THE 27TH JAIF
ANNUAL CONFERENCE
第27回原産年次大会

APRIL 13～15, 1994

JAPAN ATOMIC INDUSTRIAL FORUM
日本原子力産業会議

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平成６年４月１３日(水)～１５日(金)
於　広島国際会議場 フェニックスホール

	第 １ 日 ４月１３日(水)	第 ２ 日 ４月１４日(木)	第 ３ 日 ４月１５日(金)
午前	開会セッション (9:00～12:40) 年次大会準備委員長挨拶 原産会長所信表明 原子力委員長所感 広島県知事挨拶 ＜特別講演＞ ＜招待講演＞	セッション２ (9:00～12:00) 「原子力発電とプルトニウム」 〔パネル討論〕	セッション４ (9:00～12:00) 「アジアの原子力開発と日本の役割」 〔パネル討論〕
午後	(昼休み)	午　餐　会 (12:10～14:20) 通商産業大臣所感 於 広島全日空ﾎﾃﾙ 原子力及び広島関係映画上映 (13:00～14:00)	(昼休み)
	セッション１ (14:30～17:30) 「核兵器廃絶へ向けてー平和利用からのﾒｯｾｰｼﾞ」 〔パネル討論〕	セッション３ (14:45～17:15) 「科学技術教育と日本の将来」 〔パネル討論〕	セッション５ (14:00～17:00) 「放射線の影響ー研究成果と今後の課題」 〔パネル討論〕 閉会挨拶ー広島アピール (17:00～17:15)
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第２７回原産年次大会
プログラム

基調テーマ「核兵器のない世界へ－平和利用の役割」
平成６年４月１３日（水）～１５日（金）
於　広島国際会議場フェニックスホール
主催　（社）日本原子力産業会議

※本大会は全セッションを通じて日英同時通訳を行います。

４月１３日（水）

<u>開会セッション（９：００～１２：４０）</u>
議長：多田公熙　　中国電力(株)社長

大会準備委員長挨拶
　飯島宗一　　年次大会準備委員長
　　　　　　　広島大学名誉教授

原産会長所信表明
　向坊隆　　(社)日本原子力産業会議会長

原子力委員会委員長所感
　江田五月　　原子力委員会委員長
　　　　　　　国務大臣・科学技術庁長官

広島県知事挨拶
　藤田雄山　　広島県知事

＜特別講演＞
「世界の新しい夜明け」
　R．ローズ　　ﾋﾟｭｰﾘｯﾂｧ賞受賞作家（米国）

＜休　　憩＞

議長：青井舒一　　(株)東芝会長

＜招待講演＞
「原子力平和利用の推進と軍事利用の防止」
　H．ブリックス　　国際原子力機関（ＩＡＥＡ）事務局長

「普遍原理の応用による効果的な規制の達成」
　K．C．ロジャース　　米国原子力規制委員会（ＮＲＣ）委員

「ロシアにおける核軍縮と原子力の将来」
　V．N．ミハイロフ　　ロシア原子力大臣

4月13日（水）

セッション1（14：30～17：30）
核兵器廃絶へ向けて－平和利用からのメッセージ

原子力はすでに世界の電力の17％を供給するなど、その平和利用において大きな発展をみてきた。しかし、その一方で、核兵器の存在が平和利用のあらゆる側面において数々の影響を及ぼし、原子力の健全な発展のための大きな阻害要因となっている。ここでは、現存する核兵器をいかに縮小し、廃絶していくか、平和利用の技術が新たに核兵器の開発につながらないためにさらに努力する点は何かなどについて、開会セッションの講演をも踏まえながら討論する。また核兵器拡散防止に中心的役割を果たしてきた核不拡散条約（NPT）の評価をもとに、1年後の延長会議に向けてのNPTのあり方と課題などについても討論し、包括的核実験禁止などたしかな核兵器廃絶への努力を求めつつ、21世紀に向けて核兵器の存在の意味を問い、考える。

議長：中馬清福　　朝日新聞社論説主幹代理

<基調講演>
「核軍縮の歴史と未来」
今井隆吉　　(社)日本原子力産業会議常任顧問
元軍縮会議日本政府代表部特命全権大使

<パネル討論>
パネリスト
イブ・ボワイエ　　エコールポリテクニク戦略工学研究所次長（フランス）
崔　栄　　慶南大学極東問題研究所上級研究員（韓国）
J．W．L．ディビリアス　　南アフリカ原子力公社総裁
D．エルズバーグ　　ﾏﾝﾊｯﾀﾝ･ﾌﾟﾛｼﾞｪｸﾄII（核兵器廃絶推進ｸﾞﾙｰﾌﾟ）代表幹事（米国）
鴨　武彦　　東京大学教授
庄野直美　　広島女学院大学名誉教授

<参加者との討論>
注記：<参加者との討論>本大会では、内外の参加者とスピーカーの討論に時間を割いています。以下の各セッションとも、来会のみなさんからの活発な質問・コメントをお願いします。

ウェルカム・レセプション（18：00～19：30）
於　広島グランドホテル2階宴会場「孔雀」

4月14日（木）

セッション2（9：00～12：00）
原子力発電とプルトニウム

供給の信頼性・安定性に優れ、環境負荷の小さい技術エネルギーである原子力を長期的に有効利用していくために、使用済み燃料を再処理し、回収されたプルトニウムを燃料として本格的に利用していくことは、わが国の原子力政策の重要課題である。この核燃料リサイクル政策の根幹をなすプルトニウム利用と高速増殖炉開発については、社会的にも、国際的にも十分な理解を得ることが前提となり、今その大切な時期を迎えている。ここでは、この核燃料リサイクルの必要性と意義を再確認し、今後、プルトニウムの余剰蓄積を排除しつつ、どのように利用していくのか、軽水炉へのリサイクル利用の意義は何か、その問題点は何か、また情報公開のあり方など、再処理・リサイクル路線を進めていく際の問題点とその解決策を求めて討論を行う。

議長：中村 政雄　　読売新聞社論説委員

＜基調講演＞
「プルトニウムと文明」
秋元 勇巳　　三菱マテリアル(株)副社長

＜パネル討論＞
パネリスト
R．ヘイズ　　英原子力産業会議専務理事
池亀 亮　　東京電力(株)副社長
森口 泰孝　　科学技術庁原子力局核燃料課長
中野 啓昌　　動力炉・核燃料開発事業団理事
C．E．ペイン　　天然資源保護協議会原子力担当上級研究員（米国）
J．L．リコー　　コジェマ社副社長（フランス）
P．フェルビーク　　シナトム社特別顧問（ベルギー）

＜参加者との討論＞

４月１４日（木）

午餐会（１２：１０～１４：２０）
於　広島全日空ホテル３階宴会場「万葉」

来賓　通商産業大臣所感
熊　谷　　弘　　　　　　通商産業大臣

来賓　平　岡　　敬　　　　　　広島市長

原子力および広島関係映画上映（１３：００～１４：００）
於　広島国際会議場フェニックスホール

・「ヒロシマ：母たちの祈り」他

4月14日（木）

セッション3（14：45～17：15）

科学技術教育と日本の将来

この半世紀において、科学技術の進歩、なかでも原子力をはじめとする、より先進的な科学技術の進歩には著しいものがある。しかし、新しい科学技術へのアプローチは人類の幸福のための成果をもたらす反面、時として人間・社会にリスクをもたらす結果にもなりかねない。これまで科学技術立国として歩んできたわが国が、将来のより先進的な科学技術と取り組んでいくには、若年層より理工学分野への嗜好を高め、科学技術を容易に理解する素養を育む学校教育が重要となる。ここでは、最近の若年層の理科離れの実状を考慮しつつ、科学技術をめぐる今日の学校教育の問題点を総点検し、今、何が欠けているのか、また次世代に何を伝えていくのかなど、関係者による討論を行う。

議長：大　木　道　則　　　　岡山理科大学教授

＜基調講演＞

「科学技術教育の現状と課題」

福　井　謙　一　　　　基礎化学研究所所長、京都大学名誉教授

＜パネル討論＞

パネリスト

高　橋　景　一　　　　国際基督教大学教授

武　村　重　和　　　　広島大学教授

田　村　和　子　　　　共同通信社論説委員

田　中　義　郎　　　　広島市立美鈴が丘高等学校教諭

＜参加者との討論＞

4月14日（木）

広島市民と語る夕べ（17：30～19：30）　於：広島国際会議場地下2階ヒマワリ
ヒロシマの意味と役割

広島への原爆投下後、半世紀が過ぎようとしている。今日、広島市は近代的国際都市へと復興を果たしているが、ここに至るまでの広島市民の苦悩には大きなものがあった。ここでは、原産年次大会の開催を機に内外の原子力関係者が広島市民を含む広島関係者と、原爆とは何であったのか、原子力をどのように受けとめるべきか、また原子力平和利用のあり方などについて対話し、過去・現在・将来におけるヒロシマのもつ意義と役割について考える。

座長：森　一久　　(社)日本原子力産業会議専務理事

＜パネル討論＞

パネリスト

福原　照明	広島県医師会会長、核戦争防止国際医師会議日本支部長
片岡　勝子	広島大学教授
川本　義隆	前広島平和記念資料館館長
李　実　根	広島県朝鮮人被爆者協議会会長
高橋　昭博	(財)広島平和文化センター事業部長
伏見　康治	名古屋大学名誉教授、元日本学術会議会長
向坊　隆	(社)日本原子力産業会議会長
鈴木　篤之	東京大学教授
R．ローズ	ピューリッツァ賞受賞作家（米国）
庄野　直美	広島女学院大学名誉教授
他	

※本討論会は会場をフェニックスホールから地下2階ヒマワリに移し、本大会への内外参加者、原子力関係者および広島関係者との円卓会議形式とします。聴講は約500人が限度ですが、定員超過の場合には、別室でのテレビによる視聴などの対応をはかるものとします。

4月15日（金）

セッション4（9：00～12：00）
アジアの原子力開発と日本の役割

原子力発電開発については、欧米の多くの国において停滞している中で、21世紀に向けてアジア地域を中心に展開する動きをみせている。すなわち、わが国をはじめ、韓国、中国などにおいて、相次いで大規模な計画が打ち出されるとともに、新たにインドネシアなどの国においても具体的な計画が明らかにされつつある。世界人口の半数以上を占めるアジア地域における原子力発電の健全な発展は、エネルギー・電力の将来の安定供給確保はもとより、地球の環境保全のためにも、大きな意義がある。ここでは、アジアの原子力開発を効果的に行い、その安全確保や放射性廃棄物への対応などをどのように進めていくか、さらには平和利用と核不拡散との両立をどのように考えていくか、わが国に求められる役割は何か、などについて討論し、原子力開発を円滑に進めるための方策とわが国の役割について考える。

議長：村　田　　浩　　　　　(社)日本原子力産業会議副会長

＜基調講演＞

「国際貢献におけるわが国の役割とこれまでの実績」

林　　　暘　　　　　外務省総合外交政策局軍備管理・科学審議官

＜パネル討論＞

パネリスト

D．アヒムサ	インドネシア原子力庁（BATAN）長官
李　玉　崙	中国核工業総公司（CNNC）副総経理
林　瑢　圭	韓国原子力安全技術院院長
向　準一郎	日本原子力発電(株)常務取締役
T．スミトラ	チュラロンコン大学工学部長（タイ）
吉　川　允　二	日本原子力研究所副理事長

コメンテーター

若干名の参加を予定

＜参加者との討論＞

4月15日（金）

セッション5（14：00～17：00）

放射線の影響－研究成果と今後の課題

原子力開発をすすめていくにあたっては、放射線の健康に与える影響についての正しい科学的データにもとづいて、万全の安全対策を講じていかなければならない。わが国では、広島、長崎に原子爆弾が投下されて以来、市民の協力を得ながら、半世紀近くにわたって放射線影響調査が実施されてきており、これらの調査結果は世界で最も科学的なデータであるとともに、国際放射線防護委員会（ＩＣＲＰ）の勧告等の重要な基礎データとなっている。ここでは、広島、長崎の放射線影響調査の歴史や経緯を振り返り、今日までに明確になっている点を紹介し、チェルノブイリ事故等の調査状況などを参照しながら、放射線の影響研究について、今後の課題を探る。

議長：大　牟　田　稔　　　(財)広島平和文化センター理事長

＜基調講演＞

「放射線影響評価―広島、長崎の調査結果より」

重　松　逸　造　　　(財)放射線影響研究所理事長

＜パネル討論＞

パネリスト

伊　藤　千賀子　　　(財)広島原爆障害対策協議会健康管理センター副所長
Ｓ．ジャブロン　　　前米国癌研究所癌原因研究部門放射線疫学部専門官
Ｃ．Ｒ．ミュアヘッド　　　英国放射線防護委員会疫学グループ長
朝　長　万左男　　　長崎大学医学部付属原爆後障害医療研究施設教授
宇　吹　　暁　　　広島大学原爆放射能医学研究所助教授

＜参加者との討論＞

閉会挨拶―広島アピール（17：00～17：15）

飯　島　宗　一　　　年次大会準備委員長
広島大学名誉教授

フェアウェル・パーティ（17：15～18：45）

於　広島国際会議場地下2階ダリア

THE 27TH JAIF ANNUAL CONFERENCE
PROGRAM OVERVIEW

WED. APRIL 13

Opening Session
9:00-12:40

Session 1
14:30-17:30

Facing the Reality of Ultimate Abolition of Nuclear Weapons:
The Message of Peaceful Use of Nuclear Energy

Welcome Reception
18:00-19:30
HIROSHIMA GRAND HOTEL

THU. APRIL 14

Session 2
9:00-12:00

Nuclear Power and Plutonium

Luncheon
12:10-14:20
ANA HOTEL HIROSHIMA

Film Show
13:00-14:00

Session 3
14:45-17:15

Education of Science and Technology, and Japan's Future

17:30-19:30
Discussion together with the People of Hiroshima; the Significance and Role of **HIROSHIMA**
Himawari
INTERNATIONAL CONFERENCE CENTER HIROSHIMA

FRI. APRIL 15

Session 4
9:00-12:00

Development of Nuclear Power in Asia and the Role of Japan

Session 5
14:00-17:00

Effects of Radiation: Study Results and Future Issues

Farewell Party
17:15-18:45
Dahlia
INTERNATIONAL CONFERENCE CENTER HIROSHIMA

The 27th JAIF Annual Conference

Basic Theme : Toward Nuclear-Weapons-Free World
--the Role of Peaceful Utilization of Nuclear Energy

April 13-15, 1994

International Conference Center Hiroshima
Hiroshima, Japan

Japan Atomic Industrial Forum, Inc.

REGISTRATION (16:30-18:30, April 12)
B1F, INTERNATIONAL CONFERENCE CENTER HIROSHIMA

All SESSIONs are held at PHOENIX HALL, B1F, INTERNATIONAL CONFERENCE CENTER HIROSHIMA.

April 13 (Wednesday)

REGISTRATION (8:30-, April 13)
B1F, INTERNATIONAL CONFERENCE CENTER HIROSHIMA

OPENING SESSION (9:00 - 12:40)

Chairman:
Koki Tada
President
Chugoku Electric Power Co., Inc.

Remarks by Chairman of Program Committee
Soichi Iijima
Chairman
Program Committee
Professor Emeritus
Hiroshima University

JAIF Chairman's Address
Takashi Mukaibo
Chairman
Japan Atomic Industrial Forum, Inc.

Remarks by Chairman of Atomic Energy Commission
Satsuki Eda
Minister of State for Science and Technology

Remarks by Governor of Hiroshima Prefecture
Yuzan Fujita
Governor of Hiroshima Prefecture

Invited Lectures:
"The New Morning of the World"

Richard Rhodes
Pulitzer Prize Laureate
Author and Lecturer
U.S.A.

<Break>

Chairman:
Joichi Aoi
Chairman of the Board
Toshiba Corporation

"Promoting the Peaceful and Preventing the Military Uses of Nuclear Energy"
Hans Blix
Director General
International Atomic Energy Agency

"Achieving Effective Regulation through the application of Universal Principles"
Kenneth C. Rogers
Commissioner
U.S. Nuclear Regulatory Commission

"Nuclear Disarmament and Prospects of Nuclear Energy in Russia"
Viktor N. Mikhailov
Minister for Atomic Energy of the Russian Federation

SESSION 1 (14:30 - 17:30)

Facing the Reality of Ultimate Abolition of Nuclear Weapons: The Message of Peaceful Use of Nuclear Energy

Nuclear power accounts for 17 percent of the total electricity generation worldwide. Yet the existence of nuclear weapons taints efforts at peaceful utilization, and is a major hinderance to the sound development of nuclear energy for mankind. Today, we will consider how existing nuclear weapons can be reduced to zero level, and what efforts should be made to ensure that peaceful nuclear technologies are not misused in the new development of weapons. Invited lectures will be given at the opening session, which will provide the framework for our discussions. Opening a new page of the 21st century, we will also reconsider the unhappy reality of the existence of nuclear weapons, even as we seek the realization of full nuclear disarmament, including a comprehensive test ban for nuclear weapons. In this context, we will evaluate the Nuclear Non-Proliferation Treaty (NPT), which has played a key role in efforts toward the non-proliferation of nuclear weapons up until now; and will address the future of the NPT, including numerous problems related with it, prior to the NPT review conference to be held a year from now.

Chairman:
Kiyofuku Chuma
Vice Chairman of Editorial Board
Asahi Shimbun

Keynote
"The History and Future of Nuclear Disarmament"
Ryukichi Imai
Senior Advisor
Japan Atomic Industrial Forum, Inc.
Former Ambassador to the Conference on Disarmament in Geneva

Panel Discussion

Panelists:

Yves Boyer
Deputy Director
CREST Ecole polytechnique
France

Young Choi
Senior Research Fellow
Institute for Far Eastern Studies
Kyungnam University
Korea

J W L de Villiers
Chairman
Atomic Energy Corporation of SA-AEC
South Africa

Daniel Ellsberg
Director of Manhattan Project II
Physicians for Social Responsibility
U. S. A.

Takehiko Kamo
Professor
University of Tokyo

Naomi Shohno
Professor Emeritus
Hiroshima Jogakuin College

Discussion with the Audience

Note: "Discussion with the Audience" means discussion between the panel speakers and the audience. The audience is invited to exchange their views and make comments during each discussion.

