by all countries of responsibility for their own nuclear wastes. Consider the benefits and costs of regional waste storage facilities. |
| Economics and Financing | Develop acceptable models for determining the cost and economics of nuclear power relative to other power sources, including externalities. |
| Environmental Issues | Assess the potential benefits of nuclear power to reduce greenhouse gases, address air pollution and acid rain problems. |
| Technology and R&D | Promote R&D to ensure advanced technology. Improve regional cooperation on long-term R&D planning and implementation. |
| Public Perception | Address public concerns regarding nuclear power in an open, frank and straightforward manner. |
| Non-Proliferation | Reinforce the non-proliferation regime by implementing IAEA enlarged safeguards systems and export controls. |
| Regional Cooperation | Consider the creation of an Asian association of key institutions and experts involved in nuclear power to enhance the effective management of nuclear power operations in the region. |
| U.S. Policy | Participate closely in Asian regional efforts to develop safe and efficient nuclear power and strengthen the nuclear non-proliferation regime. The Agreement of Intent signed by Presidents Jiang and Clinton on October 29, 1997 offers new opportunities in these respects. |

# VIII. CONCLUSIONS AND RECOMMENDATIONS

This study finds that, in contrast to the slowing of nuclear power capacity growth in the rest of the world, the economies of the Asian region plan on a continued capacity expansion. The Asian region is likely to account for a large part of the total increase in nuclear capacity over the next 20-30 years. These countries are motivated by their desire to keep options open in the expansion of the power sector which will be necessary to improve living standards and promote modernization; to enhance their energy security; to protect the environment; and to have access to high technology with all its technological spin-offs. Most Asian economies share these motives. However, the region is very diverse, ranging from Japan, a highly developed economy, to poorer countries, where the relief of poverty is an urgent task and whose modern industrial infrastructure is still limited. The region also varies in policies towards nuclear non-proliferation.

The working group, in its Seoul seminar and in the course of various draft revisions, examined the challenges facing the region in fulfilling its nuclear plans and formulated the recommendations that follow. As explained in the Executive Summary, the recommendations represent a consensus view of the working group on a range of controversial and important issues. Their weight lies in the expertise and experience of the working group members who formulated them, and their ability to introduce these recommendations to decision makers in their own country on an informal or formal basis. Though the recommendations vary in coverage and content, there is one thread that runs through all — the desirability and even imperative of closer cooperation between the countries of the region, and between Asia and the rest of the world.

## LIST OF RECOMMENDATIONS

### RECOMMENDATIONS ON REACTOR SAFETY

The countries of the region should continue to recognize the paramount importance of nuclear safety, strengthen the "safety culture", and adopt strict international standards of safety in plant performance including: design, engineering and construction; operation and maintenance; and staff training at all levels.

As safety is a universal issue, the Asian countries could benefit from regional sharing of information and data, and from adhering to the many international programs and protocols governing reactor safety.

### RECOMMENDATION ON REGULATORY REGIMES

In order to ensure effective regulatory regimes, each country should demonstrate that it has an independent, competent, predictable regulatory regime, providing effective public participation, and administered by independent agencies. Other countries, regions and authoritative international organizations should help in this endeavor.

### Recommendation on Waste Management

In accordance with IAEA standards (emphasized at the July 1997 G-7 meeting in Denver) governments must accept responsibility for the management of their own nuclear wastes and demonstrate their determination to find satisfactory solutions to nuclear waste disposal. Given concerns in some countries, the possibility of regional storage facilities could be examined.

### Recommendations on Economics of Nuclear Plants

Asian countries should work jointly with international organizations and North American and European countries to develop acceptable models for determining the cost and economics of nuclear power relative to other power sources, relative to their own circumstances. These models should provide consistent means of estimating the uncertainty range for each major cost component.

All countries should take into account to the extent possible the external benefits and damages of different energy forms in formulating energy policies. The IAEA and NEA should provide guidance on the calculation of those benefits and damages.

### Recommendations on Financing

Given the high capital costs of power facilities, especially nuclear, countries should establish the long-term financial integrity and credit-worthiness of their power sectors. Above all, efforts should be made to establish meaningful tariff structures and domestic capital markets.

Given governments' expansion of nuclear power generation, particularly in Asia, these governments could open a dialogue on the role of nuclear power in power generation with the World Bank and other MDBs, especially in the light of concern over levels of greenhouse gas emissions.

### Recommendations on R&D

Given the anticipated rapid increase in demand for electricity in the Asian region, R&D, including stronger efforts at technology diffusion, will be needed for all forms of energy, including fossil fuels, nuclear power, renewables and energy efficiency.

Efforts should be made to expand networks where R&D information, activities, and proposals can be shared by countries in the region; and to collaborate on R&D where possible.

### Recommendations on Public Attitudes

Greater efforts should be made by the nuclear power community to understand and respond to general concerns of the public, media, and public opinion leaders about nuclear power.

Joint approaches could be explored to develop strategies and programs for enhancing public understanding of nuclear power. The benefits of nuclear power and other applications of nuclear technology in industry, medicine, agriculture and research should be explained.

### RECOMMENDATIONS ON NON-PROLIFERATION

The Asian nuclear power industry and authorities should work with other nations around the world to reaffirm their commitment to the non-proliferation regime, in particular enlarged safeguards systems, export control guidelines, and the security of nuclear materials and facilities. Areas for cooperation could include: material protection, control and accounting; regional cooperation in nuclear fuel cycle activities; and advanced reactor development.

Asian governments should increase their efforts at transparency and undertake systematic confidence-building measures in order to contribute to minimizing proliferation concerns in and outside the region.

### RECOMMENDATION ON REGIONAL COOPERATION

A new Asian regional association should be considered, composed of private sector groups and public institutions, concerned with the effective and safe management of nuclear power and its fuel cycle in its broadest context. Such an association would supplement – not duplicate, conflict with or replace – existing programs such as those sponsored by the IAEA, INPO and WANO.

### RECOMMENDATION ON INTERNATIONAL COOPERATION

Efforts should be made to enhance cooperation among the Asian countries on the one hand, and with those outside the region on the other, regarding nuclear programs, policies and practices.

### RECOMMENDATIONS ON U.S. POLICY

The United States should participate more closely in regional efforts to deal with proliferation challenges by: providing advanced technical assistance on safeguards and material control; fostering nuclear reactor and fuel cycle technologies that offer increased resistance to proliferation; and strengthening the IAEA.

The United States should use the 1997 Agreement of Intent on Cooperation Concerning Peaceful Uses of Nuclear Technology to help ensure the safe and efficient implementation of nuclear power development in China. Such implementation should include continuing monitoring of the conditions under which such nuclear cooperation takes place.

# Current Energy Status and Prospect of Nuclear Energy for Sustainable Development in China

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## ABSTRACT

According to the ***China's Agenda 21***, there are 3 key issues in the overall strategies for sustainable development in China: 1) population control; 2) resources conservation and 3) environment protection. Recently the Chinese government also has established the ***Ninth Five-Year Plan*** and ***Long-Term Goal for the Year 2010 for National Economic and Social Development***.

In this paper the current energy status in China is briefly discussed, some major problems, such as the fairly low energy efficiency, low energy consumption per capita, the heavy transportation pressure and increasing seriousness of environmental pollution raised from the uneven distribution of energy resources and the energy structure of taking coal as the main etc. , have constrained the sustainable development of national economy and society. In order to be consistent with the strategy of national sustainable development, major polices and issues concerning the energy sustainable development in China are presented and the role and prospect of nuclear energy development are analyzed in this paper.

# Current Energy Status and Prospect of Nuclear Energy for Sustainable Development in China

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## 1. Introduction

Energy provides the fundamental material condition for the development of human society and human society cannot advance without energy. Energy industry, acted as the basic industry of national economy, directly related to the development speed of national economy and the rise of the people's living standards. The Chinese government is paying more and more emphasis in coordinating the development among energy, economy and environment in recent years.

In 1994, Chinese government took the lead in issuing ***China' Agenda 21***. Recently the Chinese government also has established the ***Ninth Five-Year Plan*** and ***Long-Term Goal for the Year 2010 for National Economic and Social Development***. These documents are now served as significant national documents for the future domestic economic growth and medium- and long-term social development. The sustainable development of energy is regarded as an important part in ***China' Agenda 21*** and referred to as the use of energy which reconciles economic development with the protection of the environment.

First the current energy status in China is briefly discussed, some major problems constraining the sustainable development, major polices and issues concerning the energy sustainable development in China are presented and the role and prospects of nuclear energy development are analyzed in this paper.