WELCOME RECEPTION 18:00 - 19:30

BANQUET HALL "KUJAKU", 2F, HIROSHIMA GRAND HOTEL

April 14 (Thursday)

SESSION 2 (9:00 - 12:00)

Nuclear Power and Plutonium

The reprocessing of spent fuel and full utilization of recovered plutonium are important facets of Japan's nuclear efforts, which aim to make the best use of nuclear power for the long period, taking advantage of its excellent reliability and safety, and the small impact it has on the environment. On the use of plutonium and the development of fast breeder reactors (FBRs), both of which are at the core of Japan's nuclear-fuel-recycling policy, it is essential for Japan to obtain a complete understanding, both domestically and internationally, and this is now a critical time in that respect. In this session, after reconfirming the necessity and significance of nuclear fuel recycling, we will discuss various problems and solutions in continuing the policy of reprocessing and recycling, such as avoiding the accumulation of excess amounts of plutonium and the significance of the use of plutonium for light water reactors (LWRs).

Chairman:
Masao Nakamura
Editorial Writer
Yomiuri Shimbun

Keynote
"Plutonium and Civilization"
Yumi Akimoto
Executive Vice President
Mitsubishi Materials Corporation

Panel Discussion
Panelists:
Roger Hayes
Director General
British Nuclear Industry Forum, Inc.

Ryo Ikegame
Executive Vice President
Tokyo Electric Power Co., Inc.

Yasutaka Moriguchi
Director for Nuclear Fuel Division
Science and Technology Agency

Hiromasa Nakano
Executive Director
Power Reactor and Nuclear Fuel Development Corporation

Christopher E. Paine
Senior Research Associate, Nuclear Program
Natural Resources Defense Council
U.S.A.

Jean-Louis Ricaud
Vice President, Reprocessing and Industry
COGEMA
France

Pierre Verbeek
Special Adviser
Synatom
Belgium

Discussion with the Audience

LUNCHEON 12:10 - 14:20
BANQUET HALL "MANYO", 3F, ANA HOTEL HIROSHIMA

Remarks by Minister of International Trade and Industry
Hiroshi Kumagai
Minister of International Trade and Industry

Remarks by Mayor of Hiroshima City
Takashi Hiraoka
Mayor of Hiroshima City

FILM SHOW 13:00 - 14:00
PHOENIX HALL, B1F, INTERNATIONAL CONFERENCE CENTER HIROSHIMA

Latest films on "Hiroshima", and Japan's nuclear research and development activities will be presented to those who are not attending the Luncheon.

SESSION 3 (14:45 - 17:15)

Education of Science and Technology, and Japan's Future

The developments of science and technology during the past half-century have been remarkable -- not least in the nuclear field. New science and technologies, while, they can bring happiness and prosperity; they might also jeopardize entire societies and human existence itself. For Japan, which has so far enjoyed the benefits of scientific and technological advancement, to deal with an even more advanced science and technologies in the future, must provide an educational system that inspires students to become interested in science and engineering at an early stage, which will foster keen scientific minds capable of working with the most sophisticated technology. In this session, people in the field will review problems occurring in the science and technology of education with respect to modern developments. With children these days -- the next generation to carry Japan's future -- showing little interest in science, participants will discuss what is missing from the current educational system, and what can be done to solve these problems.

Chairman:
Michinori Ohki
Professor
Science University of Okayama

Keynote
"Current Status of Education in Science and Technology: A Problem"
Ken-ichi Fukui
Director
Institute for Fundamental Chemistry
Professor Emeritus
Kyoto University

Panel Discussion
Panelists:
Keiichi Takahashi
Professor
International Christian University

Shigekazu Takemura
Professor
Hiroshima University

Kazuko Tamura
Editorial Writer
Kyodo News Service

Yoshiro Tanaka
Science Teacher
Hiroshima Municipal Misuzu-ga-oka Senior High School

Discussion with the Audience

(17:30 - 19:30)

Discussion together with the People of Hiroshima; the Significance and Role of "Hiroshima"

International Conference Room "Himawari", B2F, INTERNATIONAL CONFERENCE CENTER HIROSHIMA

It has been almost 50 years since the atomic bombing of Hiroshima. Although the city has been reborn as a modern international center, its citizens have endured great suffering. Taking the opportunity afforded by JAIF's annual conference, nuclear-related individuals from Japan and abroad will meet with citizens of Hiroshima, to consider the significance and role of "Hiroshima" -- in the past, the present, and the future -- through discussion of the bombing, attitudes toward nuclear power, and the prospects for peaceful utilization hereafter.

Moderator:

Kazuhisa Mori
Executive Managing Director
Japan Atomic Industrial Forum, Inc.

Panel Discussion

Panelists:

From Participants,

Teruaki Fukuhara
President
Hiroshima Prefectural Medical Association
President of Japanese affiliate
International Physicians for the Prevention of Nuclear War

Katsuko Kataoka
Professor
Hiroshima University

Yoshitaka Kawamoto
Former Director
Hiroshima Peace Memorial Museum

Lee Sil Gun
President
Council of Atomic-Bombed Koreans in Hiroshima Prefecture, Japan

Akihiro Takahashi
Director, Enterprise Division
Hiroshima Peace Culture Foundation

Koji Fushimi
Professor Emeritus
Nagoya University
Former President
Science Council of Japan

Takashi Mukaibo
Chairman
Japan Atomic Industrial Forum

Atsuyuki Suzuki
Professor
University of Tokyo

Richard Rhodes

Pulitzer Prize Laureate
Author and Lecturer

Naomi Shohno
Professor Emeritus
Hiroshima Jogakuin College

Additional Participants to be announced.

Note: This is the round-table discussion by the participants including those from people in the field of nuclear energy and people related to Hiroshima. The seats are available for 500 people.

April 15 (Friday)

SESSION 4 (9:00 - 12:00)

Development of Nuclear Power in Asia and the Role of Japan

While nuclear-power development has slowed down in many Western nations, it is accelerating in much of Asia as the 21st century draws nearer. Large-scale nuclear-energy projects have been announced by Japan, South Korea and China, while Indonesia and certain other countries are in various stages of preparation. Sound development of nuclear energy in the Asian region, where more than half the world's population are inhabited, is of great significance in terms of securing stable electricity supplies for the future, as well as conservation of global resources and the environment. Today, we will discuss the pursuit of efficient development of nuclear energy in Asia, the securing of operational and managerial safety, the handling of radioactive waste, and the linkage between peaceful use and nuclear non-proliferation. Measures to smooth and facilitate the various development efforts, and also Japan's role in them, will be discussed.

Chairman:
Hiroshi Murata
Vice Chairman
Japan Atomic Industrial Forum, Inc.

Keynote
"The Role of Japan in its International Contribution, Past and Future"
Akira Hayashi
Councilor
Ministry of Foreign Affairs

Panel Discussion
Panelists:
Djali Ahimsa
Director General
National Atomic Energy Agency (BATAN)
Indonesia

Li Yu Lun
Vice President
China National Nuclear Corporation (CNNC)

Yong Kyu Lim
President
Korea Institute of Nuclear Safety

Jun-ichiro Mukai

Managing Director
Japan Atomic Power Company

Tatchai Sumitra
Dean, Faculty of Engineering
Chulalongkorn University
Thailand

Masaji Yoshikawa
Vice President
Japan Atomic Energy Research Institute

Commentators:
Commentators to be announced.

Discussion with the Audience

SESSION 5 (14:00 - 17:00)

Effects of Radiation: Study Results and Future Issues

Nuclear-related safety measures must be based on accurate scientific data on the effects of radiation on the human body. In Japan, investigations into radiation effects have been conducted, with the cooperation of affected citizens, over the period of almost 50 years since the atomic bombings of Hiroshima and Nagasaki. The results of these investigations represent the most complete scientific information of their kind in the world, and are important basic data for the recommendations of the International Commission on Radiological Protection (ICRP). In this session, the history of the Hiroshima and Nagasaki investigations on radiation effects, and conclusions thus far, will be summarized. Those results will be discussed, together with issues expected to arise in the future. Other investigative information will also be presented, including data gathered following the Chernobyl Accident.

Chairman:
Minoru Ohmuta
Chairman
Hiroshima Peace Culture Foundation

Keynote
"Evaluation of Radiation Effects - From Results of Studies in Hiroshima and Nagasaki"
Itsuzo Shigematsu
Chairman
Radiation Effects Research Foundation Hiroshima-Nagasaki Japan

Panel Discussion
Panelists:
Chikako Itoh
Deputy Director
Health Management Center
Hiroshima A-bomb Casualty Council

Seymour Jablon
Former Expert
Radiation Epidemiology Branch
National Cancer Institute
U.S.A.

Colin R. Muirhead

Head of Epidemiology Group
National Radiological Protection Board
U.K.

Masao Tomonaga
Professor
Nagasaki University

Satoru Ubuki
Assistant Professor
Hiroshima University

Discussion with the Audience

CLOSING REMARKS - HIROSHIMA APPEAL (17:00 - 17:15)

Soichi Iijima
Chairman
Program Committee
Professor Emeritus
Hiroshima University

FAREWELL PARTY (17:15 - 18:45)

Large Meeting Room "Dahlia", B2F, INTERNATIONAL CONFERENCE CENTER HIROSHIMA

大会準備委員長挨拶
飯　島　宗　一
年次大会準備委員長、広島大学名誉教授

原産会長所信表明
向　坊　　隆
(社)日本原子力産業会議会長

原子力委員会委員長所感
江　田　五　月

原子力委員会委員長、国務大臣・科学技術庁長官
広島県知事挨拶
藤　田　雄　山
広島県知事

＜特別講演＞
「世界の新しい夜明け」
R．ローズ
ﾋﾟｭｰﾘｯﾂｱ賞受賞作家（米国）

＜招待講演＞
「原子力平和利用の推進と軍事利用の防止」
H．ブリックス
国際原子力機関（ＩＡＥＡ）事務局長

「普遍原理の応用による効果的な規制の達成」
K．C．ロジャース
米国原子力規制委員会（ＮＲＣ）委員

「ロシアにおける核軍縮と原子力の将来」
V．N．ミハイロフ
ロシア原子力大臣

大会準備委員長挨拶

平成６年４月１３日

年次大会準備委員長

広島大学名誉教授

飯　島　宗　一

ただいま、ご紹介いただきました飯島でございます。議長、ご臨席の皆様、第２７回原産年次大会の開催にあたり、大会準備委員長としてご挨拶を申し上げる機会を得ましたことは、私の深く喜びとするところであります。今大会に、日本国内のみならず、国際機関および世界各国から多数の方々にご参加いただきましたことを、ここに厚く御礼申し上げます。

明年原爆被爆５０年を迎える広島において此の度の大会を開催いたしますことに、ひときわ深い感慨を覚える者でございますが、申し上げるまでもなく、人類に巨大なエネルギーと幸福とを約束するところの物理学上の発見が、あやまって先ず戦争の具に供され、それによって多数の人命がうばわれましたことは、かえりみてはなはだ残念なことであります。

私は本大会の冒頭原爆の犠牲となられた方々のご冥福を心より祈りたいと存じます。そしてあのあやまちを地球上において二度とくりかえさないことを誓うものでありますが、一方、原子エネルギーは平和的な人類社会の進歩のためにも生かされ、原子力エネルギーは世界の電力の１７％を供給するに至り、その平和的利用において大きな発展を見つつあります。また、東西冷戦の終結を機に核軍備競争は終息に向かい、世界的な核軍縮の努力が徐々に、しかし、確実に進められつつあることは、私どもの喜びとするところであります。

今大会は、このような諸情勢を踏まえ、その基調テーマを「核兵器のない世界へ－平和利用の役割」といたしました。原子力平和利用関係者が被爆地広島を訪れ、核兵器廃絶への悲願をより鮮明に認識したうえで、国内外の権威者、ならびに専門家による講演を行い、そして原子力について様々な立場をとる方々の意見を含め、原子力平和利用に関する国内

的および国際的な今日の課題、および今後の諸方策等について、議論を行うことにしております。

今大会のハイライトのひとつである特別講演には、その著書 「原子爆弾の誕生：The Making of Atomic Bomb」で１９８８年にノンフィクション部門のピューリッツア賞を受賞し、１９９３年に「原子力の再生：Nuclear Renewal 」の著述でひろく感銘を与えたローズ氏を米国から招請し、また招待講演では、国際原子力機関の代表から原子力平和利用の推進と軍事利用の防止、および米国の代表から原子力の規制について、またロシアの代表からは核軍縮と原子力の将来についてのご見解を伺います。

「核兵器廃絶へ向けて－平和利用からのメッセージ」を論じることになっている大会初日の午後の国際パネル討論では、米国、フランス、韓国、南アフリカ、そしてわが国の代表にご参加いただき、開会セッションの講演内容をも踏まえ、核兵器をいかに廃絶していくか、原子力平和利用の技術が軍事利用に転用されないためにはどのようなことが必要か、核兵器のない世界とはどのようなものかなど、広範囲な分野からの意見を求めることにしております。とくに南アフリカからの代表による原産年次大会への参加は初めてのことですので、忌憚ない、かつ積極的なご意見を期待したいと思います。

今大会の第二日目には、「原子力発電とプルトニウム」をテーマに国際パネル討論を行います。ここでは、米国、フランス、英国、ベルギー、そしてわが国の代表にご参加いただきます。今、内外から注目を集めているプルトニウム利用問題に焦点をあて、科学文明史の観点からまずプルトニウムをとらえ、今日の問題点とその解決策を求めての討論をお願いしておりますが、それぞれの立場から活発な議論が展開されるものと考えております。

人類の前途に横たわるさまざまなむつかしい問題をひとつひとつ解決し、新しい未来を力づよくひらいてゆくためには、人間の精神力、ことに科学的な探究、創造のいとなみが重要であり、ことに若い世代にそれがつよく期待されますが、しかし、日本では最近若い人々の間に思考・表現において論理性を欠き、浅くかつ画一的な考え方に固執し、独創性に乏しい傾向が見られるという声を耳にいたします。それはまことにうれうべきことのように思われますので、科学および科学技術をめぐる今日の学校教育の問題点がどこにある

のかなど、「科学技術教育と日本の将来」と題し、原産年次大会ではじめて教育問題をテーマにとりあげ、広い視野から問題点の摘出に取り組むことにいたしました。ここでの議論から今日の問題点が明確に提示され、今後の改革改善の方向について、関係者による率直な意見が展開されることを望みたいと思います。

さて、今大会を広島市で開催するのを機に、内外の原子力平和利用関係者が広島市民を含む広島関係者と対話をする討論会「広島市民と語る夕べ」を企画いたしました。原爆とは何であったのか、原子力をどのように受けとめるべきかなど、この対話を通して、ヒロシマおよびナガサキのもつ意味と役割について、意見を交換し、学びたいと考えております。

近隣アジア諸国において近年、相次いで原子力平和利用計画が策定され、その展開をはかる動きが活発に見受けられるようになりました。これら諸国における原子力平和利用の健全な発展のために、わが国が果たす役割には重要なものが数多くあると考えられます。近隣アジア諸国の原子力開発について、わが国は何を期待されているのか、中国、韓国、インドネシア、タイ、およびわが国からの代表にご参加をいただき、国際的な観点から討論を行います。

また大会の最後を締め括る討論テーマは「放射線の影響－研究成果と今後の課題」であります。広島、長崎の放射線影響調査の歴史や経緯を振り返りながら、放射線の影響研究について、今後の課題を探るのがこの国際パネル討論の趣旨であります。米国、英国の代表のほかに、広島、長崎からの代表にご参加いただき、正確な情報にもとづく具体的な議論の展開がみられるものと思います。

以上、大会の準備委員長として、今大会の期するところにつきまして概略を申し上げました。原産年次大会はここ数年来、内外の参加者とスピーカーの討論にも時間を割くことでプログラムを企画してきておりますので、時間の許す限り来会の皆様方にも討議に積極的にご参加いただければと思います。また今大会は、本日の午後以降、一般の方々にもご参加いただけることになっておりますので、活発な討論を期待しております。

最後に本年次大会における議長、スピーカーをご快諾いただきました大会関係者各位に

厚く御礼を申し上げますとともに、本年次大会に参加された国内および海外からの皆様に感謝の意を表し、今広島大会が実りの多い大会として終わりますように心から念願をする次第でございます。

どうもありがとうございました。

以　上

Remarks by the Chairman of the Program Committee

April 13, 1994

Soichi Iijima
Chairman
Program Committee
Professor Emeritus
Hiroshima University

Mr. Chairman, Ladies and gentlemen: It is a great pleasure for me, as Chairman of the Program Committee, to have this opportunity to speak at the opening ceremony of the 27th JAIF Annual Conference. I am indeed grateful that so many people -- not just from Japan but from abroad -- as individuals and as representatives of international organizations, are here to participate with us.

I cannot but have a special feeling as a result of the fact that we are holding this conference in Hiroshima, where the 50th anniversary of the atomic bombing will be marked next year. I naturally feel a deep regret when I think that a discovery in physics, one filled with the promise of a new energy source and the potential to bring comfort and security to people all around the world, was so wrongly used in an instrument of war, and caused such terrible human devastation.

As we begin this conference, I pray for the souls of the atomic-bomb victims, and pledge to them that we will never allow the same mistake to be repeated on this earth.

Nuclear energy, of course, has proven itself a peaceful servant as well -- to the extent that it now accounts for 17% of total electricity generation worldwide. Following the end of the East-West Cold War, the nuclear arms race is being brought to a conclusion, and we all welcome the fact that international efforts toward nuclear disarmament are being steadily, if slowly, carried out.

Taking each of the foregoing into consideration, the basic theme of this conference is "Toward Nuclear-Weapons-Free World -- the Role of Peaceful Utilization of Nuclear Energy." Those of us here who are involved in the peaceful utilization of nuclear energy, on the occasion of this visit to the atomic-bombing site of Hiroshima, are reconfirming our most earnest wish for the ultimate abolition of nuclear weapons. Over the next several days, professionals from Japan and overseas will present lectures; and participants will discuss current and future domestic and international issues related to the peaceful utilization of nuclear energy -- all in the light of the variety of opinions of people standing in differing positions on nuclear-energy issues.