## 2. Current Energy Status

### 2.1 Energy Mix Taking Coal as the Main

Energy production and consumption in China is still overwhelmingly relying on the domestic resources and market. In 1996, the total primary energy production was about 1315.57 Mtce in China, which was consisted of coal 1397.00 Mt(74.8%), oil 157.3 Mt(17.1%), natural gas 20.1 $Bm^3$(1.9%) and hydro(including nuclear power) 200.8(13.9) TWh(6.2%). The primary energy consumption and its share from 1990 to 1996 are shown in Table 1.

The feature of the energy system taking coal as the main still continues in China. As you know, the coal is the relatively outweighing energy resources and the energy resources are unevenly distributed with most coal reserves in north China and hydropower mainly in the west and north, meanwhile, the large energy consumption for coal-fired power plants etc. are in east and south-east coast areas. With the rapid economic growth, the energy consumption increases in China. The dominant consumption of coal not only increases the tensed transport pressure, but also puts more greater pressure to the environment protection. This has become an important factor to constrain the development of China coal industry and further to affect the sustainable development of national economy and society.

Table 1 The Primary Energy Consumption and its Share(%) in 1990-1996

| Year | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|
| Coal | 76.2 | 76.1 | 75.7 | 74.7 | 75.0 | 74.6 | 75.0 |
| Oil | 16.6 | 17.1 | 17.5 | 18.2 | 17.4 | 17.5 | 17.5 |
| NG | 2.1 | 2.0 | 1.9 | 1.9 | 1.9 | 1.8 | 1.6 |
| Hydro(NP) | 5.1 | 4.8 | 4.9 | 5.2 | 5.7 | 6.1 | 5.9 |
| Total(Mtce) | 987.0 | 1037.8 | 1091.7 | 1160.0 | 1227.4 | 1311.8 | 1388.1 |

Source: *'97 Energy Report of China* by China Price Publishing House, December 1997.

### 2.1.1 Impacts on Transportation

As mentioned above, coal is the main types of energy in China which accounted for 74.8% and 75.0% of the total production and consumption of the primary energy respectively in 1996. About 80% of the existing proven coal reserves is concentrated in areas of North China and north-east China of which about 60% is in Shanxi, Shaanxi and Inner Mongolia. It forms a general pattern of coal transportation, "transporting coal from the north to the south, and from the west to the east". According to the statistical data from Ministry of Communications, P. R. China, about 70% of coal product is transported by railway. The proportion of the volume of coal transportation to the total volume of the railway cargo transportation in the whole country is above 40% and is increasing in recent years. See Table 2.

Table 2 The Coal Products Transported via Railway, 1993-1995 (Mt)

| Year | 1993 | 1994 | 1995 |
|---|---|---|---|
| The total coal volume transported by railway | 653.4 | 659.4 | 673.6 |
| Share of coal in the railway transportation volume(%) | 41.7 | 42.0 | 42.3 |
| The coal transported inter-provincially from Shanxi, Shaanxi, and Inner-Mongolia via railways | 207.1 | 206.4 | 211.9 |
| The coal transported for the 5 large power networks* | | 141.6 | 158.4 |

* The 5 large power networks are North China, Northeast China, East China, Central China and Shandong power networks.

Source: *The Compilation of Statistical Data about the National Railway*, Ministry of Communications, P. R. China and *China's Energy Development Report(1997)* by Economic Management Publishing House, Beijing, June 1997.

### 2.1.2 Impacts on Environment

The environmental impact arising from energy production and consumption is a heat topic concerned in the world. At present, there are three global atmospheric environmental issues that are commonly concerned by the international community. The first is the "greenhouse effect" arising from $CO_2$, methane, etc. that might result in global warm climate; The second is the acid rain(acid fallout), caused by acid substances, such as $SO_2$, nitrogen, oxygen compound, etc.; The third is the destruction of ozone layer caused by the chloroflurocarbons compound. Among them except the chloroflurocarbons, other two are practically related to the use of energy. The energy production and consumption system dominated by coal has caused serious impacts on the atmospheric environment in China. The recent atmospheric pollution situation in China is shown in Table 3.

Table 3 Atmospheric Pollution in China

| Year | 1990 | 1991 | 1994 | 1995 |
|---|---|---|---|---|
| Total waste gas emission($Tm^3$) | 8.5 | 10.1 | 11.4 | |
| Soot discharge (Mt)<br>(percentage from coal burning, %) | 13.28<br>(88) | 13.14<br>(92) | 14.14<br>(95) | 17.44*<br>(70)* |
| $SO_2$ emission (Mt)<br>(percentage from coal burning, %) | 15.02<br>(90) | 16.22<br>(91) | 18.25<br>(90) | 23.70*<br>(85)* |
| $CO_2$ emission (Mt)<br>(percentage from coal burning, %) | 509.6<br>(85) | 537.4<br>(85) | 629.6<br>(84) | 633.8<br>(84) |

Source: *Clean Coal Technologies*(Chinese Journal), Vol.3. No.1, 1997 and * *China's Energy Development Report(1997)* by Economic Management Publishing House. Beijing, June 1997.

The discharge of $SO_2$ is mainly caused by burning coal. Generally, the sulphur content rate of coal in China is high. Some of them are as high as 6%-7%. Such kinds of coal are still used, even directly burning in China. According to the statistics of 88 cities in China in 1995, the average day value per year for the discharge of $SO_2$ is 2-424 $ug/m^3$. it is 81 $ug/m^3$ in north city and 80 $ug/m^3$ in south city. The discharge of $SO_2$ in 48 of the 88 cities exceeded the national standard; The average day value per year for the discharge of $NO_x$ is 12-129 $ug/m^3$, it is 53 $ug/m^3$ in north city and 41 $ug/m^3$ in south city. The huge amount of $SO_2$ and $NO_x$ emissions results in a very serious air pollution in China. Now more than 30% of the total territory is polluted by acid rain, and the eroded area is increasing. The eroded areas are mainly distributed in the area south of the Yangtzi River. Sichuan Basin, the area east of Tibet and Central China, the PH value of the annual average precipitation is lower than 4 in the central of these regions.

## 2.2 Low Energy Efficiency

Energy efficiency and energy conservation are the top keys to achieve a sustainable development goal of China. According to the definition of specifications of the United Nations European Economic Committee and the calculation. the total efficiency of energy system in China is still less than 10% recently. This means that over 90% of recoverable energy reserves from exploitation, processing, conversion. transportation, distribution to final use, were lost and wasted. Among them, the energy exploitation efficiency was about 32%. the efficiency of the intermediate link (processing, conversion, store and transportation) was around 70%, the efficiency of final energy use was about 41%. In China, the product of intermediate link efficiency and the efficiency of final use is usually called "energy efficiency", which is about 30%. It is ten percentage point lower than the international advanced level. There are large differences of the energy consumption per unit of product between China and the advanced nations. This means that the energy technologies and efficiency should be improved in China. The comparisons of the energy consumption per unit of some major products between China and the advanced nations are listed in Table 4.

Table 4 Energy Consumption Per Unit of Product Between China and the Advanced Nations

| Product | Unit | China(1) | Advanced(2) | (1-2) / 2 (%) |
|---|---|---|---|---|
| Energy Consumption for Coal Production | (kWh / t) | 31.19 (1994) | 17.65 (U.S.A,1994) | +76.7 |
| Energy Consumption for Thermal Power Generation | (kgce / kWh) | 417 (1993) | 332 (Japan,1993) | +25.6 |
| Comparable Energy Consumption For Steel Production | (kgce / t) | 973 (1994) | 656 (Japan,1994) | +48.3 |
| Energy consumption For Synthetic Ammonia | (kgce / t) | 1284 (1994) | 970 (U.S.A,1994) | +32.4 |
| Fully Energy Consumption for Cement Production | (kgce / t) | 175 (1995) | 107.3 (Japan,1995) | +63.1 |
| Oil Consumption in Freight Truck(Gasoline Truck) | (L / 100-km) | 6.7 (1994) | 2.7 (U.S.A.1994) | +148.1 |
| Oil Consumption in Freight Truck(Diesel Truck) | (L / 100-km) | 4.8 (1994) | 2.7 (U.S.A.1994) | +77.8 |

Source: *'97 Energy Report of China*, December 1997 by China Price Publishing House and *China's Energy Development Report(1997)* by Economic Management Publishing House. Beijing, June 1997.

## 2.3 Low Energy Consumption Per Capita

The index of energy consumption level per capita not only directly related to the people's life quality, but also is an important sign of the developed standard of a country. The total energy consumption and energy consumption per capita of some countries and of the world in 1996 are shown in Table 5. From the Table, we can see that the total energy consumption of China in 1996 only accounted for 10.4% of total consumption of the world, the energy consumption per capita was only 714.1 kg oil equivalent that was about one half of the world energy consumption per capita of 1460 kg oil equivalent.