In one of the highlights of our program, Mr. Richard Rhodes has been invited from the United States to give a special lecture. Mr. Rhodes is the 1988 non-fiction winner of the Pulitzer Prize for his book "The Making of the Atomic Bomb." His book "Nuclear Renewal," published in 1993, has received a great deal of attention as well. In other lectures by invited guests, a representative from the International Atomic Energy Agency will address the promotion of peaceful uses of nuclear energy and the prevention of military use. An American representative will speak about nuclear energy control. And a Russian representative will discuss nuclear disarmament and the future of nuclear energy.

In the panel discussion on "Facing the Reality of Ultimate Abolition of Nuclear Weapons: The Message of Peaceful Use of Nuclear Energy," to be held in the afternoon of the first day, panelists from the United States, France, Korea, South Africa and Japan will offer their opinions in wide-ranging areas -- taking the results of the opening session into account -- including how to reduce the level of nuclear weapons to zero; what should be done in order to prevent technology for the peaceful utilization of nuclear energy from being used for military purposes; and what the nature of society will be without nuclear weapons. I note that this is the first time for the conference to have a representative from South Africa, and we look forward to his full and frank participation.

On the second day, an international panel discussion will be held on the theme of "Nuclear Power and Plutonium," with participants from the United States, France, England, Belgium and Japan. Focusing on the issue of plutonium use, which has drawn so much recent attention, the panelists will first review the scientific history, and then address present problems and solutions.

In order for humanity to face the future squarely, to solve, one by one, the many difficult problems ahead, commitment, determination and spiritual strength are essential, in creative endeavors and in the scientific pursuit of truth -- all the more so in the members of the next generation. Recently, however, it is often heard that Japanese young people lack logic in their thought and self-expression; that they display a shallow, uniform way of thinking, with little creativity. I think that is quite a lamentable state of affairs, and this JAIF conference will address the associated educational problems under the theme of "Education of Science and Technology, and Japan's Future." As we look at those problems from a new, wider perspective for the first time, I hope their nature will be made more apparent, and that the opinions of our education-related participants will cast some fresh light, contributing to constructive improvements hereafter.

Taking the unique opportunity afforded by this JAIF Annual Conference being held at Hiroshima, we have planned a "Discussion Together With the People of Hiroshima," where nuclear-related individuals from Japan and abroad will meet with local citizens and others, to discuss the bombing and attitudes toward nuclear power. Through this, we hope to gain new insights into the significance and role of "Hiroshima and Nagasaki."

Recently, neighboring nations in Asia have been carrying out their own programs in regard to the utilization of nuclear energy for peaceful purposes, and continuation to fruition is the clear trend. There must be a great deal Japan can do to contribute to the sound development of these programs. Panelists from China, Korea, Indonesia, Thailand and Japan will discuss from an international viewpoint what can be expected of Japan in support of the nuclear development efforts of other Asian nations.

Concluding the conference, the final panel discussion will be on the topic of "Effects of Radiation: Study Results and Future Issues." Its purpose is to address issues expected to arise from future investigations, based on a look back at the history of the Hiroshima and Nagasaki investigations into radiation effects. In addition to representatives from the United States and England, people from Hiroshima and Nagasaki will take part in the discussion, which will be based on accurate scientific data.

I have so far talked briefly about what is expected at this conference, from my position as Chairman of the Program Committee. For the last several years, the JAIF Annual Conference has been organized primarily so as to allow sufficient time for discussions among the domestic and overseas participants and guest speakers. To the same extent, I hope all will do so actively this time as well. In addition, at this conference, members of the general audience, too, will be able to take part, starting with the afternoon session today. I look forward to some very spirited exchanges.

Finally, I would like to express my deep appreciation to the panel chairmen, guest speakers, all the participants from both Japan and abroad, and everyone else who has so generously given of their time and energy to make this event a success.

Thank you for your attention.

年次大会会長所信表明

平成６年４月１３日
日本原子力産業会議
会長　向　坊　　隆

議長、御臨席の皆様、私は日本原子力産業会議の会長を務めております向坊でございます。原産年次大会の開催に当たり、主催者を代表いたしまして、一言私の所信を述べさせていただきます。

ご高承のとおり、原産年次大会は、日本原子力産業会議がその主要活動の一つとして、１９６８年以来開催しているもので、今回で２７回目になります。本大会は、エネルギー・原子力の開発利用上の重要な問題について、内外の関係者が、広くオープンに意見の発表と討論を行うことにより、重要課題とその解決策を見いだすための指針を得るとともに、エネルギー・原子力開発利用に関する認識を深める場として毎年開催しています。今大会は、原子力関係者が被爆地広島を訪れ、核の軍事利用がもたらした影響ならびに核兵器廃絶への悲願をより鮮明に認識したうえで、原子力について様々な立場をとる方々の意見や、広島・長崎の貴重な経験を踏まえつつ、原子力の平和利用に関する今後の諸方策等を討論することと致します。この３日間、エネルギー・原子力について有意義な意見交換が行われることを期待しております。

わが国が原子力平和利用の研究を開始してから、すでに４０年が経過いたしましたが、その根底には単に自国のためばかりでなく、世界のため、人類のために、原子力の莫大なエネルギーを平和目的のために利用し、役立てていくという大きな命題があったと確信しています。唯一の原爆被爆国であるわが国が、紆余曲折を繰り返しながらも、それからわずか１０年後に、原子力平和利用の研究に踏み切ることができたのは、原子力の軍事利用は絶対行わず、人類のた

め、わが国のために、平和目的に限って利用するという原則を先ず確立し、それを実践に移すことができたからでありました。このことが、今でも原子力の平和利用を行う上での国民合意の原点となっており、それは人類が原子力の利用を進めて行く限り維持していかなければならない必要不可欠な命題でもあります。

核兵器の廃絶は、国民全体の悲願であり、全人類の悲願でもありますが、核兵器の廃絶を願う心はわれわれ原子力関係者も全く同じであります。超大国の緊張が緩和され、核軍縮が大きく進展しつつある今日、人類の悲願が現実のものとなりうる歴史的な時期にあると思います。核軍縮、核兵器廃絶についての働きかけは、わが国の政府ならびに国民の運動として、早くから精力的に進められてきました。われわれ原子力関係者といたしましても、１９８２年6月の第２回国連軍縮特別総会に、当時原産会長であった有澤廣巳先生が代表してメッセージをおくり、核軍縮について提案を行いました。そこでは、核兵器廃絶への象徴的な意志表示として、今後、原子力の平和利用に参入しようとする国々のために、核兵器を解体し取り出された核物質を核燃料のストックパイルとして提供するよう提案いたしました。いまやアメリカならびに旧ソ連では、核兵器の解体が現実になりつつありますが、それを進めるにあたっては、取り出された核物質を拡散させることなしに、平和利用に限って有効に活用できるよう保証されなければなりません。

核不拡散も今後の大きな問題であります。日本原子力産業会議は、１９９０年９月の国際原子力機関（ＩＡＥＡ）の第３４回通常総会において「国際核不拡散体制の確立のためにー平和利用国日本の立場ー」と題する小冊子を配布するなど活動を続けてまいりました。その国の安全保障は核兵器を持つことによって達成されるものではないことは、かつての二つの超大国の例にみるまでもないことであります。また核兵器を持とうとしても、世界各国からの孤立は必然であり、何よりも核を持つことにより、自国民を危険に陥れることにもなり

ます。

核兵器を新たに開発し、保有しようとする国が現れないためには、わが国のように平和利用に徹して原子力利用を進めている国が、機微な国とも積極的に情報交換、人的交流を図り、核兵器開発の愚かさを将来にわたって伝えていくことが重要であり、使命でもあると思います。国際核不拡散の中心である核拡散防止条約（ＮＰＴ）の再検討・延長会議が、一年後の４月から５月にかけて開かれます。わが国は、核兵器国が一定期間内に核兵器を廃絶すべきであるとの考えのもとに、その延長を支持しております。一部で、ＮＰＴが不平等条約であるとの理由で、その加盟に同意しない国々があります。確かに核拡散防止条約はいまは不平等ではありますが、私はこの条約が、核軍縮、核拡散防止を進展させることにより、不平等を平等に変えていくようにすべきであると考えております。

人類にとって、エネルギー供給の安定的な確保はなくてはならない重要な要素であります。原子力は、すでに世界の電力の１７％を供給し、わが国でも現在、４７基、3、８５４万キロワットの原子力発電所が稼働中で、　その発電量は全発電量の約３０％を占め、電力供給において主要な役割を果たすとともに、原子炉及び放射線は、医療、農業、工業等の分野において利用されるなど国民生活に広く定着してきております。しかし、原子力発電についてはトータルな供給システムとしてはいまだ完成するに至っておりません。それは、プルトニウムの利用や、高レベル放射性廃棄物の処分の問題などが解決されていないためです。この点については今後のわが国の原子力開発の重要な課題となっており、現在原子力委員会において原子力開発利用長期計画にいかに盛り込むべきか検討中であります。今回の長期計画策定にあたっての大きな特徴としましては、去る３月初めに「長期計画策定に関する意見を聞く会」が開かれたことからもわかりますように、原子力政策の透明度を高めるということで、内外の人々の意見を聞きながら進めているということでありまして、このような努

力がわが国の原子力政策にたいする理解を深めていくことになると考えております。

この年次大会では、繰り返しになりますが被爆５０年を明年に控えて核兵器廃絶と平和利用問題をじっくりと議論し、今後の原子力開発の根本問題について各方面から討論していただくためにプログラムを考えました。忌憚のないご意見を賜り、今後の原子力開発に役立てたいと考えています。

最後になりましたが、年次大会準備委員長の飯島氏をはじめ準備委員、各セッションの議長の方々、この大会のために御参集いただきました海外、国内の発表者の方々、ならびに会場の皆様に、心よりお礼を申し上げ、私の所信とさせていただきます。

ご静聴、ありがとうございました。

以上

The 27th JAIF Annual Conference

Address

Takashi Mukaibo

Chairman

Japan Atomic Industrial Forum, Inc.

April 13, 1994

Chairman Tada, Ladies and Gentlemen,

It is a pleasure for me, as chairman of the host organization, the Japan Atomic Industrial Forum, to address the 27th JAIF Annual Conference at its opening.

Since 1968, the Japan Atomic Industrial Forum has been holding the Annual Conference as one of its major activities. This conference, of which this is the twenty-seventh, was established as a forum for discussing important issues regarding energy and, in particular, the development and utilization of nuclear energy. By inviting persons concerned from Japan and abroad to present their views and to discuss these matters openly from a broad perspective, the organizers of the Conference hope that guidelines will be found to resolve problems and deepen understanding of the issues. During this year's conference in Hiroshima, participants will gain first-hand understanding of the impact of the military use of nuclear power and learn about the earnest commitment to the abolition of nuclear weapons. They will have the opportunity to listen to various views on the subject and to discuss the future of the peaceful uses of nuclear energy, mindful of the historic lessons of Hiroshima and Nagasaki. I am confident that the three-day conference will benefit from your valuable contributions.

Forty years have elapsed since Japan first embarked on research into the peaceful uses of nuclear energy. During this time, I believe that there has been a strong sense of mission to find peaceful ways to tap the enormous energy of nuclear power, not just for Japan but indeed for the whole of humankind. Despite being the only country to have experienced atomic bombing, Japan gathered the resolve to start studying the peaceful applications of this awesome power only a decade later -- difficult as it may have been -- because it was able to establish the principle that nuclear energy would never be used for military, but only peaceful purposes. That is still the foundation of the national consensus on the peaceful use of nuclear energy even today. It is also the prerequisite for humanity to benefit from the use of nuclear energy.

The abolition of nuclear arms is an avowed wish of Japanese people. Indeed, it is the prayer of humanity. It is also the shared wish of all of us in the nuclear industry. Today, when the tension between superpowers is relaxed and nuclear disarmament is gaining momentum, we are presented with a historic opportunity for our wishes to become reality. The government and the people of Japan have been involved in working towards nuclear disarmament and the abolition of nuclear arms. The Japanese nuclear energy industry was involved in the Second Special

Session of the United Nations General Assembly Devoted to Disarmament when the then-chairman of JAIF, Dr. Hiromi Arisawa, sent a message concerning nuclear disarmament to the UN Secretary General on behalf of the industry. As a symbolic declaration of intent, it was proposed that nuclear materials from dismantled nuclear weapons should be offered as a stockpile of nuclear fuel to those countries wishing to participate in the peaceful use of nuclear energy. The dismantling of nuclear weapons is now a reality in the United States of America and in the former Soviet Union. But the dismantling of nuclear warheads must be accompanied by an insurance that the nuclear materials thus extracted are utilized strictly for peaceful purposes and not for proliferation.

Nuclear non-proliferation is another major future challenge, and the Japan Atomic Industrial Forum has been continually involved in this commitment. For example, it distributed a booklet entitled, "For the Further Strengthening of an International Regime of Nuclear Non-Proliferation -- Views from the Japanese Private Sector" at the August 1990 NPT (Nuclear Non-Proliferation Treaty) Review Conference and the September 1990 34th IAEA (International Atomic Energy Agency) General Assembly. That national security cannot be achieved through the possession of nuclear weapons is clear from the experience of the former superpowers. A nation wishing to possess nuclear weapons will do so only at the risk of being isolated from the international community, and will certainly endanger its own people.

If we are to forestall the development and possession of nuclear weapons by additional countries, a nation such as Japan, dedicated to the peaceful use of nuclear energy, must actively engage in the exchange of information and expert personnel even with those nations under suspicion. In fact it is the mission of Japan to communicate constantly the foolishness of developing nuclear weapons.

In just about a year from now, a conference will be held to review the Treaty on the Non-Proliferation of Nuclear Weapons which has served as the pillar of international nuclear non-proliferation efforts. Japan is in support of the indefinite extension of the treaty, but has also adopted the principle that all countries possessing nuclear weapons will destroy them within a certain period of time. There are countries that have not acceded to the treaty because they see it as unequal. I believe that we should transform the unequal treaty into an equal one by promoting worldwide nuclear disarmament and preventing proliferation.

A stable supply of energy is an important requirement for humankind. Today, nuclear energy supplies 17 percent of the world's electricity. In Japan, a total of 47 nuclear power plants are now in operation with a combined capacity of 38,540 MW, accounting for approximately 30 percent of the total electricity generated in this country. Nuclear energy not only plays a major role in the electric power supply, but contributes to the national welfare in such fields as medicine, agriculture and industry. Although nuclear power is widely used, a comprehensive supply system has not been completed for its generation because the issues of plutonium utilization and the disposal of high-level radioactive wastes have not been resolved. These are major challenges to be overcome in the future development of nuclear energy. The Atomic Energy Commission is now studying how to incorporate these issues in the Long-Term Program on Development and Utilization of Nuclear Energy. A major characteristic of the latest Long-Term Program, as evidenced by the holding of a public hearing on the issue in March, is the commitment to increase transparency in nuclear energy policy. That means listening to various views expressed both at home and abroad. Increased communication, I believe, will help deepen public understanding of Japan's Nuclear policy.

In conclusion, I would like to stress that this year's Annual Conference, which is being held on the eve of the fiftieth anniversary of the atomic bombing of Hiroshima and Nagasaki, will focus on the total abolition of nuclear weapons and the exclusively peaceful use of nuclear energy. It will also address fundamental issues with regard to its future development. I invite you to be forthcoming in expressing your views, aiming at securing the maximum benefits to humankind from the future development of nuclear energy.

Last but not least, I should like to express my most sincere gratitude to Chairman Soichi Iijima of the Program Committee, as well as to its members, session chairmen and all the presenters and participants.

Thank you for your attention.

Richard Rhodes

THE NEW MORNING OF THE WORLD

Just two months short of fifty years ago, in late June 1944, the great Danish physicist Niels Bohr sweltered in Washington, D.C., in heat above 37 degrees Celsius, preparing a memorandum on nuclear energy for Franklin Roosevelt, the President of the United States. After the discovery of nuclear fission in late December 1938, Bohr had contributed significantly to understanding how fission worked. His liquid-drop model of the atomic nucleus had supplied a theoretical structure for the unexpected new reaction. He had been the first to realize that U235 was the isotope responsible for slow-neutron fission. He had doubted that an atomic bomb could result from the new discovery because he overestimated the difficulty of isotope separation. When he escaped to England from German-occupied Denmark in the autumn of 1943 he was surprised to find atomic-bomb development ongoing in England and the United States. He understood that $\underline{E = mc^2}$ and quickly worked out the numbers, as physicists in many other countries had already done. But Bohr, who was not only one of the great physicists of the 20th century but also one of the great philosophers, understood more than the numbers, and it was this new understanding that he hoped to convey to Franklin Roosevelt.

By June 1944, Bohr had already survived a disastrous encounter in London with Winston Churchill. Preoccupied with the Normandy invasion and with England's declining fortunes, Churchill was not prepared to listen to advice on the highest affairs of state from a Danish academic. "I cannot see what you are talking about," Churchill had scolded Bohr impatiently. "After all, this new bomb is just going to be bigger than our present bombs. It involves no difference in the principles of war."[1]

Bohr knew better. He knew about not only atomic bombs; at Los Alamos that spring he had learned from Edward Teller about the possibility of hydrogen bombs as well, weapons with essentially unlimited destructive potential. So, with his son Aage at his side taking dictation, Bohr sat in the Danish Embassy in Washington sewing on buttons, darning socks and composing draft after draft of his Roosevelt memorandum, lavishing as much attention on its logic as he had lavished on his papers in theoretical physics, struggling to explain the inevitable consequences of the discovery of how to release nuclear energy.

"The whole enterprise," Bohr told Roosevelt, "constitutes...a far deeper interference with the natural course of events than anything ever before attempted, and its impending accomplishment will bring about a whole new situation as regards human resources. Surely, [Bohr went on] we are being presented with one of the greatest triumphs of science and engineering, destined deeply to influence the future of mankind."[2]

Bohr told of "enormous energy sources which will be available" that would "revolutionize industry and transport." But of more immediate concern, he cautioned, was the creation of "a weapon of unparalleled power" which would "completely change all future conditions of warfare." He said that better in 1957, after the nuclear arms race had begun between the United States and the Soviet Union. "We are in a completely new situation," Bohr said then succinctly, "that cannot be resolved by war."[3]

Bohr warned Roosevelt in 1944 of "the terrifying prospect of a future competition between nations" — a nuclear arms race — unless those nations negotiated "a universal agreement in true confidence." He understood the necessity of transparency between nuclear powers to prevent what he called "a competition prepared in secrecy." He expected that there would have to be, as he put it, "such concessions regarding exchange of information and openness about industrial efforts, including military preparations, as would hardly be conceivable unless at the same time all partners were assured of a compensating guarantee of common security." Openness proved elusive, as we know, and the United States and the Soviet Union eventually came to rely on national technical means of verification. Bohr had imagined that all sides would judge openness to be a fair exchange for security, but until recently the two superpowers resisted that conclusion. They preferred extended deterrence — preferred, that is, a dangerous and expensive arms race. Now in the aftermath of that arms race, Bohr's argument for openness remains no less valid than it was in 1944. Common security against nuclear threat requires transparency; a nuclear-free world will have to be completely transparent where nuclear technology is concerned. "Bohr was clear," his protégé Robert Oppenheimer would note, "that one could not have an effective control of...atomic energy...without a very open world; and he made this quite absolute.... In principle, everything that might be a threat to the security of the world would have to be open to the world."[4]

Bohr hoped that openness achieved for nuclear security might have a complementary outcome as well. "What it would mean," he told US Secretary of State George Marshall in 1948, "if the whole picture of social conditions in every country were open for judgment and comparison, need hardly be enlarged upon."[5] If peoples could see each other, that is, they could judge each others' form of government and way of life and use that information to improve or change their own. Bohr would seem to have modeled his vision of the world on the Scandinavian countries, which had fought each other and the rest of Europe bloodily for centuries before coming to understand the futility of such conflicts. "An open world," Bohr told the United Nations in 1950, "where each nation can assert itself solely by the extent to which it can contribute to the common culture and is able to help others with experience and resources must be the goal to put above everything else."[6] And then, most generally and profoundly, Bohr concluded: "The very fact that knowledge is itself the basis for civilization points directly to openness as the way to overcome the present crisis."[7]

Roosevelt listened, but Churchill continued to refuse to do so, and Niels Bohr's lonely initiative went unheeded. Indeed, Churchill almost succeeded in having the Danish physicist thrown into jail. Britain and the United States did not sit down with the Soviet Union before the end of the Second World War to confront the common problem of controlling nuclear weapons. Instead, the Western nations tried to keep secrets of technology that were already being worked out independently by Soviet scientists or had been lost to Soviet espionage. Britain and the United States agreed to use the atomic bomb against Japan without warning or demonstration, hoping to end the Pacific War sooner, to limit Soviet participation and to save American lives. When Japan had attacked China in the 1930s, the United States had publicly condemned what it called Japan's "inhuman bombing of civilian populations."[8] The atomic-bombings of Hiroshima and Nagasaki by two American B29s made starkly clear the change in the scale of destructiveness that nuclear weapons initiated: in Hiroshima alone, of 76,000 buildings, 70,000 were damaged or destroyed, 48,000 totally. Ninety percent of all Hiroshima medical personnel were killed or disabled. Up to September 1st at least 70,000 people died. More died later of the effects of radiation. By the standards established in the charter of the Nuremberg trials — or by any other standards, for that matter — the atomic-bombings of Hiroshima and Nagasaki were unquestionably crimes against humanity: they comprised, in the language of the Nuremberg charter, "murder...committed against any civilian population...during the war."[9]

The tragedy of Hiroshima and Nagasaki would be unique; theirs would be the only atomic-bombings. In 1945, the "completely new situation" Bohr foresaw that "cannot be resolved by war" had not yet become reality; while there was yet only one nuclear power on earth, that nuclear power could dare to use its weapons against an opponent not similarly armed. For four years after the war, the United States continued to hold such a monopoly, and then the Soviet Union tested a plutonium bomb, the superpower arms race began with a tumult of atmospheric testing in 1951 and the confrontation moved rapidly to stalemate. Not deadlock, as in Korea, nor even defeat, as in Vietnam and Afghanistan, would ever justify escalation. The danger was too great. McGeorge Bundy, national security adviser to Presidents John F. Kennedy and Lyndon Johnson, put that danger in perspective in a 1969 essay. "In light of the certain prospect of retaliation," Bundy wrote, "there has been literally no chance at all that any sane political authority, in either the United States or the Soviet Union, would consciously choose to start a nuclear war. This proposition is true for the past, the present and the foreseeable future.... In the real world of real political leaders [Bundy went on]...a decision that would bring even one hydrogen bomb on one city of one's own country would be recognized in advance as a catastrophic blunder; ten bombs on ten cities would be a disaster beyond history; and a hundred bombs on a hundred cities are unthinkable."[10]

In the expert judgment of at least one experienced national security adviser, that is, one hydrogen bomb, guaranteed deliverable, has been for many years a sufficient deterrent. The vast gulf of numbers between that minimum deterrent and the tens of thousands of nuclear weapons that the superpowers stockpiled in the years of the Cold War and continue to maintain despite laudable reductions, reveals the extent to which nuclear arms have served purposes other than self-defense. Among those purposes have been political warfare, economic warfare and domestic economic stimulus. The truth is, through much of the Cold War, the United States and the Soviet Union dangerously and opportunistically contended for hegemony by building and testing nuclear weapons, risking all our lives.

Yet, though they bristled with genocidal armaments, paradoxically, across the past five decades, with reluctance and often with ill will, every nuclear power, large and small, has felt compelled to limit its power to make war — compelled to limit the exercise of its national sovereignty. Who or what drove that unprecedented compellence?

Science compelled that limitation. Knowledge — the knowledge that in Bohr's phrase is "itself the basis of civilization" — compelled that limitation. Nuclear energy was deliberately released for the first time minutely on a laboratory bench in Berlin in December 1938. Four years later, in December 1942, a small graphite reactor at the University of Chicago increased that manifestation of the new knowledge to half a watt of power. In 1945, a plutonium implosion device tested in the New Mexican desert increased nuclear energy's compass further to the equivalent of eighteen thousand tons of TNT. Then bombs that exploited nuclear energy destroyed this city where we meet this morning and tens of thousands of lives and then another city and more thousands of lives. Then the process bifurcated and began to manifest itself simultaneously as a source of energy and a source of destruction, but the destructive potential was encapsulated and went latent and only the energy was expressed. Nuclear energy now accounts for about 17 percent of the world's energy supply. At the height of the Cold War, the encapsulated destructive potential reached at least 10,000 megatons of explosive equivalent, two tons for every man, woman and child on earth. This remarkable chronology charts an enlargement of influence across only fifty-six years — a dispersion of knowledge, if you will — of orders and orders of magnitude.

Most of us were taught that the goal of science was power over nature, as if science and power were one thing and nature quite another. Niels Bohr observed to the contrary that the more modest but relentless goal of science was, in his words, "the gradual removal of prejudices."[11] One of those prejudices, which has accounted for immense human suffering, was certainly the belief that in an anarchic world there are no limits to national sovereignty except those that conflict might determine. Knowledge of how to release nuclear energy, knowledge that only science was structured to perceive, has now defined a natural limit. The authority of the institution we call science, that is, has taken precedence, at least in this extreme arena, over the authority of the nation-state. Science has fielded no armies in order to do so and is indeed pacifist; rather, it has gradually removed the prejudice that there is a limited amount of energy available in the world to concentrate into explosives, that it is possible to accumulate more of such energy than one's enemies and thereby militarily to prevail. Science has revealed at least world-scale war to be historical, not universal, a manifestation of destructive technologies of limited scale. In the long history of human slaughter, that is no small achievement.

Today we seem to have come to a turning point in the history of the application of nuclear energy, the leveling off of the first steep learning curve. It's possible to trace that change, by the way, in the fifty-year cumulative record of nuclear weapons tests, which followed a classic logistic curve of natural growth during the first thirty years of the Cold War but which have fallen away nearly to zero today from a maximum of 143 in 1962.[12] The major nuclear powers were slow learners — slower than many smaller and wiser nations which have foregone nuclear weapons entirely — but the history of war preached caution and they had much to lose. Now the major nuclear powers are scaling back their stockpiles, reducing vertical proliferation in particular. Horizontal proliferation has slowed progressively over the years. If the American experts are correct who estimate that some twenty to twenty-five nations in the world have explored acquiring a nuclear-weapons capability and could go nuclear within a relatively short time but have chosen not to do so,[13] then the fears of those who believe that nuclear-weapons acquisition is driven primarily by technology would seem to be unfounded. To the contrary, since the beginning of the nuclear age, when Britain and the United States feared a German atomic bomb, going nuclear has represented an often desperate attempt to solve problems of vulnerability and prestige that may seem in the short run to be military and strategic but that in the long run inevitably turn out to be political. The real tragedy of arms races, nuclear or otherwise, is that they substitute barricades and threat displays for negotiation and in the process make negotiation that much more protracted, that much more difficult and that much more expensive.

The vertical proliferation of the superpowers in particular was driven primarily by political problems that such proliferation was intended to solve. Tactical nuclear weapons, for example, were an American invention intended to reassure NATO that the United States would respond to a conventional attack by Warsaw Pact forces.[14] Tactical weapons were supposed to give the United States a less apocalyptic choice than unleashing the Strategic Air Command. Of course they did not resolve the problem, since the question in their presence as in their absence continued to be whether America had what was called the "political will" to use nuclear weapons to defend Europe. With the dissolution of the Warsaw Pact and the end of the perceived threat, the problem has now found peaceful resolution. Indeed, an increasing number of nations are coming to recognize that international conflicts can only be resolved by non-military means. "The elimination of nuclear weapons," Pugwash's Francesco Calogero comments, "will be achieved by de-emphasizing their relevance, thereby coming eventually to a situation in which nobody really cares much about them, because they indeed play no significant role."[15]

The diminished third wave of nuclear-weapons development that is now proceeding, particularly in this region of the world, is not likely to rise as steeply nor continue for as long as the first superpower arms race; the world knows more now than it knew then, including the economic waste and the ultimate futility of piling up nuclear arms.

The first great historical consequence of the discovery of how to release nuclear energy, then, has been to limit national sovereignty and to forestall world war. The next great consequence, already ongoing, will be to add significantly to human welfare by increasing sustainable energy resources and decreasing pollution.

Violence and scarcity are connected. At the end of the 20th century, when the world does not lack for resources, scarcity is itself a form of violence — structural violence, as it's termed, meaning violence that is built into the structures of societies, violence that results from repression and exploitation. The fact that blacks in the United States have an average four years' shorter lifespan than whites quantifies one evident manifestation of structural violence. The vast difference in standards of living between rich nations and poor, and between extremes of rich and poor within a country, are partly manifestations of structural violence.

If some violence is structural, then structural change away from repression and exploitation among and within societies will be necessary to decrease it. But there is another and less refractory process ongoing in the world, driven by enlightened self-interest, that decreases structural violence. That process is science and the embodiment of its discoveries in technology. Science and technology decrease structural violence by creating material wealth, a rising tide that lifts all boats. "The work of creation," writes the American philosopher Elaine Scarry, "...always has at its center the work of rescue."[16] To create material objects, that is — chairs, lasers, penicillin, hybrid rice — out of the silence of the inanimate is always to some degree to work at the alleviation of human suffering. So is the creation of nonmaterial objects — symphonies, religions — but nonmaterial objects have the profound disadvantage that they must be recreated — performed, enacted — each time they are used. In contrast, once material objects have been imagined and constituted, they perform their work of alleviation on demand: the chair rescuing its occupant from gravity, the laser from a detached retina or perhaps simply from one of the myriad subsets of ignorance, penicillin from disease, hybrid rice from hunger. And material objects are significantly open and nondiscriminatory. (Nuclear weapons are also material objects, to be sure, and it is difficult to imagine them wishing us well. But many material objects are simultaneously weapons and tools, and even nuclear weapons, loathsome though they may be, have served constructive purposes as tools for political change, as tools with which to dislodge an old and now mortally dangerous prejudice. Even as weapons, these manmade objects are rendered less seductive by their anonymity and lack of discrimination. They are as dangerous to us as to our enemies — exactly the reason we do not use them.)

The great human project, the ongoing work of human imagination, is the progressive materialization of the world. That project, it seems to me, complements Bohr's version of the scientific project, "the gradual removal of prejudices." Bohr would remind us that our work, our institutions and our values must finally conform to the limitations of the natural world in which we are inextricably embedded. The earth does indeed revolve around the sun; humankind is not a separate creation; no amount of slaughter, of so-called "ethnic cleansing," will make one human culture superior to another; and the threat of nuclear war limits the wildest extravagances of national ambition.

Complementarily, Elaine Scarry would remind us that the honest work of shaping the materials of the natural world into useful objects — the work of technology harnessed to science — has as its dignified and compassionate purpose the alleviation of suffering. Material objects — chairs that reduce the burden of gravity, computers that automate monotonous tasks, nuclear reactors that generate electricity to pump our water and light our way — are sailboats harnessing the subtle winds of physical law and they are inventions as profound as the inventions of art. They are less glamorous than objects of art, superficially less "spiritual," more fully realized and therefore more anonymous, which is perhaps why many intellectuals disparage them. But their reach is wider and their compassion more encompassing.

They are world-building; in Scarry's words, "the general distribution of material objects to a population means that a certain minimum level of objectified human compassion is built into the revised structure of the human world, and does not depend on the day-to-day generosity of other inhabitants...."[17]

David Lilienthal, the first chairman of the United States Atomic Energy Commission, saw benevolence similarly in the products of science and technology. "Energy is part of a historic process," Lilienthal wrote, "a substitute for the labor of human beings. As human aspirations develop, so does the demand for and use of energy grow and develop."[18]

Satisfying human aspirations is what our species invents technology to do. Some people, secure in comfortable affluence, may dream of a simpler and smaller world. However noble such a dream appears to be, its hidden agenda is elitist, selfish and violent. Millions of children die every year in the world for lack of adequate resources — clean water, food, medical care — and the development of those resources is directly dependent on energy supplies. The real world of real human beings needs more energy, not less. As oil and coal continue their historic decline, that energy across the next half-century will necessarily come from nuclear power and natural gas.[19]

Those who fear the diversion of plutonium in such an economy should look more carefully at the historical patterns of horizontal proliferation and the behavior of terrorists. Nations that choose to develop a nuclear-weapons capability find ways to do so. Iraq turned to electromagnetic separation of uranium, a technique the United States abandoned at the end of the Second World War, when Israel destroyed its Osiraqreactor. Certainly plutonium should be strictly controlled. But nuclear proliferation is far less a technical than a political problem. And terrorists have shown little inclination or ability to add nuclear engineers and metallurgists to their ranks. The weapon of choice in New York's World Trade Center bombing was nitrate fertilizer and fuel oil, which the terrorists found it easy to purchase in a foreign country and were confident they knew how to ignite. Highly-enriched uranium is a far more dangerous material where terrorists are concerned than plutonium; as the Nobel laureate physicist Luis Alvarez pointed out some years ago, the background neutron rate of HEU is so low that terrorists would have a good chance of setting off a high-yield nuclear explosion simply by dropping one 30-kilogram piece onto another. HEU can be diluted, of course, but plutonium can be effectively poisoned through such processes as the fuel-recyling system planned for Argonne's Integral Fast Reactor. We should make an effort to distinguish betwen the fictions of the Tom Clancys of the world and sober reality as we discuss a plutonium economy.

Adjusting across the last five decades to the new knowledge of how to release nuclear energy has put us at no little risk. With the demise of the former Soviet Union and its replacement by a volatile but resourceful collective of new states, we are already moving to a new level of world security with reduced numbers of nuclear weapons and — what is equally valuable — extended response times for the arsenals that remain. We will not easily find our way to a world free of nuclear weapons. Certainly it will also be necessary to pursue major reductions in conventional armaments. But the evident uselessness of nuclear weapons may bring that millennium sooner than it seems. The end of the Cold War surely counts as the new morning of the world.

In a world less militarized, less spendthrift of resources, science and technology can enlarge their work of rescue. The population of the earth has increased fivefold since 1850 — from one billion to more than five billion — primarily because of science and technology — because of improvements in public health, nutrition and medicine. And we will be sustained in the centuries to come by science and technology as well. Far from threatening civilization, the promise of science and technology, the only human institutions so far devised that consistently learn from their mistakes, is that they will continue to civilize us. And you work honorably in the vanguard of that progress.

Tsui ni yuku
Michi to wa kanete
Kikishi kado
Kinō kyō to wa
Omowazarishi wo

I have always known [wrote the poet Narihira]

That at last I would

Take this road, but yesterday

I did not know that it would be today.[20]

Thank you.

NOTES

1. Jones, R. V. 1966. Winston Leonard Spencer Churchill. Biog. Mem. F. R. S. 12:35, p. 88ff.

2. Niels Bohr to Franklin Roosevelt, 3.vi.44; J. Robert Oppenheimer Papers, Box 21, U.S. Library of Congress.

3. Quoted in Nielson, J. Rud. 1963. Memories of Niels Bohr. Physics Today. Oct., p. 30. Emphasis added.

4. Oppenheimer, J. Robert. 1963. Niels Bohr and his times. Three lectures, unpublished MSS, J. Robert Oppenheimer Papers, Box 247, U. S. Library of Congress. Lecture III, p. 9.

5. Quoted ibid.

6. Rozenthal, Stefan, ed. 1967. Niels Bohr. North-Holland Publishing Company, p. 350.

7. Op. cit., p. 351.

8. Quoted in Markusen, Eric, and David Kopf. In press. The Holocaust and Strategic Bombing: Genocide and Total War in the Twentieth Century. Westview. MS p. 167.

9. Quoted op. cit., MS p.120.

10. Bundy, McGeorge. 1969. To cap the volcano. Foreign Affairs 48:1 (Oct.), pp. 9 - 10.

11. Bohr, Niels. 1958. Atomic Physics and Human Knowledge. John Wiley, p. 31.

12. Cf. Nuclear notebook: known nuclear tests worldwide, 1945 to December 31, 1992. 1993. Bul. Atom. Sci. Apr., p. 49.

13. Theodore Taylor, personal communication. Cf. also Deutsch, John. 1992. The new nuclear threat. Foreign Affairs 71:4, p. 125: "It would be a simple matter for

nations like Japan, Germany, Switzerland and Canada to build a number of weapons in a matter of months, with no advanced preparation."

14. Cf. Carl Kaysen, Robert McNamara and George Rathjens, Nuclear weapons after the Cold War, in Rotblat, Joseph, et al. 1993. A Nuclear-Weapon-Free World. Westview Press, p. 33ff.