Table 5 Energy Consumption and Energy Consumption Per Capita of Some Country and in the World(Mtoe)

| Country | Total | Oil | N.G. | Coal | Hydro(N.P.) | Per Capita (kg) |
|---|---|---|---|---|---|---|
| U.S.A | 2130.3 | 833.0 | 569.2 | 516.0 | 212.1 | 8090 |
| Canada | 223.1 | 79.5 | 66.4 | 23.1 | 54.2 | 7563 |
| France | 243.4 | 91.0 | 29.0 | 14.7 | 108.6 | 4196 |
| Germany | 345.0 | 137.4 | 75.2 | 88.9 | 43.5 | 4228 |
| U.K | 230.1 | 83.7 | 76.7 | 44.9 | 24.8 | 3910 |
| Russian Fed | 605.4 | 128.0 | 317.0 | 119.0 | 42.3 | 4095 |
| Japan | 501.8 | 269.9 | 59.5 | 88.3 | 84.2 | 4005 |
| China | 874.0 | 172.5 | 15.9 | 666.0 | 19.6 | 714 |
| World | 8380.1 | 3312.8 | 1971.6 | 2257.0 | 839.4 | 1460 |

Source: *'97 Energy Report of China*, December 1997 by China Price Publishing House and *China Statistical Yearbook*, State Statistical Bureau, P.R. China, 1997.

It should be mentioned here that there is a great difference between urban and rural areas in the energy consumption in China. By the end of 1996, the total population in China was 1223.9 million of which the total population of cities and towns was 359.5 million, accounted for 29.37%; the total population of rural area was 864.4 million, accounted for 70.63%. The rural energy consumption was 640 Mtce in 1996, accounted for a little less than 40% of the total energy consumption in China as a whole(bioenergy included). From 1980 to 1996, the consumption of non-commercial energy almost remained the same as in the past, something between 220-250 Mtce, however, the consumption of commodity energy rose drastically with annual growth rate of 9.3%. With the mechanization of agriculture and the improvement of living standard of rural peoples, the vast Chinese rural areas will become a major energy consumer. This will be inevitable to greatly increase the energy consumption in rural areas, demands of energy will be steeply increased in the near future in China.

## 2.4 Downward Trend of Energy Consumption Per Unit Output Value

At present the energy consumption per unit output value and energy consumption of unit main products in China are higher than the international advanced standard, however, in 1980-1990 the yearly average growth rate of gross domestic product(GDP) was about 9% and the annual average growth of energy consumption was 5%, the energy consumption for each RMB 10,000 yuan of GDP was reduced from 7.64 ton coal equivalent(tce) in 1980 to 5.32 tce in 1990, the annual average reduction rate was 3.7%. it saved or used less energy totally 285 Mtce in the decade. In the Eighth Five-Year period(1991-1995), the annual average growth rate of GDP in China was 12%, the average annual growth rate of the primary energy production and consumption was 4.37% and 5.5% respectively. The elastic coefficient of primary energy production and consumption was 0.364 and 0.458 respectively.

On one hand, we can say that the elastic coefficient of energy consumption in China(the average value was larger than 1.50 in 30 years before 1980, and was reduced to about 0.60 in 15 years after 1980) shows that the relative low energy growth has supported the high speed growth of national economy and a certain progress has been made in reducing the energy consumption per unit output value. The energy consumption per RMB 10,000 Yuan of GDP from 1991 to 1996 was listed in Table 6; On the other hand, The elastic coefficient of the energy consumption is larger than that of energy production, so the energy development has exerted, to some extent, the "bottle-neck" effect on the development of national economy and society.

Table 6 Energy Consumption per RMB 10,000 Yuan of GDP (1991-1996)
(the Monetary Base Year: 1990)

| Year | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|
| Energy Consumption(tce) | 5.24 | 5.11 | 4.74 | 4.19 | 3.95 | 3.91 |

Source: *'97 Energy Report of China*, December 1997 by China Price Publishing House.

## 3. Polices Concerning Energy Sustainable Development

According to the ***Ninth Five-Year Plan*** and the overall strategic target of the plan to 2010, the growth rate of the Chinese economy should be kept in a high rate and the people' life quality should also be improved. The strategy of national sustainable development was emphasized by Chinese government to well coordinate the development among energy, economy and environment. To be consistent with the national development strategy, the following polices are stressed in the energy sustainable development in China:

------ rely mainly on domestic resources and market, meanwhile, the energy supply and consumption should be regulated by making full use of foreign resources and international market,

------ lay equal emphasis on both energy development and conservation with energy conservation being put at a dominant position,

------ develop clean coal technology and implement the policy of substituting oil with coal,

------ strive to exploit oil and natural gas resources, actively develop new and renewable energy sources in order to optimize the structure of energy system,

------ give priority to hydropower development, develop nuclear power to an adequate degree while making great efforts to develop advanced thermal power in power industry,

------ and pay more attention to tackle environmental pollution during energy exploitation and utilization.

## 4. Prospect of Nuclear Energy Development

Nuclear power is a significant component of the world's energy supply at present. There are 441 nuclear power plants in operation with a total generating capacity of some 353.5 GWe that generated about 2406 TWh in 1996. World-wide, the nuclear share in total electricity generation is approximately 17%. By the end of 1996, the national installed capacity of electricity generation exceeded 230 GW and the annual output of generated electricity is 1,070 billion KWh, with 81.5% from fossil power, 17.2% from hydro power, 1.3% from nuclear power in China. The nuclear power development is still at an initial stage with three units of 210 MW capacity in operation and eight units of 6600 MW capacity under construction in the mainland of China.

In the ***Outline of the Ninth Five-Year Plan and Long-Term Goal for the Year 2010 for National Economic and Social Development***, the principle has been decided for the electric power industry --- adapting to regional characteristics, combining hydropower and fossil fuel power, developing nuclear power to a certain extent. By the end of 2000, the installed capacity of electric power is expected to reach 290 GW, with the annual generated electricity of 1,400,000 GWh; By 2010, the installed capacity is expected to reach about 550 GW, with the generated electricity of around 2,750,000 GWh. According to the experts' estimation, by 2020, the total installed capacity of electric power will reach 800-900 GW and that of nuclear power will be 40-60 million KW. The proportion of nuclear power installed capacity is small but its absolute figure is not. The nuclear energy development is determined by the long-term energy sustainable strategy and the following actual situation as mentioned in the section of current energy status in China:

------ low energy resources per capita, especially, oil and natural gas,

------ lack of fossil fuel and hydro resources, particularly in coastal area, where the economic growth is much faster than that of other areas and the energy consumption takes almost half of the total of the national energy consumption each year,

------ serious air pollution and acid-rain resulting from burning tremendous amount of coal, and

------ the expanding strained pressure on transportation system in China.

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# PEACEFUL USE OF EXCESS PLUTONIUM FROM DISMANTLED RUSSIAN NUCLEAR WEAPONS. SAFETY ISSUES

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ABSTRACT

Beginning from 1992 a number of studies were performed for W-Pu peaceful utilization in Russia. Very important results were obtained from Russian-German, Russian-French and Russian-Canadian Feasibility Studies, as well as from ISTC project and some of the US-Russian Projects. These Studies have demonstrated technical feasibility of W-Pu utilization as MOX-fuel in certain power reactors. Some of the Studies contained preliminary economic results. Technical feasibility implies safety assurance for all W-Pu management activity.

All safety-related aspects (criticality, equipment and protective barriers reliability, radiological protection, etc.) have to be taken into account for W-Pu utilization. Safety has to be guarantied for all the W-Pu disposition stages:

- Pu storage;
- Pu conversion from metal to oxide;
- MOX fuel fabrication and transportation;
- MOX irradiation in power reactor;
- MOX spent fuel management.

The paper is mostly dedicated to safety-related issues of W-Pu conversion and MOX fuel fabrication for . It is based on results of Russian-German and Russian-French (AIDA-MOX1) Studies.

## 1.W-Pu conversion safety

Two primary objectives for conversion of metal Pu into oxide are:

- production of plutonium oxide suitable for next stage of MOX-fuel fabrication;
- removing of impurities (Am, Ga).

Different technologies could be used for this purpose. Russian scientists developed two of them in All-Russian Institute of Inorganic Materials (Moscow) and in Institute of Nuclear Reactors (Dimitrovgrad).

First process includes direct dissolution of metal Pu in $HNO_3$ +HF with further Pu purification by liquid extraction. Pu oxide could be produced through oxalate or hydroxide precipitation. The process is complicated by secondary waste management. Nuclear criticality is one of the most important issue in this case. It means strict control of W-Pu metal to be dissolved, limitation of Pu concentration in water solutions, use of equipment with nuclear safe geometry, etc. Nevertheless this process offers the best warranties of safety. It is based on large experience and could be implemented without extensive R&D.