15. Franchesco Calogero, An asymptotic approach to a NWFW, in Rotblat, et al., op. cit., p. 200.

16. Scarry, Elaine. 1985. The Body in Pain. Oxford University Press, p. 276.

17. Scarry, op. cit., p. 291.

18. Lilienthal, David. 1980. Atomic Energy: A New Start. Harper & Row, p. 10.

19. Cf. Modis, Theodore. 1992. Predictions. Simon and Schuster, p. 139.

20. Rexroth, Kenneth. 1964. 100 Poems from the Japanese. New Directions, p. 58.

Promoting the Peaceful and Preventing the Military Uses of Nuclear Energy

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Hiroshima, 13 April 1994

Not much time remains till we reach the moment that we call year 2000. As on a new year's eve we look back over the past year and forward to the coming one, perhaps now is a moment to look at our situation from a longer perspective than we usually do. This is said to be the nuclear age. Indeed, questions concerning the uses of nuclear energy - for destruction and for development - have been at the top of the international agenda for the last 50 years. There are at present great changes occurring which oblige us to reexamine the roles of nuclear energy.

No place could be more appropriate for that re-examination than Japan, because Japan is among the very few countries which have consistently and successfully tamed the atom to use in medicine, in agriculture and, above all, to give a substantial and independent energy base for its growing standard of living and its fast expanding industry. When today we rejoice in the phenomenal growth of Asian economies and the rising standard of living it brings to billions, we might do well to remember that this evolution began in Japan and that important elements - apart from education, hard work and stability - were the privilege of early demilitarization and a determined use of peaceful nuclear power. We should ask ourselves whether this recipe is not one that the world at large could and should follow reduced military spending and a greater use of environmentally benign energy.

In Japan no place could be more appropriate than Hiroshima for this discussion. The spectre of nuclear war between great powers, which has haunted the world ever since the bombs fell on Hiroshima and Nagasaki, is at last losing its grip on us. The discussion is no longer about mutually assured destruction but about how we can do away with existing nuclear arsenals and prevent new nuclear weapons from coming into being. Certainly the use of armed force at national and regional levels is not over, but cold war and containment are no longer the dominant factors they once were. They are giving way to commercial competition and co-operation, negotiation and integration. In this new era disarmament must go hand in hand with renewed efforts to help the hundreds of millions who live in deprivation, with efforts to uphold human rights, and to maintain cultural diversity, with efforts to protect the environment from mindless destruction and efforts to consolidate and develop regional and global institutions, notably the United Nations system.

Those who work in the nuclear field must contribute their thinking and expertise especially to two vitally important items on this new world agenda: the practical elimination of nuclear weapons and the safe and expanded use of nuclear energy for health, development and environmental protection. I shall address the second issue first.

Promoting the peaceful uses of nuclear energy

There are an ever increasing number of beneficial and peaceful applications of nuclear energy in medicine, agriculture and industry. While all of them require full attention to radiation protection, only a few of them evoke any resistance. As we all know public concern is focussed on nuclear reactors and the disposal of nuclear wastes. Promoting the peaceful uses of nuclear energy requires inter alia understanding those concerns and meeting them or showing that they are not well founded. I shall leave aside the many other peaceful uses of nuclear energy and address the issue of nuclear power.

There is no doubt that the accident at Three Mile Island and the disaster at Chernobyl have had a heavy impact on public opinion regarding nuclear power and that there is a continuing preoccupation with nuclear safety especially in many reactors of older Russian design.

It would also appear that mass media, ever in search of what can attract the public's attention, by disseminating any news which play on the public's fears of anything connected with radiation, actually help to confirm and amplify these fears. It is true that in many countries where there is no immediately compelling need to add further electric capacity - as is the case in many industrialized States - the public will also resist further fossil fuelled plants and large hydro schemes, while in East Asia, where electricity demand is growing fast and it is understood that a higher standard of living depends directly upon responding to this demand, the public seems ready to cope with whatever concern it may feel and accept an expansion of nuclear power in the same way as it accepts other sources of electricity. However, public acceptance of or resistance to nuclear power does not depend only upon the presence or absence of strong demand for electricity. Even in the face of a strong need for more electricity the expansion of nuclear power at present would meet insuperable resistance in several industrialized countries - not only those few, like Austria, Denmark and Ireland, which have made rejection of nuclear power a policy. To take a recent example, Finland, with a largely pro-nuclear government, with four existing nuclear units with an absolutely superb safety and production record, needs additional electric power. Yet, the Finnish Parliament last year rejected a government proposal for more nuclear power. By contrast, France, with a relatively comfortable electricity balance based on a large and well-functioning nuclear sector, continues to build nuclear power plants without much public concern. There is not one simple explanation as to why nuclear power is accepted or rejected. Each community has its own history and power situation and must decide in its own constitutional way what energy sources it will rely on.

Nuclear power must first of all compete with other power sources on its own economic, safety and reliability merits. The rapid expansion of nuclear power in East Asia and the slow but continued growth in some other countries, like France, shows that competition on these grounds alone is possible. Today, it is imperative, however, that the comparisons between different energy sources also take their respective health and environmental impacts into account. This necessity ought to lead to a renewed interest in nuclear power. Indeed, the global climate change that is presently foreseen as a result of the excessive emissions of so-called greenhouse gases, notably CO_2 and methane, would appear to make an early revival of nuclear power crucially important. It is curious that few of the many governments, international authorities and non-governmental groups who are deeply engaged in the question of global warming have highlighted this point. In my view this has given a certain Alice in Wonderland character to what should be a serious public discussion. Let me give illustrations.

Although global climate change was one of the principal concerns at the 1992 Conference on Environment and Development in Rio, few speakers at the Conference addressed the question of energy. The Framework Convention on Climate Change which was adopted by the Conference established the aim of stabilizing greenhouse gas concentrations in the atmosphere at levels which would not interfere dangerously with the climatic system. However, the convention does not stipulate *how* this is to be done. The aim of some countries to contain man-made greenhouse gas emissions at 1990 levels by the year 2000 is characterized in the World Energy Council's authoritative report "Energy for Tomorrow's World" as simply unrealistic. Indeed, in all the Council's global energy scenarios for the time up to the year 2020 - even the most optimistic - there is an *increase* in the use of fossil fuels and an increase in CO_2 emissions. To anyone looking around in the world today, it is evident that there is a global growth in reliance on the burning of fossil fuels and a global growth - not reduction - in CO_2 emissions.

The International Panel on Climate Change (IPCC) is looking much beyond the year 2020 and is working with scenarios up to the year 2100. Under a "renewable sources scenario" which it has before it, renewable sources, including hydro, would in the year 2100 have a share of 83% of the total energy supply - as compared to 6% commercial renewables at present. Both fossil and nuclear power would be practically phased out. Biomass would provide 50% of the world energy consumption, most of it being solid biomass used for electricity generation. One may query how meaningful such theoretical exercises are. In particular the rapidly accelerating and dominant role of renewable energies in the IPCC scenario I have referred to appears highly speculative. The World Energy Council foresees for biomass, solar, wind and geothermal power still only a very minor role even 30 years from now.

The paradoxical situation might be summed up as follows:

First, relying today for over three quarters of our energy needs on the burning of fossil fuels, we are drastically interfering with the ecological balance of the Earth by releasing into the atmosphere at a fantastic speed huge quantities of carbon dioxide taken from the very same atmosphere in the course of millions of years and stored underground;

Second, it is suggested to us that the phasing out of this enormous and risky interference should occur through the phasing in mainly of biomass, solar, wind and geothermal power - sources which after more than a decade of development contribute only a fraction of a percent of the world's energy and whose real development potential remains highly hypothetical;

Third, it is deemed inopportune at the very least by most leading participants in the greenhouse discussion to suggest that nuclear power, which now contributes about 5% of the world's energy and hardly any of its CO_2, should be expanded, although it is a proven and presently available technology which could easily and rapidly expand. and which - with breeder reactors - could offer an almost inexhaustible source of CO_2-free energy.

The dominant voices in the global environmental debate are so loud in their rejection of nuclear power and their advocacy of conservation and the hypothetical vastly expanded use of renewables that comments about the now existing and significant potential contribution of nuclear power are almost drowned out. Even among important groups of scientists the focus seems sometimes to be chiefly on speculative recipes. For example, reports from the recent annual meeting of the American Association for the Advancement of Science highlight suggestions that we might shoot a thin layer of dust into the atmosphere every few years to shield the earth from too much warming. Certainly, the exploration of imaginative scientific ideas should not be discouraged but the world-wide attention given to ideas such as this is perhaps a sad sign that the nuclear option is placed on a distant, almost forgotten, back-burner. However, there are some exceptions coming from quarters other than from the nuclear industry itself.

The 1993 report "Energy for Tomorrow's World" by the World Energy Council states - I quote - that "nuclear power has immense technical potential" and that "there is a need to continue to seek a way of exploiting the immense energy reserves of nuclear power which is publicly acceptable across the whole fuel cycle from procurement and processing through disposal." The report also suggests that a major drive will be required to "achieve the early rehabilitation of nuclear energy" and to advance the introduction of renewable energy supplies "if a significant decline in the world's relative dependence on fossil fuels is going to occur over the next century" (page 90). To these considerations one might add the observation that already in today's world more than 400 nuclear power reactors help us to avoid some 1800 million tons of CO_2 emissions that would have resulted from an alternative use of coal. This is about 9% of total CO_2 emissions of 20 000 million tons from fossil fuels. One might also have added the observation that the average CO_2 emission per kWh in the UK, where 70% of the electricity comes from coal combustion was 0.78 kg, while in France, where more than 70% of electricity comes from nuclear power, the CO_2 emission per kWh was about one tenth of the UK value, or 0.086 kg.

More than two years ago a Club of Rome Report concluded that - I quote - "the use of coal and oil is probably more dangerous to society, because of the carbon dioxide they produce, than nuclear energy. There are therefore strong arguments for keeping the nuclear option open and for the development of the fast breeder reactors ...".

It is also reported that the Government of Japan, in a document submitted last December to the UN Committee on Sustainable Development states - I quote - that "Japan should promote development and utilization of nuclear power on the assumption of safety assurance, regarding it as an energy source which does not release CO_2." It is gratifying that at least one important government breaks the curtain of official silence about nuclear power and global warming. There is a certain risk that political parties and governments which are in fact positive or at least open to the nuclear power option simply for fear of alienating some voters remain completely silent on the issue, leaving discussion to vocal anti-nuclear groups. This could result in the option being unavailable one day when it may be needed to meet compelling demands for additional power capacity. One conclusion to be drawn from this discussion is that scientists, and engineers and others familiar with the nuclear power option must speak up so that the public can obtain a balanced picture of both the potentials and problems of nuclear power. It should be understood, for instance, that if industrialized countries, which have the economic, scientific and technological capacity to expand their reliance on nuclear power used this capacity, the pressure on fossil fuels would diminish to the benefit of developing countries, Although these countries are the most energy hungry, nuclear power is mostly not a viable option for them today, because it is very demanding in technological infrastructure and in capital.

Public discussion, with an active participation by scientists and engineers, is needed for a wide nuclear revival. However, there are also a number of other things that this group could and should do to promote the use of nuclear energy.

The first and foremost is to ensure consistently good operation of existing nuclear plants. Much has been attained in this sphere in the last ten years. The notion of a nuclear safety culture to be emulated by all countries, is generally accepted and is propagated and assisted at the international level by the IAEA as well as the World Association of Nuclear Operators (WANO). There is now every prospect that an international convention on the safety of nuclear power plants will be adopted this year under IAEA auspices. Through this convention, States will bind themselves to a number of important safety principles and accept participation in periodic peer review of implementation of the obligations under the convention. This convention may be expected to be followed later by the elaboration of another, similar convention on the safe disposal of nuclear waste. The international legal infrastructure relating to nuclear safety is thus slowly growing beyond the familiar instruments on civil liability, physical protection and notification and assistance in the case of emergencies.

While we can now register over 6000 reactor years with the Chernobyl accident as being the only one which has caused significant off-site radioactive releases, there is still concern that safety improvements are not taking place quickly enough in many older power reactors of Russian design. Scarcity of resources in the former Soviet Union and too slow assistance from abroad are the reasons. It is essential that all concerned accept their responsibility. There is a compelling common interest in ensuring that no further accident occurs. At the IAEA we are at present particularly concerned about the situation at Chernobyl, where two reactors are still in operation and where many skilled operators have left. A special meeting will soon be held in Vienna on this subject.

A second important area of activity is the further development of nuclear power technology. The nuclear recession which still prevails in many countries in the Western industrialized world does not encourage expensive investment in such development. However, we should be aware that the emergence of advanced types of reactors might do much to increase acceptability of nuclear power. When public opinion does recognize the need to expand the use of nuclear power, as I trust one day it will, it should find that technology in this field as in others has not been standing still.

Many new demands are being placed upon the next generation of reactors. Their safety should be such that no plans are needed for the emergency evacuation of people living in their vicinity. They should be economically competitive and easier to operate than present reactors. With a renewed acceptance of the nuclear power option, new functions can be foreseen for nuclear energy. The fast growing number of huge cities around the world could be supplied with electricity from reactors which are located not too far away. Regions which must increasingly rely on the desalination of sea water could look to a new option. Heat producing reactors could have wide industrial use and reactors could be used for district heating in the cold regions of the world.

Japan is taking a prominent part in the development of the next generation of nuclear reactors. This is far sighted and may one day pay off well. The high temperature gas cooled reactor is an interesting example. Even the much maligned breeder reactors may one day be warmly welcomed. It is true that the economic case for breeders is not present today - with uranium prices at a very low level and it is true that the use of plutonium raises special security demands. However, looking toward the next century the experience that a few countries, including Japan, France and Russia, are gaining in the design and operation of breeders may turn out to be valuable - for themselves and for the world as well.

The issue of waste from nuclear power still looms large in the public debate. However, it is not of the same dimension as the issue of operational safety and it is likely to be of limited duration. Once suitable sites have been selected and appropriate installations been built, problems are unlikely to arise. The operation of waste disposal installations is not very complicated. Nevertheless there are some matters in the area of radioactive waste which deserve particular attention. First, it is known that the handling of nuclear waste in the *military* sector in the US and Russia has had serious deficiencies. This must be remedied over time and in a planned manner. Second, it is important to get on with the selection of sites which are suitable for waste disposal and to consult the local population. Experience from several countries, including France, shows that acceptance is by no means unattainable when full information is patiently given to the public and the potential benefits to the local communities are explained. Third, despite the fact that there exist today fully satisfactory methods of managing and disposing of all levels of radioactive waste, it is desirable that research and development continue. Just as we may expect a new generation of power reactors offering new and positive features, new methods of waste handling may emerge which may be less costly or, perhaps, shorten the time span during which the wastes remain radioactive.

The concept of "alternative energy" has been much in fashion. We should coin the term "alternative waste". Nuclear waste is an alternative to the waste from burnt fossil fuels. If the wastes from burnt fossil fuels could be managed and disposed of as safely as the waste from nuclear power, our global environment would not be endangered. It is the wastes from burnt coal, oil and gas - not the waste from nuclear power plants - that cause acid rains and greenhouse gases. These wastes are so voluminous that they cannot be contained and buried. Sites for the ultimate disposal of these wastes are not selected. They are our atmosphere and the surface of our earth.

Preventing the military uses of nuclear energy

After decades of nuclear arms races, the world is beginning to descend the arms spiral. Russia and the United States have agreed to cut the number of their nuclear warheads from some 65 000 together to around 3000 each. Although even this number still represents a formidable destructive potential, it points to a decisive turning of the tide and indicates that the nuclear-weapon States no longer consider nuclear armed conflicts between themselves to be realistic. The great powers appear to feel that they have no choice in this new era but to co-operate and to bridge differences which inevitably arise. Although the Security Council of the United Nations is not immune to paralysis through a veto, common action is now routinely and sincerely sought and often achieved. This, too, augurs well for the future.

In this situation many new questions arise with a specific bearing on the nuclear sphere.

A current problem is the safe dismantling of redundant nuclear warheads and the storing, managing and eventual use or disposal of the plutonium and highly enriched uranium regarded as excess to defence requirements. It must be verified that the material does not go back to military use. President Clinton has declared that the United States will place recovered material under the control of the IAEA and we expect considerable quantities of such material to be placed permanently under safeguards already this year. While the recovered enriched uranium is expected to be transformed into low enriched uranium and made into fuel for light water reactors, there is still considerable discussion about the future of the recovered plutonium: whether it is to be used in special dedicated reactors, or as MOX fuel in light water reactors or be mixed with nuclear waste and disposed of as such. In either case international verification of such peaceful use and disposal of such material will be much more demanding than simply verification of storage.

It is in the context of the proposals to place excess HEU and Pu under safeguards that a discussion has started about the Pu which will come back from the reprocessing of spent power reactor fuel - e.g. from Japan - and which is already under safeguards. Although efforts will be made to limit the quantities which have to be temporarily stored, special measures are being discussed to enhance confidence and transparency in all aspects of the transport, storing and use of plutonium.

With a growing surplus of plutonium and highly enriched uranium connected with nuclear weapons, it is not surprising that attention is now turning to proposals for a universal prohibition of the production of further fissionable material for use in weapons or other nuclear explosive devices - a so-called cut-off. Such a ban would prevent the dismantling of nuclear weapons being offset by the simultaneous production of fissionable material for new weapons. If universally accepted and not limited to the declared nuclear-weapon States, such a ban would also put a cap on any further production of fissionable material for weapons in the so-called threshold States, i.e. in India, Pakistan and Israel. Verification of a universally accepted cut-off would require a very extensive effort, as reprocessing and enrichment plants and - probably - all nuclear reactors in declared nuclear-weapon States and in India, Pakistan and Israel may have to be safeguarded.

It has been argued that participation by India, Pakistan and Israel in a cut-off agreement, although preventing these States from producing any *further* fissionable material for weapons, would *legitimize* whatever stocks of such material they might have had when joining an agreement. I do not find this argument very convincing. There is no reason to let the best - no nuclear weapons - be the enemy of the good - no further material for nuclear weapons.

A complete ban on nuclear testing is at long last under serious negotiation in Geneva. Its conclusion and universal acceptance would give a powerful signal that the era of further nuclear weapon development is over. It would also give a powerful boost to the non-proliferation treaty by eliminating one inequality between its non-nuclear weapons and its nuclear weapons parties.