Second process is based on pyrometalurgy with direct dissolution of metal in molten salt media (NaCl+KCl) and chemical precipitation of compact Pu oxide (or electrodeposition of $UO_2+PuO_2$). This oxide is not suitable directly for MOX fuel fabrication and needs additional treatment. The process seems to generate relatively small amount of secondary wastes, but it was not proven at industrial scale. Implementation of this technology needs further extensive R&D. Nuclear safety is not a major issue for this case.

As a result of French-Russian Feasibility Study it was also selected mixed process: calcination of metal Pu in air followed by dissolution of the resulted oxide in $HNO_3$ in presence of Ag(II). Resulted Pu solution is purified and Pu oxalate is produced [1].

Dry process like HYDOX process was examined in AIDA-MOX 1 Study and finally has been turned down in view of additional work needed for qualification. Operational safety of the oxidation of plutonium hydride into oxide will be one of the most important issues in this technology. Another challenge is volatile Ga oxide waste formed during high temperature treatment of the initial plutonium dioxide.

## 2. Safety issues for MOX Fuel Fabrication from W-Pu

Different safety-related issues of MOX fabrication were considered under bilateral feasibility studies mentioned above [1, 2, 3]. Generally speaking the safety provisions and safety related design characteristics should be similar for MOX-fuel fabrication from civil as well as from weapon-derived plutonium. Main safety aspects of MOX fuel production are covered in NEA/OECD Reports [4,5].

To prevent risk of plutonium release a multi-barrier system is designed for MOX fabrication facility. A graduated low air pressure supports the system to avoid Pu contamination outside enclosure, which is provided by glove boxes and caissons or shielded hot cells.

All initiating events (internal and external) which could bring the possibility to damage the multi-barrier system are to be taken into account. Working personnel have to be protected from ionizing radiation. Doses are to be well under authorized limits.

Within the framework of Russian-German Feasibility Study experts from both sides developed safety criteria for MOX Pilot Facility designated for W-Pu processing into MOX fuel. Based on technical information from German side and Russian regulatory documents experts developed "Safety Concept for Pilot Plant for Uranium-Plutonium Fuel Manufacture from Weapons-Derived Plutonium". This document was approved by Russian Supervision Authorities (Ministry of Health and Gosatomnadzor) and by Russian Minatom. German equipment designed for the new Hanau MOX Plant offers unique opportunity to process W-Pu due to the fact that nuclear safety is ensured for $PuO_2$ with isotopic composition of 95% Pu-239 and 5% of Pu-240.

Low Pu-238 and Am-241 content in W-Pu make it possible to minimize radiation dozes for personnel (5 mSv per year) which is well below new authorized limit of 20 mSv/year. 4 stages of HEPA (high efficiency particulate filters) prevent any environmental effect for normal operation of the plant and for the design-based events.

For the MOX Pilot Plant as well as for TOMOX-1300 Facility special containment building was considered as a necessary protection from external hazard such as airplane crash [1,2].

For the Russian-Canadian Feasibility Study calculation of radiation protection and safety was performed for handling of low-enriched W-Pu fuel bundles at MOX facility (fuel bundles assembling) and reactor site (loading reactor). According to NRB-95 Regulations the permissible distance from the body to MOX fuel bundle is about 80 cm. It means necessity for the shielding or use of special devices to handle MOX bundle.

One of important issues is safe transportation of MOX fuel from MOX fabrication facility to the designated reactor site. In case of MOX fuel transportation within Russian Federation special transport container is to be designed. European experience in MOX transportation is of great value for that case. For overseas transportation of MOX CANDU fuel with W-Pu special new package was proposed with 18 MOX fuel bundles capacity.

**Conclusions.**

Safety related issues are of highest importance when excess W-Pu disposition and/or utilization is considered. All technologies and operations are to be evaluated taking into account operational, nuclear and radiation safety.

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# Japan's Approach to the Management of Surplus Weapons Plutonium (Position Paper)

In engaging in international cooperation for the safe and effective management of fissile material derived from nuclear weapons, Japan attaches importance to three cardinal principles, irreversibility, transparency and efficiency. With these principles in mind, we have been contributing to international efforts that address this issue. To make further headway, intensive consultation and coordination are necessary both between Russia and the United States, and among the G8 states. For the present, Japan is focusing its efforts on tasks of immediate need.

## 1. Tasks essential for the promotion of nuclear disarmament and warranting non-proliferation

With the end of the Cold War, the international community has witnessed emerging opportunity for nuclear disarmament. Already under way is the START process, which represents future milestones for large-scale reduction in the strategic nuclear forces of Russia and the United States. In order to bring us closer to a world free of nuclear weapons, successful implementation of the START process matters in great deal. Nevertheless, the actual work of this process entails difficulties well beyond what many people might imagine. The ongoing dismantlement of nuclear weapons under the terms of START I has been leading to large-scale stockpiles of highly enriched uranium and plutonium derived from nuclear warheads, and such stockpiles will increase with the projected implementation of START II and START III. Moreover, in their present state, this fissile material can easily be reused for military purposes and thus could pose a serious threat to international security should it fall into the hands of terrorist groups or be turned over to nations intent on developing nuclear weapons. Therefore, it is imperative that such fissile material be safely managed and transformed as quickly as possible into forms unusable for military purposes. This, however, constitutes an enormous challenge requiring advanced technology and large-scale financial resources.

## 2. International efforts to date

The Moscow Summit on Nuclear Safety and Security, held in April 1996, offered the first major opportunity to focus international concern on the management of surplus weapons fissile material. Following the Moscow Summit, an international experts met in Paris in October that year. There, the participating states reached a consensus on several points: (1) among all the surplus weapons fissile materials, the management of plutonium is a matter of particular importance, and the most suitable and technically feasible means of disposing of such plutonium is through consumption in nuclear reactors, (2) immobilization of plutonium in glass or ceramic form is a possible complementary option; and (3) whichever option is selected, interim storage of surplus weapons fissile material is necessary until its ultimate elimination. These conclusions were supported at last year's Denver Summit in the Foreign Ministers' Progress Report. At the same time, the Report welcomed a number of ongoing concrete international efforts and reaffirmed the importance of ensuring transparency in the management of the plutonium. The Report pointed the importance of preventing its reuse for military purposes by placing it under international verification as well as by taking appropriate measures for physical protection, control and accountancy.

## 3. Japan's basic position

### Active engagement

In principle, the primary responsibility for the management of plutonium derived from nuclear weapons rests with the states that possess them. Thus the ways of managing such plutonium should be determined and carried out by these states. At the same time, Japan recognizes the significance of the management and disposition of such fissile material for the purpose of promoting nuclear disarmament and ensuring nuclear non-proliferation and, to date, it has taken various concrete actions. For example, Japan has been extending specific assistance as part of its efforts to dismantle nuclear weapons in Russia and other former Soviet Union states. We also established, in September 1996, an informal study group composed of experts to study technical aspects of managing surplus weapons plutonium, and the group's findings were very helpful in the technical discussions at the international experts meeting in Paris. Since then, Japanese experts have exchanged views with their counterparts in the states concerned regarding future technical contributions by Japan. Furthermore, with a view to promoting greater awareness of the importance of this issue throughout the international community, Japan submitted a resolution on nuclear disarmament to the United Nations General Assembly last fall. This resolution, among others, welcomed ongoing efforts for the dismantlement of nuclear weapons and advocates the importance of safe and effective management of the resultant fissile material. It was adopted with the support of an overwhelming majority, including all the nuclear-weapon states and most of the non-nuclear states.

### Japan's policy

In tackling this issue, Japan attaches a special importance to three cardinal principles: irreversibility, transparency, and efficiency.

a)Irreversibility

The term "irreversibility" as used here means ensuring that the fissile material once designated not to be used for military purposes will not be used for such purposes. In May 1995, the Presidents Clinton and Yeltsin committed their countries to not reusing excess fissile material in nuclear weapons whether it be from dismantled nuclear weapons or from civil programs. Such a clear commitment is a crucial step for nuclear disarmament, and Japan has a high regard for this commitment. To ensure irreversibility, it is also important to place such plutonium under IAEA safeguards and effective measures for physical protection. Japan has been very strong on this point. At the Moscow Summit on Nuclear Safety and Security, the participants arrived at a common understanding on the need to implement such measures as soon as they become practicable. However, it is difficult to determine appropriate measures for IAEA verification, unless the plutonium derived from nuclear weapons is converted to plutonium oxide or other forms that do not contain sensitive information of military significance. On this point, Japan welcomes the ongoing talks among the Untied States, Russia, and the IAEA to explore means for verification, and upon the conclusion of this study, we expect that all surplus weapons plutonium including those with sensitive information will be placed under IAEA safeguards.

b)Transparency

In order for surplus weapons plutonium to be managed safely and effectively, it is vital to ensure transparency by disclosing information such as the amount of plutonium involved, the term of management required, and the physical and chemical form of such plutonium. It is only when these pieces of information are made available that we can define the cost for disposition, the technologies and facilities to be employed, and consequently, an appropriate schedule for management.

c)Efficiency

To promote nuclear disarmament and to warrant nuclear non-proliferation, we should dispose such surplus weapons plutonium as rapidly as possible and thus restrain its accumulation to a minimum level. In this context, due consideration should be given to making use of existing facilities and established technology. Also, when we make any facilities available, a priority should be given to the disposition of surplus weapons plutonium as long as such material continue to exist. The critical importance of efficiency was affirmed at the international experts meeting in Paris as well.

In order to reduce stockpiles of surplus weapons plutonium, it is necessary to end fresh production of weapons-grade plutonium, and in this connection we welcome the agreement reached in September last year between the United States and Russia, stipulating that the three nuclear reactors for commercial use in Russia which produce weapons-grade plutonium will cease production of such material by the year 2000.

d)Other considerations

In addition to these cardinal principles, other concerns, such as safety and environmental impact, should be carefully considered in the management of fissile material.

## 4. Japan's contributions

The management of surplus weapons plutonium consists of various processes, such as the dismantlement of nuclear weapons, the storage of resultant plutonium and, its transformation (conversion into a material substance, fabrication of fuel from such material, and consumption in reactors). International efforts are under way with regard to each of these processes. The following are Japan's contributions.

### Dismantlement

While Russia and the United States are carrying out the dismantlement of their nuclear weapons steadily in accordance with START I, Japan intends to play its role in order to advance this process. Specifically, we are promoting a project to provide Russia with equipment to deal with the emergencies that could arise during transportation of fissile material from the site of the dismantlement of nuclear weapons to storage facilities.

### Interim storage

It would take dozens of years to transform all of the surplus weapons plutonium into a form that is unattractive for military purposes. It is, therefore, essential that this material be safely stored over a long period of time until its eventual transformation. For that purpose, the construction of appropriate facilities is an urgent task. In this connection, a storage facility for highly enriched uranium and plutonium from dismantled nuclear weapons is under construction in Mayak, a suburb of Chelyabinsk in the Ural Region. Works for designing and construction of this facility are jointly conducted by Russia and the United States. Being mindful of the importance of this storage facility, Japan is trying to help the project by providing fissile material containers to be used in this Mayak facility, and discussions are under way with the United States and Russia.

Japan strongly expects the early completion of the construction of this facility, which will contribute to efficient management of surplus weapons plutonium. At the same time, I would like to reiterate the importance of placing the fissile material stored in this facility under appropriate safeguards. For this purpose, fissile material kept in this storage site should be subject to an appropriate control and accounting system and be placed under IAEA safeguards with the least possible delay. We were encouraged by President Yeltsin's statement at the Moscow Summit on Nuclear Safety and Security in April 1996, according to which we understand that roughly 40% of Russian surplus weapons plutonium would be stored in that facility, and thus placed under IAEA safeguards. It is superfluous to say that, such a storage facility should incorporate the physical protection which meets international standards.

### Transformation

Surplus weapons plutonium must be transformed into material that is unattractive for military purposes. As noted above, consumption in nuclear reactors is regarded as a promising option for effecting such a qualitative change, and the international community has been considering the implementation of this option.

In order to consume it in reactors, the alloyed metal plutonium derived from nuclear warheads must first be converted into plutonium oxide. Russia and the United States are considering cooperation for this pit conversion process. Since the plutonium before conversion may contain sensitive information of military significance, it is difficult for non-nuclear weapon states like Japan to cooperate in such a conversion process. Still the transparency is very important in such a process as well, and Japan keeps interests in it.

France, Germany, and Russia are planning to construct a demonstration-scale MOX fuel fabrication facility in Russia. This plan initially started in 1992 in separate discussions between France and Russia, and also between Germany and Russia. Later these three countries decided to implement this project as a trilateral cooperative scheme. Japan welcomes this progress in that such coordination is conducive to avoiding project duplication and thus promote the efficient management of surplus weapons plutonium. However, Russian reactors as they stand cannot burn MOX fuel and studies are required for necessary adjustments and modifications. Japan has considerable experience and technology acquired through its peaceful use of atomic energy, and is looking into the possibility of assisting in these studies.

The CANDU initiative, as proposed by Canada, intends to fabricate the surplus weapons plutonium into MOX fuel in the United States and Russia and then transport it to Canada for consumption in CANDU (Canadian Deuterium Uranium) reactors. This initiative, if realized, would speed up the disposal of the plutonium. In light of this benefit, Japan undertook an evaluation of the research related to this initiative by making use of its experience in the production of MOX fuel for Japan's advanced thermal reactor Fugen, which is similar to CANDU reactor.

## 5. Task for the future

### Coordination between the United States and Russia

In order to ensure the efficient disposition of surplus weapons plutonium, we believe that it is important to take a comprehensive approach that encompasses the whole process, including dismantlement, storage and transformation. At present, however, a number of international projects are under consideration without a well coordinated structure of the whole process. First, further coordination should be sought out between the United States and Russia. A report on a joint US-Russian study proposed that the two countries should undertake parallel disposition so as to reduce their respective stockpiles of surplus weapons plutonium to equivalent amounts. We await this proposal sealed by a formal commitment of the respective governments. If such coordination advances between the United States and Russia in various matters, the overall picture covering all the processes will become clearer, making it easier to formulate comprehensive plans.

### Coordination within the G8

Coordination within the G8 could be guided by the coordination between the United States and Russia. It is important that major contributors of each project make relevant information available to all other G8 states to the maximum possible extent. G8 is now trying to assess commercial feasibility of multilateral projects. In this connection, the G8 governments clearly need to share information among themselves as well as with the private sector. We expect such information sharing and coordination will further facilitate this important endeavour towards the next century, and Japan will continue to take an active part in this process.

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# Disposition of Excess Weapons Plutonium: A View from the United States

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## Abstract

It is urgent to dispose of the fissile materials declared surplus by U. S. and Russia through the START agreements. Until these materials are disposed of in a form that assures that they will never again be returned to nuclear weapons, the risk of their diversion remains high and the vision of a global nuclear disarmament regime remains elusive.

A "road map" for appropriate disposition of excess weapons plutonium, to be carried out in parallel by the US and Russia, has been agreed to by an independent scientific US-Russian Commission established by Presidents Clinton and Yeltsin. The Commission recommends that a two-track approach be followed for the plutonium: (1) burning it in existing nuclear power plants and (2) immobilizing it with highly radioactive defense wastes.

Although evaluations and experiments are underway in the US and Russia on these plutonium disposition processes, actual disposition urgently requires several important steps by the two countries, in cooperation with the international community: completion of a formal US-Russian government agreement to pursue the two track disposition approach, development of an effective joint work plan, establishment of the necessary institutions to carry out the plan, provision of the resources needed to get the job done, and placement of the excess fissile material under international monitoring.

## An International Commitment

The United States has made a strong commitment in cooperation with Russia, the P-8 countries, and the IAEA to provide for the safe storage and ultimate disposal of the fissionable materials from the nuclear weapons declared excess in the START agreements. Storage in highly secure facilities is a first urgent step since the existence of tens of thousands of highly enriched uranium (HEU) and plutonium "pits" from the dismantled warheads poses a serious risk of diversion which must be minimized. The second essential step is disposition of these materials in a form to assure that they will never again be returned to nuclear weapons. This step is essential for two major reasons: (1) The highest practical level of proliferation resistance, comparable to that of commercial spent fuel, will be achieved. (2) The pattern of irreversibility needed to make a global nuclear arms reduction regime will become a reality. This paper presents my view from the U. S. on the progress to date and the work ahead to dispose of these excess nuclear weapons materials.

## Actions to Date

Significant progress has been made in up-grading excess weapons materials storage facilities both in Russia and in the U. S., with substantial financial and technical support by the U. S., in constructing new, centralized safe storage facilities in Russia. Progress is also being made in implementing the disposition step, at a high pace for the HEU but a much slower pace for the plutonium.