From the media and from some international public discussion, one might get the impression that as the world progresses toward nuclear disarmament the risk of a spread of nuclear weapons to further States has paradoxically been growing. The discovery that Iraq - an NPT State - was pursuing a sizeable clandestine programme for the enrichment of uranium to use in nuclear weapons was a severe shock raising the questions of whether there are other clandestine programmes and whether guarantees can be created against such developments.

Some new dangers can, indeed, be identified but also a number of positive developments. Let me first focus on the dangers. At the time when the NPT was concluded, the concern was that the more industrialized countries might use nuclear energy for military purposes. This has not been the case. Japan and other advanced industrial nations have not sought their security in these weapons. Today, however, more developing countries are reaching a technological level that might enable them to make nuclear weapons. Iraq was secretly trying. India, Pakistan and Israel - not parties to the NPT - are deemed by most observers to have the capacity for the military use of nuclear energy. At present, an ominous question mark is attached to the DPRK which has adhered to the NPT but which - despite Security Council requests - is rejecting effective IAEA inspection, especially in the plant built for plutonium separation.

Another new concern about proliferation is linked to the changes in and the break-up of the former Soviet Union. It may be hoped that the risks identified are short-lived and that not only Kazakhstan and Belarus but also Ukraine will join the NPT and will, with appropriate economic and security arrangements, transfer any nuclear weapons on their territories to Russia. With the active co-operation of these countries the IAEA is preparing for safeguards inspection of all nuclear facilities in them.

Another risk is that nuclear material, know-how and experts might trickle out to States or groups potentially interested in making nuclear weapons. The response to this risk lies in strengthened regulatory control in the States of the former Soviet Union and in increased alertness against smuggling. So far, none of the many instances of smuggling which have come to light has involved nuclear material of types or quantities which give rise to proliferation risks. But there is no room for complacency.

The new risks of proliferation which I have mentioned have an important counter-balance in new commitments to non-proliferation. Argentina and Brazil have opened the whole of their nuclear programmes to each other and to IAEA inspection. If - as we now have reason to hope - Cuba joins the Tlatelolco Treaty, the whole of Latin America could soon become a Nuclear Weapon Free Zone. In Africa, South Africa has become the first State in the world to roll back from a nuclear weapon capability and to request IAEA verification of the termination of its weapons programme. If, as recently declared, Algeria adheres to the NPT, the path would be open to Africa becoming a second nuclear-weapon-free continent.

In the Middle East, the peace process offers some hope for the establishment of a nuclear-weapon-free zone. Indeed, it is hard to see how the peace process could be complete without a well verified nuclear-weapon-free zone or zone free of all weapons of mass destruction. The IAEA has been asked to assist the parties in exploring the necessary verification arrangements.

A special arrangement involving India and Pakistan and several other countries, may also be needed as part of the efforts to free the world from military applications of nuclear energy.

It is too early to speculate on the arrangements necessary for a world in which no single nation can threaten others with the use of nuclear weapons. The genie is out of the bottle. Until the United Nations has developed as an effective security system - and we are far from that situation - the five declared nuclear-weapon States are unlikely fully to abandon their capacity. There is much, however, that can and should be done to promote non-proliferation before we reach that advanced level of global organization.

Above all, it is important that the major States continue the policy of detente. Since the end of the cold war tremendous progress has been achieved, e.g. in Nicaragua and El Salvador, Mozambique, Namibia and Ethiopia, Lebanon and the Middle East, Cambodia. But there are still areas of large scale or limited armed conflicts, e.g. Bosnia, Somalia, Angola, Rwanda, Afghanistan. As security interests drive arms races, including nuclear arms races, detente is the first barrier against nuclear proliferation. In this respect, we might perhaps dare to be optimistic. We seem to be in an age of negotiated settlements of conflicts - whether about territory, economics or even human rights.

A second barrier to proliferation may lie - as we have learnt from failure in the case of Iraq in more effective controls over exports of nuclear material and equipment. A third barrier may lie in verification so effective that it will help to deter States from any secret military uses of nuclear energy. In this regard, too, experience in Iraq has helped us to make progress. The safeguards system of the IAEA has been considerably strengthened. In the case of the DPRK it was the use of the latest techniques which led the IAEA to sound the alarm. Today it is not detection and verification techniques that are in question but rather the means available for inducement and enforcement. However, further consolidation and development must occur in the field of verification of the peaceful uses of nuclear energy. Full national nuclear transparency coupled with full co-operation with the international safeguards system may lead to greater confidence about the exclusively peaceful use of nuclear energy.

ACHIEVING EFFECTIVE REGULATION
THROUGH THE
APPLICATION OF UNIVERSAL PRINCIPLES

PRESENTED BY

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AT THE

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ANNUAL CONFERENCE IN HIROSHIMA, JAPAN

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ABSTRACT

The speaker will describe the experience of the U.S. Nuclear Regulatory Commission in efforts to improve regulatory effectiveness, the practices that have developed during these efforts, and the universal principles supporting those practices. Effective nuclear safety regulation involves much more than technological decision making. To achieve its primary regulatory objective, regulation must involve many multi-dimensional aspects including:

- Development and maintenance of a broad base of knowledge.
- Establishment of an early and active dialogue with all the interested parties, particularly the public.
- Consideration of the resource requirements and impacts associated with regulation.
- Ensurance of the timeliness of regulation.
- Frequent assessment of the regulatory infrastructure, and revision as necessary.

Effective regulation results in an environment that fosters self-assessment and the quest for excellence among those regulated. The speaker will also provide examples of the application of the universal principles including descriptions of specific regulatory actions and processes.

INTRODUCTION

Good afternoon, ladies and gentlemen. I feel very honored and pleased to speak to you today at this 27th annual conference of the Japan Atomic Industrial Forum. After spending thirty years in academe as a physics professor and administrator, for the past seven years I have been a Commissioner at the Nuclear Regulatory Commission and, in that capacity, have been intimately involved in ensuring that nuclear energy in the United States is developed and utilized in a safe manner. I have brought to my work on the

Commission my personal commitment to learn and generalize from experience and to distill the essence of that experience into general principles.

The basic theme of this conference, "Toward a Nuclear-Weapons-Free World – the Role of Peaceful Utilization of Nuclear Energy," is most appropriate now with the ending of the Cold War and the start of dismantlement of the world's arsenal of nuclear weapons. For the purpose of this talk, when I refer to utilization of nuclear energy, I will be restricting myself to the employment of nuclear reactors for power generation. There are myriad other peaceful medical and industrial applications of nuclear materials but these are more appropriately the subject of another forum. Before further peaceful use of nuclear energy can be realized in the United States and, I venture to say, in many other countries of the world, there are four primary conditions that must be satisfied, namely:

1. The continued safe operation of existing nuclear power plants.

2. Resolution of the issue of how to dispose of spent nuclear fuel elements.

3. A regulatory process that provides a clear set of ground rules for evaluating future nuclear power applications.

4. The ability of nuclear power plants to compete economically with other available forms of power generation. Clearly, this will be dependent, to a large extent, on particular situations in each individual country.

Unless all of these conditions are met, I seriously believe that there will be no near term viable nuclear power option. The nuclear regulatory process can have a significant influence on the likelihood that the four conditions are met.

I will devote the rest of my talk to describing to you how we at the NRC have learned to improve the effectiveness of our regulatory process, the universal principles that we believe should guide and support improved regulatory practices, and the practices that have developed from application of the principles.

EFFECTIVE REGULATION

While national regulations can influence nuclear safety, no amount of regulation can ensure safety if those who run the nuclear plants do not take it upon themselves to operate as safely as possible. It is not possible, nor is it desirable, for a regulatory agency to have ultimate responsibility for the safety of nuclear power generation. There must exist in the nuclear plants a safety culture which recognizes that the primary responsibility for safety lies with the operators of the plants. Thus, effective regulation should promote an environment that fosters self-assessment and a quest for excellence among those regulated.

REGULATORY PRINCIPLES

At the NRC we have identified a number of universal principles that we are using to guide us in our decision making and in our behavior as individuals and which we find help lead to effective regulatory processes. We refer to them as the Principles of Good Regulation and have made a commitment to adhere to these principles because we believe they promote consistently high performance and address inadequate performance.

Good regulation identifies the conditions necessary to ensure safety and creates an environment which insists on compliance with established standards while allowing and encouraging licensees to take the lead in maintaining excellence and to exercise initiative in identifying and solving potential as well as actual problems. Good regulation encourages sound and effective practices, discourages unsound practices, and identifies questionable practices. It must, therefore, establish both standards by which to judge practices and the means to encourage the sound and discourage the unsound. To accomplish this, regulation must be:

INDEPENDENT. Nothing but the highest possible standards of ethical performance and professionalism should influence regulation. However, independence does not imply isolation. All available facts and opinions must be sought openly from licensees and other interested members of the public. The many and possibly conflicting public interests involved must be considered. Final decisions must be based on objective, unbiased assessments of all information, and must be documented with reasons explicitly stated.

OPEN. Nuclear regulation is the public's business, and it must be transacted publicly and candidly. The public must be informed about and have the opportunity to participate in the regulatory processes as required by law. Open channels of communication must be maintained with legislators, other government agencies, licensees, and the public, as well as with the international nuclear community.

EFFICIENT. The public, the rate-paying consumer, and licensees are all entitled to the best possible management and administration of regulatory activities. The highest technical and managerial competence is required, and must be a constant regulatory agency goal. The regulatory agency must establish means to evaluate and continually upgrade its regulatory capabilities. Regulatory activities should be *consistent with the degree of risk reduction they achieve.* Where several effective alternatives are available, the option which minimizes the use of resources should be adopted. Regulatory decisions should be made without undue delay.

CLEAR. Regulations should be coherent, logical, and practical. There should be a clear nexus between regulations and agency goals and objectives whether explicitly or implicitly stated. Agency positions should be readily understood and easily applied.

RELIABLE. Regulations should be based on the best available knowledge from research and operational experience. Systems interactions, technological uncertainties, and the diversity of licensees and regulatory activities must all be taken into account so that risks are maintained at an acceptably low level. Once established, regulation should be perceived to be reliable and not unjustifiably in a state of transition. Regulatory actions should always be fully consistent with written regulations and should be promptly, fairly, and decisively administered so as to lend stability to the nuclear operational and planning processes.

These principles have not merely been drafted and then forgotten. They have served as the framework for the development of standards of performance and professionalism within the NRC. Each NRC employee has received a copy of the Principles. Each technical staff member has also been given a set of performance expectations, based on the Principles, for different types of work responsibilities.

FEATURES OF AN EFFECTIVE REGULATORY PROCESS

We have developed a self-consistent set of regulatory processes that derive from the Principles of Good Regulation. From application of the Principles, we have found that an effective nuclear regulatory process must include certain essential features:

- Development and maintenance of a broad base of knowledge

  Regulation of the operation of nuclear power plants to protect the public health and safety requires a technically well informed and skilled staff capable of employing relevant technical knowledge in its decision making. To be fully effective, this staff must be supported by a body of technical information readily available to it in a useable form. The NRC is a knowledge-based organization whose vitality rests upon its ability to transform scientific and technical knowledge into sound regulatory practice.

- Establishment of an early and active dialogue with all the interested parties, particularly the public.

  In order to ensure that all impacts and aspects of a particular regulation are appropriately considered, it is essential that all those entities that may be affected by the regulation have ample opportunity to express their views. The regulated community will generally offer their views in the early stages of the regulatory process with very little solicitation needed. However, special efforts are needed to obtain the views of the general public during the early stages of the formulation of a new regulation. If the public does not have the opportunity to actively participate early in the process, it is very difficult to gain its acceptance of the eventual regulatory decisions that are made. To move forward toward greater utilization of nuclear energy, it is necessary to convince the public that this can be done with no adverse safety impact.

- Consideration of the resource requirements and impacts associated with regulation.

  While the primary thrust of nuclear regulation must always be that safety considerations are paramount, regulators cannot simply add conservatism upon conservatism. The resources of both the regulators and the regulated are limited. Unreasonably burdensome requirements, with no significant safety improvement, can dilute the available human and financial resources and result in an emphasis on relatively unimportant issues. This can lead to reduction in safety and, very likely, eventual elimination of the nuclear option on both safety and economic considerations.

- Ensurance of the timeliness of regulation.

  For a regulatory system to be effective, it must be able to quickly respond to the perceived need for a particular regulation. Thus, when new operational experience or research indicates that a new or revised regulatory position is appropriate, the regulatory process must facilitate the prompt achievement of a soundly based decision.

- Frequent assessment of the regulatory infrastructure, and revision as necessary.

  The regulator must continuously monitor the effectiveness of the regulatory process and revise it in response to changing conditions. As the nuclear industry changes and matures, new operational experience is gained, or new performance trends and patterns develop, it may be necessary to adjust the basic regulatory infrastructure.

EXAMPLES OF NRC REGULATORY ACTIONS THAT REFLECT THE PRINCIPLES

- Enhanced Participatory Rulemaking

Since early 1992, the NRC has been engaged in a rulemaking process to establish the radiological criteria for the decommissioning and decontamination of licensed nuclear facilities. In accord with the principle of openness and the desire to provide for early and comprehensive input from affected interests on important public health and safety issues, the NRC decided to follow a process that would include enhanced participation by the affected interests. The objective was to obtain input on the rulemaking issues from the affected interests before the NRC developed even a provisional regulatory position.

This early participation was accomplished through a series of seven public workshops, held in various locations throughout the United States. The workshop format was selected to provide the affected interests with an opportunity to discuss the issues with each other and to question each other about respective positions and concerns. The workshops were open to the public and the public was given the opportunity to comment on the issues. The workshops utilized the services of trained facilitators who were experts in setting up and conducting these types of meetings thus improving the likelihood that all the issues, positions and concerns of the parties were considered. Participants were invited from many diverse groups including state, local and Native American tribal governments, federal agencies (including NRC), citizens groups, professional societies, and the affected nuclear industry. Selected participants who would not otherwise be able to participate in the workshops were provided with financial assistance for their travel expenses.

The Commission is very pleased with the progress being made on this rulemaking. A draft of the resulting proposed regulation is being circulated to all the workshop participants and to other interested parties, and we expect that a proposed regulation will be published for public comment in the near future. During the course of the workshops, there was a significant change in the attitudes of citizen group representatives. From expressions of distrust and lack of credibility of the NRC, there was a shift toward the view that NRC was taking an important first step in re-establishing the trust and credibility needed to accept its regulatory decisions. NRC understands that it is important to demonstrate that the public comments at the workshops were heard and seriously considered in arriving at the final regulatory proposal. We at NRC have been so pleased with this new regulatory approach that we are seriously considering it for additional purposes.

- Cost Beneficial Licensing Actions (CBLAs)

  The NRC has encouraged its nuclear power plant licensees to identify both a) regulatory requirements that provide little or no safety benefit yet incur significant costs to implement, and b) instances where licensee commitments to the NRC exceed what is necessary to meet the regulatory requirements and where cost savings can result if the commitment is revised. Licensees have requested relief from these requirements and commitments that are viewed to be marginal to safety. They are referred to as cost beneficial licensing actions or CBLAs. In many cases, after due consideration of all the factors, the NRC has granted the requested relief. For example, in 1993, out of about 34 requests the NRC approved 14 and has another 15 under review. In 1994, we already have 25 new submittals under review.

  There are both direct and indirect safety benefits from these CBLAs. A direct benefit results when the costs averted are applied to safety enhancements in areas that have greater risk significance. An indirect benefit ensues when the reduction in operational and maintenance (O&M) costs results in a more efficient and competitive organization.

- Siting of Nuclear Power Plants

  The NRC's siting criteria for nuclear power plants have been essentially unchanged since 1962. As a result of concerns regarding the siting of nuclear power plants near major metropolitan centers and following the Three Mile Island accident, the NRC sought to revise its siting criteria so as to strengthen siting as an added element of defense-in-depth. The intent was to decouple siting considerations from plant design so that plant design could not be made to compensate for unfavorable sites.

  A proposed rule was published for comment in late 1992 that would decouple siting from plant design. It had the following major features:

  - A minimum distance to the exclusion area boundary of 0.4 miles;

  - Offsite population densities averaged over any radial out to 30 miles should not exceed 500 people per square mile.

- Site meteorology was to be eliminated as a factor in determining site suitability.

Well, the response to the proposal was that almost everyone, both within and outside the United States, was emphatically opposed to it for many different reasons. Countries that do not have the United States' luxury of large open spaces felt that if the United States adopted these regulations it would be very difficult for them to justify the siting of plants in their countries. As a result of this groundswell of opinion, we have reconsidered our previous position. The Commission now understands the undesirability of including rigid numerical criteria in the regulations. Numerical values for exclusion area size and population density will probably not be part of the regulations and may or may not be included in the guidance documents. We are in the process of developing this revised regulatory approach which will in turn be subjected to a full and open public discussion.

My primary motive in discussing this rulemaking is to emphasize that, while we are independent regulators, we cannot create regulations in isolation and must continue to remain open to the ideas and concerns of all interested parties.

- National Performance Review

I would just like to mention a new initiative that we have recently taken as a result of Vice President Gore's National Performance Review (NPR) for Federal Government agencies initiated at the request of President Clinton. The NPR began in March 1993 under the leadership of Vice President Gore as a six-month review study to make government work better and cost less. On September 30, 1993, President Clinton issued an Executive Order on Regulatory Planning and Review that began "a program to reform and make more efficient the regulatory process." One of the objectives of the program is "to make the process more accessible and open to the public." The Order also includes a set of Principles of Regulation that all Federal Agencies are urged to follow and which contain many similarities to the NRC's own Principles of Good Regulation. As a result of the President's Executive Order, our plans to enhance public participation in the regulatory process by giving the public easy access to NRC information of interest to them have been reinforced.

We are now considering a pilot rulemaking project in which the public and other interested parties can directly participate in the development of a regulation by interacting with NRC personnel via an easily accessed computer network. The technical details are now still in the conceptual stage but information and computer technology currently exist to realize this idea. We are now in the process of installing software and hardware, setting up the necessary infrastructure, and exploring the legal implications of the proposed process.