Acting for their respective governments, the U. S. Enrichment Corporation (USEC), presently in the process of being privatized, and the Russian Ministry of Atomic Energy have entered into a contract to dispose of the excess HEU from some 20,000 Russian warheads. The highly enriched material is being converted to low enriched form in Russia and then shipped to the USEC to be used as fuel in U. S. LWR nuclear power plants. The fuel will generate an estimated six trillion kw-hrs of electricity, enough to light the entire U. S. for about two years. The first shipment arrived in the U. S. in June 1995. The USEC will pay the Russian Ministry $12 billion over the 20 years needed to complete the conversion. This step is an important example of the "swords-to-plowshares" role industry can play in moving the world away from nuclear weapons.

The disposition of excess weapons plutonium by converting it to fuel is more complex than for highly enriched uranium because the conversion and fabrication of plutonium into the required uranium-plutonium mixed oxide fuel form is much more expensive and political issues associated with the recycle of plutonium in power reactors are introduced. Nevertheless, significant progress has been made in the planning and initial development work preliminary to the actual disposition of the plutonium.

The U. S. Department of Energy (DOE) issued a Record of Decision(1) in January 1997 to follow a "dual track" approach to the disposition of excess weapons plutonium: (1) utilizing it as (MOX) fuel in existing power reactors, and (2) immobilizing it by mixing it in a glass or ceramic matrix with high level defense radioactive wastes. On each track the objective is to reduce the plutonium to a form that meets the "Spent Fuel Standard"(2),(3), i.e., makes the excess weapons plutonium roughly as inaccessible for weapons use as the much larger and growing quantity of plutonium in spent fuel from commercial power reactors. A subsidiary objective is to maintain high resistance to proliferation during the disposition process by maintaining the same level of proliferation resistance as exists in safe storage, that is, the "Stored Weapons Standard"(2) until the material reaches the higher level of proliferation called for in the "Spent Fuel Standard".

**International Cooperation**

It is of course important that the U. S. and Russia implement the disposition process on similar schedules, meeting standards equivalent to the Spent Fuel and Stored Weapons Standards. Recommendations(4) for appropriate disposition of excess weapons plutonium, to be carried out in parallel by the U. S. and Russia, have been made by an independent scientific U. S.-Russian Commission established by Presidents Clinton and Yeltsin. The Commission recommends that a two-track approach similar to that in the U. S. DOE's ROD be followed for the plutonium: utilizing it as fuel in existing nuclear power reactors and immobilizing it with highly radioactive defense wastes. The amount of material disposed of in each track is to be determined by each country as each program progresses.

Preparatory work along these lines is underway in both countries. DOE is preparing bid specifications for existing commercial light water reactor power plants to participate in the reactor "track" and has contracted with their national laboratories to develop the immobilization process. Work is underway in Russia to design and test the MOX fuel systems to be used to burn the plutonium in their VVERs. Both countries are developing the technical processes for conversion of the metal plutonium pits to plutonium oxide as input to both "tracks". Full implementation of the plan awaits completion of formal agreements, contractual and organizational arrangements, and financing mechanisms.

Substantial assistance is being provided to this effort by other countries. For example, France and Germany are working cooperatively with Russia to develop MOX fuel fabrication capabilities in Russia with which to implement its excess plutonium disposition program. Canada and Russia are jointly evaluating the use of the CANDU reactor to burn some of Russia's excess plutonium. The U. S. is seeking the know-how of experienced European organizations in developing its MOX capability and is considering the utilization of European facilities for initial MOX fabrication and irradiation demonstrations.

**The Work Ahead, Schedule, and Cost**

The schedules and cost estimates prepared by the U. S. DOE(5) in its planning to implement the disposition processes make it clear that the task is a major one. It will take 8 to 10 years before the disposition process goes into production. The DOE schedules for the start of production are: plutonium conversion from metal to oxide in 2002, immobilization in 2005 and reactor irradiation in 2007. The disposition of the presently declared U. S. surplus of 50MT of plutonium will then take from 9 years (most rapid immobilization variant) to 14 years (reactor option) to complete. The costs of plutonium disposition are high. DOE estimates that the disposition will cost about $2 billion whether it be the reactor option including credit for the energy value of the plutonium, or the least expensive immobilization variant, or a hybrid approach in which the plutonium will be dispositioned on both tracks in parallel. The irradiations will then take 14 years to complete. An indication of why the task is so costly and time consuming can be gained by summarizing the specific processes and facilities which must be put in place.

Front End Processing

The surplus weapons plutonium exists in many forms: pure plutonium metal " pits" from dismantled nuclear weapons, pure and contaminated plutonium metal, oxides, alloys, and compounds from related military activities, and unirradiated military reactor fuels. Approximately 33 of the 50 MT U. S. surplus plutonium consists of high purity metals and oxides from nuclear weapons reductions.

Generally, these high purity forms of plutonium must be converted and conditioned before they can be used as feed materials for either disposition track. The plutonium must first be extracted from the pits, converted to plutonium hydride and then to oxide or metal, masked from classified information, which can be used as feed to the disposition tracks. An additional thermal processing step may be required to make the feed pure enough for the MOX track. A more complicated mixed feed processing is required for the 30% of the material which does not contain pure plutonium, but the processing is simpler and less expensive if its purpose is to prepare feed only for the immobilization track. The U. S. is developing a hydride-dehydride process for the conversion to oxide since it is a dry process with a minimal level of waste produced. Russia prefers the conventional wet hydride/oxide process since it has few technical uncertainties.

Conversion processing operations for the remaining materials are more complex because there are a variety of forms with significant differences in their impurities. These plutonium forms, will have to be purified for use in the reactor option. On the other hand, this material can be accepted in the immobilization option without having to be purified, which has led to serious consideration of a hybrid alternative in which 33 MT would be processed on the reactor track and 17 MT on the immobilization track.

It is planned to select one DOE site from among Hanford, INEL, Pantex, or Savannah River to construct and operate a pit disassembly/conversion facility and to choose between Hanford or Savannah River to construct a mixed feed processing facility for non-pit plutonium. The mixed feed processing facility will be co-located with the immobilization facility.

Immobilization in Glass or Ceramic

In the immobilization approach, the surplus plutonium is mixed with military high level radioactive wastes in a glass or ceramic matrix and placed in a large canister. The size, weight, and radiation levels of the canister are similar to those of spent fuel assemblies so as to provide barriers to plutonium recovery comparable to spent fuel assemblies and thereby meet the " spent fuel standard". It is presently estimated that an immobilization canister will be about 3 meters long and 0.6 meter in diameter, will weigh one to two tonnes, and its gamma radiation field will be about 3000 rem/hr at its surface 30 years after initial fabrication.

Two variants to accomplish the mixing of plutonium and radioactive wastes are being considered for both the glass and ceramic forms: (1) mixing the plutonium and radioactive materials homogeneously or (2) placing small canisters of plutonium in a large canister containing the radioactive glass or ceramic matrix, called the " can-in-canister" variant. Progress to date on the R&D to develop these processes and their variants indicates a preference for utilizing a ceramic matrix with the " can-in-canister" variant because of advanntages in time and cost.

It is planned to construct and/or modify existing facilities at either the Hanford or Savannah River DOE complexes to carry out the immobilization processes. When the canisters have been loaded they will be readied for permanent storage, which is expected to be at the national geological spent fuel repository now under development. DOE has committed to immobilize at least 8 metric tons (MT) of surplus plutonium materials that it has determined are not suitable for use in MOX fuel.

Irradiating MOX Fuel in Existing Reactors

Once the plutonium metal pits have been converted to plutonium oxide for use in MOX fuel, the oxide is blended with low-enriched or depleted uranium oxide to form MOX fuel pellets which are inserted in fuel rods and then fabricated into fuel assemblies. The completed fuel assemblies are shipped to a commercial nuclear plant where they are used to refuel the reactor and generate energy for electricity production. The spent fuel assemblies will be disposed of in the national geologic spent fuel repository now under development. A typical MOX fuel assembly is 4 meters long and 0.4 meter wide, weighs 0.7 tonnes, and its gamma radiation field will be about 7,000 rem/hr at its surface 30 years after discharge from the reactor.

The MOX fuel will be used in a once-through fuel cycle, with no reprocessing or subsequent re-use of the spent fuel. Contractual provisions will be enforced to limit the reactor license modifications solely to the use of MOX fuel involving surplus weapons plutonium so as to discourage general civil use of plutonium-based fuel. It is planned to fabricate the U. S. MOX fuel pellets, rods, and assemblies in a domestic, government owned facility at one of the four DOE sites at Hanford, INEL, Pantex, or Savannah River. Depending on location, the facility may be newly constructed or a modification and up-grade of an existing facility.

It is planned to use approximately six existing commercial nuclear power plants in the U. S. to burn the MOX fuel. DOE has left open an option to utilize the CANDU nuclear power plants in Canada to burn some of the MOX fuel. Russian planning consistent with the Independent Scientific Commission report would be to use their operating VVERs and the BN-600.