- INPO and NEI

  I would like to end my discussion of examples of the use of our regulatory principles with a mention of the fruits of the process. As I said earlier, effective regulation should result in an environment that fosters self-assessment and a quest for excellence among those regulated. I believe that the United States' nuclear industry provides evidence of the existence of a safety culture that emphasizes self-assessment and strives for excellence. The primary mission of the Institute for Nuclear Power Operations (INPO) is to promote excellence in safety and reliability. There is a strong atmosphere of cooperation and exchange of information through INPO and through other industry associations, including the newly formed Nuclear Energy Institute (NEI). INPO has a very rigorous program of plant evaluations that has contributed to continuing improvements in plant performance as measured by various indicators. The industry is taking upon itself, in many cases, the improvement of safety without NRC prodding. There have been numerous times when plant changes were made as a result of vulnerabilities discovered during a probabilistic risk assessment conducted by the licensee.

<u>CONCLUSION</u>

The initiatives and actions I discussed today reflect a conviction that regulation in the United States must evolve in response to changing conditions. We, as regulators, have been subject to the criticism, whether earned or not, that nuclear regulation has been a major factor in the failure of nuclear power to achieve its full potential. I do not share this view. I believe that we have provided a major impetus to ensure that nuclear power is safe power. This is fundamental if nuclear power is to be a viable option. However, I do believe that there is room for improvement. The defacto moratorium on new plant construction in the United States has provided us the time for reflection and review, and the opportunity to search for a better way to regulate... a way that will ensure safety while not forcing nuclear power to be economically non-competitive... a way that will not stifle entrepreneurial spirit but will ensure that concerns of both the public and the industry will be fairly and honestly considered.

I have tried to describe what I believe are universal principles and the essential features of an effective regulatory process that may be a first step toward improved nuclear regulation. Effective regulation of the users of nuclear materials requires constant and faithful adherence to basic principles. Only then can the safety of nuclear energy be assured, to the satisfaction of the decision makers, the nuclear industry, and the public at large.

I am very pleased to have had this opportunity to be with you this morning and would be happy to respond to any comments or questions you may have.

Report of Minister V.N.Mikhailov, compiled for Japan Nuclear Industrial Forum, April 1994.

NUCLEAR DISARMAMENT AND PROSPECTS OF NUCLEAR ENERGY IN RUSSIA

Invention of each new source of energy always resulted in profound changes in society and led to new epoch of the mankind development, acquiring with the time its own history and inevitably struggling through a hard development.

Russian nuclear industry has its own history and its own current state. Moreover, my colleague and I are positive that it also has a prospect in the future - a broad and significant one. But to ensure that this future fits the past, a great effort is required from us and from all those who are interested in a stable, just and confident future of the planet.

It so happened that the nuclear science from the very moment of its entry in the broad arena has been primarily associated with nuclear weapons. But modern physics considers creation on the basis of science and technology progress as well as comprehension of whole Universe as its principal task. And that is why it is of synthesizing and unifying character. I hope that in the process of deliverance from out of date images and straight-vision the international community is going to realize with increasing distinctiveness these creative features of this science - science of development of nuclear energy and space, microelectronics and intellectual calculators, laser and radiation medical technologies, thermonuclear energy of fusion and technologies of 21 century.

In our country development of nuclear physics started in the pre-World War II years. The most meritorious impact was provided by the Leningrad Physics and Technical Institute, headed by Academician A.F.Ioffe. That was the Institute where Academicians I.V.Kurchatov, U.B.Khariton, N.N.Semenov and A.P.Aleksandrov started their careers. They were scientists - creators, who have contributed enormously into science development.

Students of A.F.Ioffe, as well as other prominent Russian scientists - I.E.Tamm, L.D.Landau, A.N.Tikhonov, E.I.Zababakhin, A.A.Samarsky, I.M.Gelfand, A.A.Bochvar, M.B.Keldish, G.N.Flerov, I.B.Zeldovich, D.A.Frank-Kamensky, I.K.Kikoin, L.A.Aptsimovich and a great number of others formed the framework of the collective, which resolved the problem of a nuclear bomb and peaceful use of nuclear energy.

First practical steps in this direction were taken back in 1943 when, following the report of German physicist K.Fuks, the Government instructed I.V.Kurchatov to take over the first nuclear scientific center - Academy of Science Laboratory of Measurement Equipment (LIPAN). In August 1945 First Main Division (FMD) of Council of Ministers of the USSR - an inter-ministerial body for coordination of works in nuclear sphere - was organized. And as early as in December 1946 the first European reactor with the controlled chain reaction of uranium nucleus fission was commissioned in what is now Russian Scientific Center "Kurchatov Institute".

The task was a complicated one for the country which has just lived through World War II - the most merciless out of all wars in the history: to concentrate development of fundamental science in such determinedly important sphere of science as physics and at the same time to reach vitally urgent goals of defense. This determined, on the one hand, secret character of the newly born branch, and, on the other hand, - its unique complexity.

Let me remind you the fact that during the years, preceding World War II and even during hard post-war period our country occupied leading science and technology positions in a number of areas of fundamental physics and mathematics. Traditional state policy of overall support of fundamental science provided positive results of establishment of first-class science and research institutes, such as Moscow Institute of Physics named after P.N.Lebedev, Leningrad Radium Institute, founded by famous scientist V.I.Vernandsky, Kharkov Physics and Technical Institute, Leningrad Chemical Institute, Moscow Institute of Theoretical and Experimental Physics. And a possibility to concentrate enormous material and human resources on key directions of science and technology development provided an opportunity to create new industry and to exercise a decisive breakthrough in science and technology progress.

The country proved to be capable of establishment in a limited period of time of a number new, highly complicated and qualified enterprises. Prominent managers and engineers V.A.Malyshev, A.P.Zaveniagin, B.L.Vannikov, P.M.Zernov, B.G.Muzrukov, E.P.Slavsky, N.L.Dukhov, K.I.Shelkin, V.I.Alferov and many others of our compatriots contributed great effort and a lot of skills in the development of the new branch. Today one comes to think, what made bright physicists, designers and managers work selflessnessly from early morning till late night. I believe, it was first of all devotion to Motherland, real patriotism and natural desire to demonstrate their knowledge and talent. It is this combination of state and personal interests that ensures encrease in real all-human values outside any dependence on epoch and geography.

On August 29, 1949 first Russian nuclear test explosion was carried out at the test site in the vicinity of Semipalatinsk and in early 1950s we have already developed thermonuclear weapons of our own ("hydrogen" bomb). Leading role in this work was played by the brilliant physicist A.D.Sakharov.

These successes were of exceptional importance for national security and global stability. But development of such a qualitatively new and potentially destructive method did not just announced a new stage of the humanity development. At the same time a number of new important problems of philosophical and ideological character emerged. The level of responsibility of politicians and people under their rule for the very global existence of life is becoming qualitatively different.

In our opinion it is important now not to lose what have already been reached. In the process of dismantlement of the Berlin Wall for souvenirs and creation of the Commonwealth of Independent States it is critical not to destroy the military-political and defence and technical balance, which served as a basis for confident construction of a rather stable building of the post-war world. The building that could withstand the thrust of Caribean Crisis and prevent a new world war. The Warsar military and political treaty disintegrated, but other treaties, including NATO, today tend to spread, "opposing" their right to determine fates of different regions to United Nations (UN). Today the new military and political map of the world of the XXI century is still under development; there is a clear desire of redistribution of spheres of strategic interests' influence and a natural desire of some countries and treaties to define fates of the humanity. Besides, peoples' tendencies to form independent democratic states on the basis of ethnic and national interests, joint national will and religion create preconditions for reconsideration of post-war boarders. It now depends on us what the future world would look like.

Today even conceptions of "Global state" and "Regional State" have become parts of the every-day vocabulary. No, people of our planet cannot be divided into global and regional people, and the reason for that - history of the civilization development.

I wrote about that before and now I would just repeat: nuclear weapons today represent first of all a vehicle to maintain global political, military and economic stability on Earth irrespectively of whether or not there is any controversy between the countries holding these weapons. The only alternative to the nuclear balance is the regime of comprehensive trust, complete transparency, regime of elimination of military and political treaties and comprehensive and complete ban on nuclear weapons and development thereof. But this is our final goal, to reach which we've got to undertake a lot of effort, keeping reasonable amounts of nuclear military and technical means of stability maintenance.

From the practical point of view it seems important to distinguish those types of nuclear weapons, which are most capable of provoking aggressiveness, a desire to use nuclear weapons in limited military conflicts or to deliver the first strike. It is necessary to select and to destroy first of all those excessive, politically out of date and provokingly dangerous types of nuclear weapons. But we are living in a complex and dynamic world and that is why it is important to keep , so to say, most "stable", easily controlled and predicted systems of strategic weapons.

Another fundamental characteristic of the leaving century is large-scale reduction of Russian and the U.S. nuclear arsenals. We can only welcome this process: it has long been evident for us, weapons' designers, that the amount of nuclear weapons is redundant. But we are to be realistic in our approach to pace and management of nuclear desarmament. Fuss and incompetence are capable of laying a trap here.

The problem of nuclear arsenals reduction acquired extreme international importance with the CIS creation, with introduction of three more "nuclear states".

Kazakhstan, Ukrain and Belarus found themselves in the most dramatic situation after the unprecedented since the Perestroika start-up anti-nuclear campaign in these republics, where strategic nuclear weapons, and in Kazakhstan and Ukrain - also nuclear power plants, are deployed. Economic and scientific potential of these countries of the Commonwealth does not enable them either to independently ensure safety or to carry out dismantlement of nuclear weapons, or to maintain safe operation of NPPs, which "now" turned out to be so important for economy stabilization.

Orientation to the West did not resolve any of these problems, as the cost of dismantlement of only one nuclear munition is about one hundred thousand dollars; and, besides, a sober-thinking politician would never allow foreign nuclear arsenals to be imported in the country and be dismantled there. As far as nuclear energy is concerned, NPP decommissioning expenditures total to many tens of billions dollars, let along their substitution by alternative sources of energy.

Russia, having inherited 80 per cent of industrial and 100 per cent of nuclear weapons complexes of the USSR Ministry for Medium Machine-Building, is capable of solving all these problems. Though that requires good will, real patriotism and understanding of common interests of the Commonwealth countries, tightly bound together in the history of the XX century by cultural, scientific and economic life tiers.

Today we are spending up to thousand billion rubles per annum for dismantlement of nuclear weapons. This is an extremely complicated and responsible technological process, especially in the circumstances of unstable political and economic state of the country. To encrease scale of nuclear weapons dismantlement in these conditions is a very important problem for Russia, requiring vast investment, and today, I'm stressing - today, there is no place for any talk about profit from dismantlement. As for the Agreement with the U.S. on weapons grade uranium utilization over the period of 20 years, it can only be considered as a partial compensation of nuclear arsenals dismantlement cost, we are incurring now, through utilization of fissile materials as nuclear fuel for NPPs. But Russia again addresses transitional period problems of the CIS countries with understanding.

This work employs the whole of the nuclear weapons complex of Minatom of the Russian Federation, that itself suffers through the most hard financial crisis.

At present more than 100 thousand people are working in the in the nuclear weapons complex of the country. The basis of the complex is in two largest national centers of nuclear weapons development: federal nuclear centers in Arzamas-16 and Cheliabinsk-70, on the bank of the Sinary Lake, Cheliabink region.

The oldest one is the All-Russian Scientific Research Institute of Experimental Physics in Arzamas-16. By the way, the location of the center - Sarovsky cloister, is known for its specific religious role: Saint Seraphim Sarovsky was living here in a large monastery of Sarovsky Desert between XVIII and XIX centuries. At the beginning of this century Russian tsar Nikolai the Second and his wife visited the place to pray for a heir. The fact that a year later the one was born added to the fame of Sarov.

Unfortunately, the time of miracles is gone: at present depreciation of the nuclear weapons complex fixed assets is more than 50 per cent. Even for non-experts it should be evident that profound modernization is required to meet needs, that include the needs of dismantlement and utilization of nuclear weapons, amount of which was hard to predict before Perestroika. In terms of comparison I would remind that similar complex of the U.S. DOE is supposed to be updated in the next 20-25 years to meet environmental and staff health requirements. Naturally, at the expense of the, first of all, state budget. This should serve us in Russia an example. But unfortunately, sometimes we have to deal with different approaches.

Unfortunately, mentioned problems of the nuclear weapons industry do not complete the list of complicated aspects of the situation. The whole of the country' nuclear complex is facing difficult situation. Is it normal or natural? I think, it is evident that there is a lack of logic and rationality in what is going on, when the most powerful potential often skids and works with far from high efficiency because of not only insufficient turnover and investment, but also due to attempts of hasty implementation of universal "market orientation" without having an appropriate legal system.

In the short period a unique branch of the most advanced scientific and technical knowledge was created. From scientist, to designer, engineer and worker - this is the unbreakable chain, that always served a guarantee of success, based on the common technological process and tens of thousands of developed branch standards, concentrating scientific knowledge, which keeps together the whole process of creativity. Among the reasons of the branch success are purpose-programming method of the scientific and technical progress planning, as well as selected-target method of management, natural monopoly of the majority of designs and enterprises, when competition is shifted to the level of enterprises within the complex. Therefor, is it possible to instantly cut off part of this complex, even construction companies, without losing them for the further development of the nuclear energy? A great time is needed to improve efficiency of work in the new economical situation, including also development of appropriate state legislation, sub-law legal acts and standards on reliable and safe operation of specific parts of the complex.

Many of the enterprises and technologies, vitally important for the society and state, are not capable of producing direct economical profit. But without them normal operation of other, quite profitable, part of economy would be impossible. Important role here is played by the process of establishment of financial-industrial groups with a system of licensing, that would embrace everybody from a director to a shopfloor worker, head of group and etc. To achieve this time and high competence throughout the whole of technological cycle is required. Mere desire to accomplish that overnight is clearly insufficient. In my opinion basis of successful transition to a new economy system lies in reasonable combination of vertical management and horizontal enterprises' links, developed on the basis of new legislation and the strategy "from the shopfloor - upwards". This is a way towards establishment of powerful market goods manufactures, operating on the principle of competition in the international market place, where monopolies are long gone.

Economy demands an evolutionary way of development, not a revolutionary one. We have struggled already along the path of revolution.

The first thing to be created in the country is a basement of market relationships, represented by the free market of goods and services manufactures to satisfy social and every-day necessities of our people. It is this free market, aimed at society, that is, in its tern, to determine and to create conditions for development of a market of high technologies and of science and technology progress.

There is an international market of this kind, but, since the days of Cold War, we have been facing a number of obstacles, which we are today to apply enormous effort to break though. Situation is less complicated with developing countries, striving for high technologies, but in this case "big policy" is activated...

A priority of economical merit should be clearly specified in the course of resolving political problems of strengthening safeguards of existing UN international organizations.

Today the whole economy is a hostage of banking and currency stock market systems. Currency stock market and bank market place is rapidly integrating under the authority of leading world banks into a world market, that takes in pledge what constitutes in reality natural treasure of our country. At the same time home manufacturer, bound with outstanding payments and debts, splintered into parts by the anti-monopoly campaign is standing "in the street with outstretched arm", looking for sponsors. State system of tax regulation and management should become such a sponsor.

As I have mentioned already, from the very beginning our principal distinctive features were secrecy and related to it complex and universal character of the branch. They are to be added with the high level of notorious budget dependence.

It had both positive and negative features. Secrecy is gradually going and we welcome this process. But we should not lose complex character, common purpose-driven management of the branch and a possibility of significant budget investments. Minatom of the Russian Federation is among those, who, from the system point of view, are quite independent. Today such structures should be elaborated instead of being banned, since they concentrate advanced knowledge and technologies and strongly facilitate scientific and technical progress in all areas of industry. Being obsessed with social and political troubles we miss the fact that we are surrounded by practical results of XX century physics science and technology achievements. What are we going to leave for our children and grand-children? If we do not preserve and encrease this potential, we would be "swallowed" by developing countries.

Officially our Ministry was organized in the year of 1953 as a Minister of Medium Machine-Building of the USSR. In 1989 it was transformed into Ministry for atomic energy and industry, and since 1992 it has been existing as a Ministry of the Russian Federation for Atomic Energy. Purpose-driven management inn the Ministry is carried out through operational units.

Under the Ministry there are dozens of big science and research and design institutes, hundreds of state-of-art mining, processing, machine-building and equipment producing enterprises, facilities of the nuclear energy complex, as well as well-equipped and well-staffed construction organizations.

Minatom of Russia is in charge of all NPPs in the territory of Russia, their designing, construction, and, following Chernobil accident, - operation.

The branch science represents in many aspects a basis for the state fundamental science. Besides, our scientific centers are characterized by diversified character. Profound research and applied works are carried out in the field of nucleus physics, physics of high energy and superconductivity, nuclear energy, thermonuclear fusion, electronics, equipment design and automatization, material study, advanced technologies and machine building.

Today the whole of this complex is in disastrous state: new developments collapse with crisis trends, successes of some enterprises - with failures of others. But this is not the theme I would like to discuss now. The only reason for my keeping going back to it is to address the issue of possibility and expediency of foreign investment in the country's nuclear branch. Mainly investment, coming from countries with already developed market of scientific and technological progress and advanced technologies.

My opinion is that, along with large internal state investment, our participation in the high technologies and scientific and technical progress market with application of the reasonable and mutually beneficial amount of foreign capital would be useful for each party. We have things to demonstrate, to sell and, of course, to buy. Sometimes it may be efficient to look for foreign sources of funding for some projects, developed in the Ministry institutes, followed by joint utilization of the final product. Today we are receiving about 80 million USD per annum in terms of additional funding of scientific and technological research. I'm still going to return to prospects and possible forms of cooperation, but now I would like to note: being upset over difficulties is a low-productive work. The best thing is to look into the future, without forgetting, however, to watch you fit.

And in the future we are merely doomed to develop joint large-scale and equal partnership with our neighbors on the Planet.

Global potential of the whole branch is reflected in the example of the oldest weapons center Arzamas-16 - Institute of Experimental Physics. Only several years ago the level of secrecy of this facility was so high, that even the name of the "nuclear" city was not printed in official maps. At the place of the city vast forests of Mordov reserve were depicted.