**Environmental, Safety, and Proliferation Impacts**

The final programmatic environmental impact statement[6] concludes that the environmental impacts are minimal. The impacts were fully considered by DOE in reaching its Record of Decision. The largest impacts from the disposition processes were identified to be (1) a slight increase in the risk of latent cancer fatalities, in the worst case 1 chance in 5,000 and (2) a slight increase in fatalities during transportation from normal expected traffic accidents, in the worst case 6 potential fatalities over the entire life of the disposition campaign. When the site selections are made for the front-end processing, immobilization, and MOX fabrication facilities, site-specific environmental impact statements will be prepared.

Non-Proliferation and arms control assessments[7] thus far conclude that the dual track disposition approach: (1) will meet the Spent Fuel Standard and, if implemented appropriately, offer major nonproliferation and arms reduction benefits compared to leaving the material in safe storage in directly-usable form; and (2) will substantially reduce, although not eliminate, the risk of reversal of current nuclear arms reductions. The most vulnerable steps from a non-proliferation standpoint are during those portions of the disposition processes in which plutonium is in bulk form and/or is being transported.

For both tracks: (1) progress in disposition will be monitored and made transparent by placing the surplus materials under bilateral U. S.-Russian monitoring and IAEA safeguards; (2) stringent standards of safeguards will be maintained throughout the disposition process, as called for by the Stored Weapons Standard; (3) improved materials accountability methods and international safeguards approaches will be applied in the bulk-handling of plutonium, including near real time accounting, increased automation in the process design, and improved containment and surveillance; and (4) the transport of plutonium in forms vulnerable to diversion will be minimized by co-locating key facilities.

For the MOX track, the perception of change in U. S. fuel policy has been mitigated by commitments only to once-through processing and to surplus weapons plutonium. For the can-in-can variant, the current effort will be continued to develop a design that will prevent removal of the cans from the canisters to assure that the Spent Fuel Standard is met.

**Programmatic Uncertainties**

There are substantial uncertainties in implementing the dual track program, some internal to the program and some external. The internal uncertainties arise principally from unanticipated R&D results, construction cost and time underestimates, and delays in resolving environmental impact issues and obtaining the necessary licenses. The external uncertainties arise principally from the level of national priority and funding, legal challenges, regulatory changes, public acceptance, and the progress in negotiating agreements with Russia and other countries to assure a parallel and equitable effort.

Broadly stated, the MOX track is more subject to the external uncertainties since using reactors for plutonium disposition is politically more controversial and the licensing process with the Nuclear Regulatory Commission is subject to delay. Since MOX fuel fabrication and its use as a reactor fuel is presently a routine process in Europe and has been done on an experimental basis in the U. S., the technical uncertainties are small. On the other hand, the immobilization track is more subject to technical uncertainties since the process is new and not proven. Immobilization is less vulnerable to external uncertainties since it is less politically controversial and licensing procedures will be less demanding for its totally government owned and operated set of facilities. Both tracks, of course, are sensitive to the impacts of national priority and funding and the development of appropriate international agreements.

**Developing a Broad Consensus**

The need to develop a consensus on the importance and the means of disposing of excess weapons plutonium has been highlighted in the U. S. effort. Such consensus must be developed among many constituencies: the technocrats who are depended upon to define the technical means and implement them; the industry who are depended upon to participate in key elements of the effort; the Russian government and its agencies who will implement in parallel the disposition of their surplus weapons plutonium; the other P-8 countries and the IAEA who must participate to achieve the global nuclear arms reduction regime; the U. S. government officials who have to forge the plans, schedules, and budgets in competition with other goals and interests and have to negotiate the necessary international agreements; the Congress who have to approve the plans and subsequently authorize the funds to carry them out, and the public who need to be supportive of such a long standing endeavor if it is to sustain and succeed.

The DOE has devoted major effort to gaining this consensus as the program has progressed. Public announcements were issued and meetings were held throughout the country to identify, and gain feedback on, every major phase of the program: the intent to proceed with the program and prepare the appropriate environmental impact statements; the technical assessment which screened the options and evaluated their effectiveness, timeliness, and cost; the non-proliferation and arms control assessment which evaluated the proliferation resistance and irretrievability of each option; and the Record of Decision which selected the preferred "two track' approach.

The U. S. and Russia have cooperated to gain agreement on the preferred disposition processes and schedules and to engage in joint evaluations and R&D on the options. The P-8 countries, largely at their Summit meetings, have committed formally to cooperate on the disposition processes and to make the overall arms reduction processes transparent through the IAEA. Meetings of the P-8 countries' technical experts have been convened to discuss the disposition options and their characteristics.

These efforts have gone a long way toward achieving consensus among the first three groups, the technocrats, the industry, and the responsible government officials, but not all the way. There is still some opposition from the environmental community because of their unwarranted perception that the reactor option will foster plutonium recycle and this concern is shared by a small number of officials in the cognizant U. S. agencies. Although the U. S.-Russian Independent Scientific Commission has reached agreement on the preferred disposition processes and President Yeltsin has authorized a high ranking interagency working group to implement the program, no formal agreements between the U. S. and Russia on theses matters have yet been implemented. Further, there are some officials in the Russian agencies who object to plutonium disposition in any way other than through the reactor option.

The Congress is generally disposed favorably to the effort as is evidenced by their funding of the storage facility up-grading and the weapons materials production cut-off initiative in the U. S. and Russia and for the initial studies of plutonium disposition by DOE. Yet, the test of their full support will not come until DOE submits its plans and budget requirements for the full program.

On the other hand, the necessary level of consensus has not been reached with the public in spite of DOE's public participation efforts, largely because the bulk of the public are unaware of the importance and urgency of the matter. The end of the cold war has introduced an unwarranted level of complaisance as to the risks from nuclear weapons and little has been done by government or the media to challenge that complaisance. Testimony to the Congress by the Director of the CIA and statements by Congressional leaders have clearly identified the present risks and the U. S. National Academy has termed them "a clear and present danger", but the public is largely unaware of these concerns. It is an anomaly that there is so little public awareness of these indisputably certain risks while there is widespread public awareness of, and concern for, the highly uncertain risks of global warming. This meeting sponsored by PNC in Tokyo is important in helping to develop consensus, but it would be more appropriate if such a meeting received the attention and media amplification of the recent meeting on global warming in Kyoto.

The most significant technical barrier to achieving consensus is contention over the use or non-use of the excess plutonium as a reactor fuel. This contention threads itself through the U. S. acceptance process, in the forging of international agreements among the U. S., Russia, and the other P-8 countries, and in gaining solid political and public acceptance. This contention existed in the early stages of the National Academy study in which I participated. It was eliminated by acceptance of the following principle which is well stated in the report of the U. S.-Russian Independent Commission to Presidents Clinton and Yeltsin: "We believe that agreement on these urgent steps to address the security risks posed by excess weapons plutonium can and should be reached even while differences remain about the longer-term issues of the future of nuclear energy and the nuclear fuel cycle; resolution of these two important problems need not and should not be linked.... Arrangements for international cooperation in carrying out this critical disarmament mission should be carefully designed so as not to force any of the parties to repudiate their views on the future of the fuel cycle: the mission of disposition of excess weapons plutonium can and should be implemented without the United States having to support steps that would contribute to additional reprocessing and recycling of plutonium, and without Russia or the other participating states having to agree to permanently foreclose reprocessing and recycle." I would hope that those of us participating in this Forum can subscribe to that principle and can help design the arrangements which preclude forcing a position on the future of the nuclear fuel cycle.

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# Japanese Technical Potentialities for the Cooperation pertaining to Russian Excess Weapons Plutonium Disposition

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## Abstract

Potential areas and items for the international cooperation pertainig to Russian excess weapons plutonium disposition are introduced and reviewed technically. Based on Japanese experience and experties accumulated through it's FBR recycle technology development and actual cooperation experiences, there could find certain areas and items for the cooperation regarding to MOX option. Trilateral project, U.S.-Russia joint study, Russian FBR program, CANDU option, Gas reactors option, etc are the candidates. It is necessary to keep close contact with each country and identify certain items for the cooperation.

## 1.Introduction

A lot of experiences and experties pertaining to burn MOX fuel in nuclear reactors such as JOYO, MONJU and FUGEN have been accumulated in Japan since the recycle option for the use of nuclear energy has been adopted in order to use resources effectively. Making the most of these experiences and experties, it can be said that Japan has strong potentials to participate in an international cooperation which intends to turn excess weapons plutonium into MOX fuel and burn in nuclear reactors as a disposal option. With regards to the immobilization option, which is another disposal option, Japan has experience in vitrification technology for high-level wastes. Japan also has actual international cooperation experiences such as installing a flow monitor system of BN350 in Kazakstan.

The area and items for the technical contribution candidates are introduced based on the above mentioned potentials and experiences.

## 2.Technical Potentials

The technical potentials of Japan are summarized as follows:

(1) The actual burning of MOX fuel in reactors has been conducted abundantly in the experimental fast reactor "Joyo", the prototype advanced thermal reactor "Fugen" and the prototype fast breeder reactor "Monju". Although small in quantity, the Mihama No. 1 Reactor and the Tsuruga No. 1 Reactor have had experience in burning the MOX fuel. Japan, therefore, has technological abilities concerning reactor core characteristic analysis, safety analysis, fuel design, fabrication and so on, of the reactors of these types. In addition, although there has been no actual use of plutonium, research on the burning of the MOX fuel in a high-temperature gas-cooled

reactor has been conducted.

(2) As for the irradiation examination, a large number of examinations have been conducted using research reactors in Japan and overseas countries, as well as "Joyo" and "Fugen". Furthermore, as for the post irradiation examinations, Japan has many facilities available for destructive and non-destructive examinations. Without mentioning, Japan has the analytical technologies(performance analysis of fuels, etc.) necessary for these examinations.

(3) With respect to the fabrication of MOX fuel, approximately 150 tons of the MOX fuel has been fabricated for "Joyo", "Fugen" and "Monju". Japan has three MOX fuel fabricating facilities, and two of them were constructed using domestic technologies. Japan, therefore, has affluent technological abilities concerning the design, construction and operation of MOX fuel fabrication facilities.

(4) Through the MOX fuel used for "Fugen", it is technologically confirmed that the handling and storage of approximately 90 tons of MOX spent fuel is basically not different from the handling and storage of the uranium spent fuel.

(5) Japan has technologies substantiated by much experience in land and maritime transport, with respect to both fresh and spent fuel, concerning the transport and development of the transportation container of MOX fuel.

(6) Regarding safeguards, Japan has accepted the IAEA full-scope inspection and has technologies guaranteed through a lot of experiences.

(7) In regard to the vitrification technology of high-level wastes, the Tokai Vitrification Facility(TVF) was constructed and has been operated to vitrify actual high level wastes received from Tokai Reprocessing Plant, and a facility which succeeds this technology is under construction at the Rokkasho Reprocessing Plant.

## 3. Possibilities of International Cooperation

The most potent option for the Russian plutonium disposition is the trilateral project being progressed by France, Germany and Russia. It is understood that the final coordination has been promoted towards the signing of a written agreement which stipulates the contents of the cooperation. There are also potent studies being conducted by the U.S. and Russia jointly. Thirdly, it seems that Russia intends to promote the disposition using Russian original technologies. Canada proposes to utilize CANDU reactors in Canada for the disposition.

Based on Japanese technical advantage mentioned before, and taking the trend of each country mentioned above into consideration, it is desired to promote cooperation by making emphasis on the fast reactor while keeping the VVER and CANDU into vision. It is accordingly necessary to consider specific measures to the feasible items of cooperation through negotiations with France, Germany, the U.S. ,Russia and Canada while paying attention to the policy of avoiding activities being duplicated with each other.

(1) Participation in the Trilateral Project

Judging from the experience and technological level of Japan, to participate in this project as the fourth country is feasible. In the trilateral project, items being considered are the irradiation test of a few assemblies in the VVER1000, the construction of the DEMOX plant which is MOX fuel fabrication facility for both types of VVER1000 and BN600, and the plant modification necessary for the acceptance of MOX fuel to these reactors.

The fields in which Japan can participate are the construction of fuel fabrication facilities, the fuel performance analysis in a reactor, the irradiation test, transport, safeguards, quality assurance and quality control associated with them, etc. Participation possibilities can be considered in all of the foregoing fields.

Japan's contributive objects towards the DEMOX Project can be composed of hardware technology such as the BN600 pellet fabrication equipment with fast reactor specifications, the technology which prevents in process powder accumulation and was recently developed by PNC, as well as software technologies such as for plant operation control, in all of which Japan is a bit more experienced.

It is said that the trilateral agreement takes the coming two years into vision, and what holds as most important in the agreement seems to be the irradiation test of a few assemblies in the VVER1000. This is especially meaningful for acquiring a positive achievement in plutonium disposition in an early stage, and for starting an early experience in MOX fuel burning in the VVER1000, because Russia has not been experienced in it.

It would also be possible to offer the transport containers for plutonium oxide powder or fuel assemblies.

(2) Participation in the U.S.-Russia joint study

A lot of studies have been conducted for various options for the disposition of excess weapons plutonium by the U.S.-Russia joint study. Some of them are being conducted and, among them, fast reactor option and light water reactor option seem to be a candidate for Japan's participation as an international cooperation. Safety analysis, severe accident anlysis and core characteristic analysis using computer code could be the examples of cooperation items.It would also be possible for Japan to cooperate the activiities regarding immobilization of plutonium.

(3) Fast reactor option

In Russia, apart from the Trilateral Project and the U.S.-Russian joint study, the processing measures using Russian original technologies are under consideration. Among them, by way of the measure in which Japan could have technological interests, there is a method to process fast reactor fuel by the vibro compaction(vibropacked) system and burn the fuel in BN600. Specifically speaking, reactor core analysis, support of fuel fabrication on a demonstration basis and demonstrative irradiation with

BN600, and furthermore, the design of industrial fuel facilities for the purpose of establishing the vibropacked fuel fabrication technology may be considered to be the technological items. Japan has already experienced the international cooperation of fast reactors such as installing the flow monitor system and the computer system for materials accountancy into BN350 in Kazakstan.

(4) CANDU option

This option intends to conduct the disposition of plutonium at CANDU reactors, after both the U.S. and Russia have processed its own plutonium into MOX fuel and brought it into Canada. As a method for the disposition of excess weapons plutonium, the option contains a factor which is not shared by other options in that the plutonium is brought out of Russia for the disposition. Moreover, the basic understanding is that both Russia and the U.S. must offer the same quantity of plutonium.

Because the capacity of disposition in Russia with the use of existing reactors is comparatively small, this option is regarded as a measure which easily increase the capacity of disposition.

In this issue, Japan has merits that the experience in burning MOX fuel at Japan's advanced thermal reactor "FUGEN", the irradiation test conducted for development of a demonstration reactor, and MOX fuel fabricating technology can be used almost as they stand. Requests for cooperation have come from the Canadian side, taking these facts into consideration. In addition, there was a request for the evaluation of a feasibility study which was carried out jointly by Canada and Russia concerning whether the function of CANDU fuel fabrication can or cannot be added to the DEMOX facilities under examination by the Trilateral Project. On the 14th and 15th of October, '97, the Canadian and Russian experts to whom the evaluation was offered were invited to Japan.

Participation in the small quantity irradiation test (PARALLEX Project) at the CANDU test reactor to be carried out at the next step by the U.S., Canada and Russia, as well as in the detailed design of the MOX facilities, are considered to be the items of cooperation.

(5) Gas cooled reactor option

This issue has been examined as an option researched jointly by the GA(U.S.), FRAMATOM(France) and MINATOM(Russia) on the feasibility of the disposing of plutonium by constructing a new gas cooled reactor. The recent situation shows that a Japanese manufacturer with gas cooled reactor technology joined in the design study. Because Japan has the potential to reflect its experience in the design and construction of a high-temperature gas cooled reactor and technological development on this issue, further progress in the cooperation might be possible.

(6) International joint research about safeguards

In order to cooperate in the disposition of plutonium from dismantled nuclear weapons, it is necessary that both "putting under international safeguards" and "improving transparency" should be guaranteed. Therefore, based on the discussion between the U.S., Russia and the IAEA, when the technological measures for safeguards to guarantee the framework of the international safeguards becomes to be clear, Japan could propose to consider the approach for the safeguards, conduct the design and R&D works for the safeguards system by the international cooperation.

(7) Long term safety management of spent MOX fuel

Although there are arguments between the U.S. and Russia concerning the treatment of spent fuel resulting from the MOX option, it is obvious that safe and secure storage and management must be inevitable for the time being. In order to prompt the negotiation between the U.S. and Russia, it could be worthwhile for Japan to propose to establish the arena for an international discussion on the IAEA safeguards system concerning the spent MOX fuel storage.

## 4. Conclusion

It is considered that the seven options mentioned above will be the technologically possible candidates with which Japan can participate, for the time being, in the international cooperation. It is necessary to identify certain items for the cooperation as soon as possible through the discussion with related countries and start the actual cooperation using the budget approved by the government for the first time in JFY'98.

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