By now dozens of foreign delegations from the U.S., Great Britain, Germany, China, France, Norway, etc. have visited the Institute. Many experts, including those actively working in weapons development sector, leave for other countries to participate in symposia, conferences and negotiations. Agreements are concluded on joint development and research. In late January 1994 Arzamas-16 hosted third Russian-American simposia on hazardous goods, including radioactive materials, transportation safety. The first one was held in Cheliabinsk-70, second one - in Albuquerque, USA, in 1993. And this is only one example from the list of joint discussions of extremely sensitive problems.

Not long ago neither of the parties could have imagined that. It couldn't have been dreamt of even at the best of circumstances. But it turned out to be possible to find common language for specific talk even in such a vulnerable and peculiar area of national interests as nuclear weapons safety, let alone cooperation in the field of peaceful fundamental and applied science. Necessity of such cooperation for world science development has always been evident for our scientists. It was back in 1956 when we established Joint Institute of Nuclear Research in Dubna, a "path" towards peaceful use of nuclear energy. This institute was visited by the prominent Danish scientist N.Bor, American scientist G.Siborg, French physicist F.Jolio-Curi. Is that not an example of international acknowledgement of Russian science achievements?

International science and technology and business cooperation is a long known in our country sphere of human relations. But new wider and much more extensive than previously involvement of Minatom closed organizations and institutes creates, in my opinion, entirely quantitatively and qualitatively new situation.

The map of international technical progress used to lack entire "continents" of scientific and engineering knowledge, industrial achievements and vast opportunities. Only having removed from this map all the "white spots" we will acquire the right for full value integration in the international community.

Is there any other way? Any significant endeavor contains the natural potential of mutual attractiveness and is international by definition. This is extremely important in the conditions of large scale conversion.

Science and technology, as well as commercial cooperation with leading countries are vital for us. We see establishment of joint manufactures of scientific and technical and industrial products as a way to preserve our highly qualified experts and to encrease efficiency of work in the international market of high technologies. Opportunities for such cooperation are numerous:

- from a search for new principles, frameworks and element-database of highly efficient calculation systems to modelling of micro- and macro-environment;

- from joint use of unique systems, modelling gamma, neutron and laser emission to development of new physical, chemical and mechanical specifications of materials, that can be also applied for medical treatment;

- to fabrication of modern equipment, diagnostic and information devices, applying new technologies on the basis of super-powerful electro-magnetic fields and super-pure materials, energy of chemical explosives, super-high pressure and temperature.

In other words - on the basis of intellectual potential of the branch. And no price is to high for human intellect.

Today we are facing a very important problem of exclusive international importance. This is the problem of nuclear energy. Development of peaceful use of nuclear energy is one of the most important directions of our work.

This year we are celedrating 40th anniversary of the countries nuclear energy. On June 27, 1954 first nuclear power plant in the world was commissioned in the city of Obninsk, USSR. Therefor, we are going to celebrate also the anniversary of the world nuclear energy. The very word "atom" has become the symbol of "creation" for inhabitants of Obninsk. The city of peaceful nuclear energy is situated in the center of Russia at the place of former village Turliki, known since XVII century. It took less then 3 years to construct the first nuclear power plant in the world in the Institute of Physics and Engineering, which became the core around which the city of Obninsk was settled. The first NPP became also an experimental base for testing uranium-235 fuel assembles and new scientific and engineering designs for nuclear energy. Prominent scientists and managers of the Institute A.I.Leipunsky and D.I.Blokhintsev pioneered in development of fast reactors, where now our country is occupying leading positions.

At present 17 per cent of overall electricity in the world is generated by nuclear power plants, the total number of which is more than 400. In some of the industrially developed countries nuclear energy share is from 50 to 80 per cent. In our country this share is 12 per cent, and in the European part of Russia - about 30 per cent. Today a nuclear reactor is not only a source of heat and electricity, but also a tool of nuclear and thermonuclear fuel reproduction, synthesis of artificial materials, materials' properties tailoring, fabrication of medical radioactive isotopes. All this determines the future of electronics, medicine, metal treatment and other areas - in other words, determines science and technology progress.

The 40 years of development were not associated only with successes. Chernobyl accident and the following crisis seriously challenged many of our contemporaries and the very idea of nuclear energy utilization to produce electricity. Those supporting the idea of ban on nuclear energy became very active and again, as it already happened in previous centuries, there is a number of prosecutors of new science of the XX century. But today's inquisition is not after the property of a prosecuted individual, but after enormous scientific and technical treasures of the whole country.

Research, carried out in Russia and abroad demonstrate limited opportunity of utilization of alternative energy sources without destroying heat and water balance of the planet in certain areas. Besides, we should keep in mind concern over the "green house" phenomenon and deterioration of ozone stratum through release into atmosphere of mineral fuels burning products. Let alone consumption of oxygen - the source of life in the planet. That means that the mankind cannot do without nuclear energy resources. The only aspects for discussions are scale, pace and profitability of implementation, linked with measures of safety of nuclear energy, nuclear wastes utilization and measures of preservation of natural radiation background, which defines life development in our world.

It should be mentioned that each source of energy is associated with a certain risk, has its advantages and disadvantages.

Development of designs for the new generation of heating and electricity producing nuclear reactors is based on the principle of enherent safety, precluding a possibility of uncontrolled reactor runaway, principle of closed fuel cycle with the safe system of wastes utilization, including reactors on fast and slow neutrons, on MOX fuel and uranium-thorium cycle.

Today we consider an opportunity to raise additional funds for investment in this branch by extending export of nuclear equipment and fuel for NPPs, utilization of weapon grade uranium and plutonium, export of rare-earth elements, export of high-calorie fertilizers we produce, medical isotopes, machine- and equipment- building products, etc. The final purpose of this work is to encourage search for ways to resolve problems of safety and reliability of nuclear technologies. In the next year our export is to encrease to 1 billion dollars.

Our state-of-art technologies already enable us to create high added value to the our export uranium products. But my opinion is that export of electricity generated by NPPs is potentially more profitable, especially when based on construction of modern nuclear power plants. Besides, our technologies of underground leaching and drilling for extraction of precious metals and gems have just started penetrating into the world market and are very potential in the international market place.

It is evident that close international cooperation, including world market, and mutual support of national programs are needed to make use of economical and environmental advantages of nuclear energy. In my opinion this area of joint scientific and commercial cooperation has no limits.

By today designs have been developed for NPPs of high and low Capacity with enherent safety and principle of localization of fission products inside the reactor unit. These projects have successfully passed most thorough international examinations. Our next step is development of so-called hybrid NPPs with external source of penetrating particles initiating fission process combined with the chain reaction of fission of sub-critical mass of fissile materials. These are reactors which preclude a possibility of spontaneous chain reaction of fission. And our long-term plans are to master the energy of light nucleus fusion.

Implementation of the nuclear energy development programs in Russia is directly linked with stabilization of economy. At the same time stability of the nuclear energy complex is one of the significant parts of overall economical stabilization.

Nuclear energy of the XXI century is to be built on the basis of joint efforts of leading states with keeping in mind interests of developing countries throughout the world. To cut the cost of construction of NPPs and nuclear district heating plants nuclear industry is to develop standard units of reactor systems of the next century on the basis of modulus units plant assembling. Today we are ready to start such international projects. And we expect steps from partners.

We have heard a lot about economical "miracle" of Japan, France, Germany and South Korea during the post-war period. The key reason of it was industrial adaptation of nuclear energy and intensive construction of nuclear power plants on the basis of broad cooperation.

The great treasure of our green planet - organic fuels - should not be burned up in furnaces, but be preserved for generations to come for more reasonable and expedient utilization. And we should do our best to ensure that satisfaction of energy demand of the current generation will not undermine opportunities for coming generations development.

And for future generations development of nuclear energy in all countries as a basis for science and technical progress will lead our planet towards the new understanding of peaceful cooperation, towards the world without local conflicts.

Nuclear energy branch of the Russian state was born and developed under hard and dramatic historical conditions. But even a brief list of its achievements is extremely impressing: nuclear and thermo-nuclear weapons, nuclear energy, most powerful accelerators of elementary particles, space and naval energy systems, nuclear ice-breaking fleet, metallurgy and production of precious and rare-earth metals, super-pure materials and alloys, etc. Without these achievements there would have been no impressing successes in technology, nor the whole industrial potential of the leading countries of the world.

But the most precious thing, created during the almost half a century of work, is, first of all, reliably ensured national sovereignty and related to it global stability, and, secondly, the very nuclear industry of ours, our people, without whom neither a scientific breakthrough, nor any achievements would have been tangible.

This treasure, as well as any other treasure obtained by the humanity in its global movement ahead, belongs not only to Russian people, but to the whole world. This is one of the all-human treasures, that, being in the disposal of specific peoples, at the same tine belongs to the whole mankind in its development towards the prosperous world.

Today we are overcoming difficulties and are looking into the coming day with the hope for encreasing understanding of mutual merits and extending of mutually beneficial and equal cooperation.

Minister of the Russian Federation for atomic energy

V.N.Mikhailov

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ЯДЕРНОЕ РАЗОРУЖЕНИЕ И ПЕРСПЕКТИВЫ АТОМНОЙ ЭНЕРГЕТИКИ РОССИИ

Каждый новый вид источника энергии неизменно приводил к крупным изменениям в обществе, к новой эпохе развития общества, приобретая со временем свою историю, неизбежно проходя сложный путь своего развития.

У отечественной Атомной промышленности - своя история и настоящее . Я и мои коллеги уверены, что есть у нее и будущее - масштабное и значительное. Однако для того, чтобы это будущее было достойно прошлого, надо немало потрудиться и нам, и всем тем, кто заинтересован в стабильном, справедливом и уверенном будущем всей планеты.

История распорядилась так, что ядерная наука с самого начала своего выхода на широкую арену связывалась прежде всего с атомным оружием. Однако современная физика своей магистральной задачей видит созидание на пути научно-технического прогресса и понимание целостной картины мироздания. И уже поэтому она носит характер синтетический, объединяющий. Надеюсь, что по мере избавления от старых догм и зашоренности, мировое сообщество все более отчетливо будет осознавать именно эти, созидательные успехи этой науки, науки освоения ядерной энергии и космического пространства, микроэлектроники и интеллектуальных вычислителей, лазерной техники и радиационной медицины, термоядерной энергии синтеза ядер и технологий двадцать первого века.

У нас в стране ядерная физика зарождалась в довоенные годы. И особенно велики тут заслуги Ленинградского физико-технического института во главе с академиком А.Ф.Иоффе. В Физтехе начинали академики И.В.Курчатов, Ю.Б.Харитон, Н.Н.Семенов, А.П.Александров. Это были ученые-созидатели, внесшие неоценимый вклад в прогресс науки.

Ученики Абрама Федоровича Иоффе, а также другие крупнейшие отечественные ученые - И.Е.Тамм, Л.Д.Ландау, А.Н.Тихонов, Е.И.Забабахин, А.А.Самарский, И.М.Гельфанд, А.А.Бочвар, М.В.Келдыш, Г.Н.Флеров, Я.Б.Зельдович, Д.А.Франк-Каменецкий, И.К.Кикоин, Л.А.Арцимович, да разве всех перечислишь, и составили костяк того коллектива, который решал проблему атомной бомбы и мирного использования атомной энергии.

Первые практические шаги в этом направлении были сделаны еще в 1943 году, когда после информации немецкого физика К.Фукса правительство поручило Игорю Васильевичу Курчатову возглавить первый атомный научный центр -Лабораторию измерительных приборов Академии наук (ЛИПАН). В августе 1945 года был образован межведомственный орган по координации атомных работ - Первое главное управление (ПГУ) при Совете Министров

СССР. Уже в декабре 1946 года в Москве, в нынешнем Российском научном центре "Курчатовский институт", был пущен первый на Европейском континенте реактор с управляемой цепной реакцией деления ядер урана.

Задача была не из легких для страны, которая пережила самую жестокую за свою историю Вторую мировую войну: концентрировать развитие фундаментальной науки в такой, определяюще важной для технического прогресса, области как физика, и параллельно решать жизненно насущные задачи оборонного характера. Это обусловило с одной стороны закрытость новой, только еще создаваемой отрасли, а с другой - придало ей уникальную комплексность.

Напомню, что в довоенные годы и даже в трудное послевоенное время наша страна занимала передовые научно-технические позиции в мире по ряду областей фундаментальной физики и математики. Дала положительные результаты традиционная политика государства по всемерной поддержке фундаментальных наук, благодаря которой были созданы первоклассные научно-исследовательские институты, такие как Физический институт имени П.Н.Лебедева в Москве, Радиевый институт в Ленинграде, основателем которого был знаменитый ученый В.И.Вернадский, Харьковский физико-ехнический институт, Химический институт в Ленинграде, Институт теоретической и экспериментальной физики в Москве. А способность сосредотачивать огромные материальные и человеческие ресурсы на главных направлениях развития науки и техники позволила создать новую индустрию и сделать решительный рывок в научно-техническом прогрессе.

Страна оказалась способной в кратчайший срок обрести ряд новых, чрезвычайно сложных и квалифицированных производств. Выдающиеся организаторы и инженеры В.А.Малышев, А.П.Завенягин, Б.Л.Ванников, П.М.Зернов, Б.Г.Музруков, Е.П.Славский, Н.Л.Духов, К.И.Щелкин, В.И.Алферов и многие другие выдающиеся наши соотечественники вложили в дело становления новой отрасли много сил и умения. Сегодня задумываешься: что заставляло замечательных физиков, конструкторов и организаторов самоотверженно трудиться с раннего утра до поздней ночи? Я думаю, прежде всего любовь к Родине, истинный патриотизм и естественное желание проявить свой ум и талант. Именно такое сочетание государственных и личных интересов обуславливает приумножение настоящих общечеловеческих ценностей вне зависимости от эпохи и географии.

29 августа 1949 года на полигоне под Семипалатинском был проведен первый советский испытательный ядерный взрыв, а уже в начале 50-х годов - создано термоядерное оружие ("водородная" бомба). Ведущая роль принадлежала здесь замечательному физику Андрею Дмитриевичу Сахарову.

Эти успехи имели исключительное значение для обеспечения национальной безопасности и глобальной стабильности. Однако создание такого качественно нового потенциально разрушительного средства не просто знаменовало собой новый этап в развитии человечества. Одновременно возник ряд новых важных философских и мировоззренческих проблем. Качественно иным становился и уровень ответственности политиков и руководимых ими народов за само глобальное существование жизни!

На наш взгляд, сегодня важно не утратить уже достигнутое. Разбирая на сувениры Берлинскую стену, создавая Содружество Независимых Государств важно не разрушить тот военно-политический и оборонно-технический баланс, на котором уверенно выстраивалось весьма прочное здание послевоенного мира. То здание, которое могло выдержать потрясения Карибского кризиса и недопустить развязывание новой мировой войны. Варшавский военно-политический союз распался, однако другие союзы, в том числе НАТО, сегодня имеют тенденцию к расширению, "противопоставляя" Организации Объединенных Наций (ООН) свое право решать судьбы отдельных регионов. Сегодня только формируется новая военно-политическая карта мира XXI века, налицо стремление пересмотра сфер влияния стратегических интересов и естественное стремление некоторых стран и блоков определять судьбы всего человечества. Да и тенденции народов к формированию самостоятельных демократических государств на основе этнических и национальных интересов, общей национальной воли и религии создают предпосылки к пересмотру послевоенных границ. Какой будет будущий век зависит от нас с вами.

Сегодня пущены в обиход даже термины "Глобальная страна" и Региональная страна". Нет, народы нашей планеты нельзя будет разделить на глобальных и региональных людей, а основа тому - история развития цивилизации.

Мне уже приходилось писать об этом, и сейчас я лишь повторю: Атомное оружие сегодня - прежде всего средство поддержания глобальной политической, военной и экономической стабильности на Земле вне зависимости от того, противостоят ли в какой-либо области страны, им обладающие. Единственная альтернатива ядерному равновесию - это режим полного доверия, полной открытости, режим ликвидации военно-политических блоков и всеобщего и полного запрещения ядерного оружия и его разработок. Но это - конечная наша цель, на пути к которой надо еще многое сделать, сохраняя разумные количества ядерных военно-технических средств обеспечения стабильности.

Думаю, в практическом отношении важно выделять те виды ядерного оружия, которые в наибольшей степени способны провоцировать агрессивность, желание использовать ядерное оружие в ограниченных военных конфликтах или применить его первым. Выделять и избавляться прежде всего от этих избыточных, политически устаревших и провокационно-опасных видов ядерных вооружений. Однако мы живем в сложном и динамичном мире и поэтому важно сохранить наиболее "устойчивые", так сказать, наиболее легко контролируемые и прогнозируемые системы стратегических вооружений.

Еще одной фундаментальной особенностью уходящего столетия становится крупномасштабное сокращение ядерных арсеналов России и США. Такой процесс можно лишь приветствовать: избыточность количества ядерного оружия нам, вооруженцам, была видна уже давно. Но надо трезво и реально подходить к темпам и организации ядерного разоружения. Поспешность и некомплексность способны сослужить здесь недобрую службу.

Проблема сокращения ядерных арсеналов приняла исключительно важное международное значение с созданием СНГ, с выходом на сцену еще трех "ядерных держав".

В наиболее драматическом положении оказались Казахстан, Украина и Беларусь после беспрецендентной с начала перестройки антиядерной компании в этих республиках, на территории которых находятся стратегические ядерные вооружения, а в Казахстане и на Украине - и атомные станции. Промышленный и научный потенциал этих стран Содружества не позволяет им самостоятельно ни обеспечить безопасность, ни проводить демонтаж ядерного оружия, а также поддерживать безопасную работу АЭС, как "теперь" оказалось, так необходимых для стабилизации экономики.

Взгляд на Запад не решил ни одну из этих проблем, так как демонтаж только одного ядерного боеприпаса стоит около сотни тысяч долларов, да и любой здравомыслящий политик не позволит завозить в страну и разбирать чужие ядерные арсеналы. Что касается атомной энергетики, то и здесь затраты исчисляются многими десятками миллиардов долларов на вывод АЭС из эксплуатации, не говоря уже о замене их на альтернативные источники энергии.

Россия, которая унаследовала от союзного Министерства среднего машиностроения около 80 процентов промышленного и полностью ядерно-оружейный комплексы, способна решить все эти проблемы, но для этого необходима добрая воля и истинный патриотизм и взаимопонимание общих интересов стран Содружества, которых сама история XX века тесно переплела нитями культурного, научного и экономического бытия.

Сегодня мы тратим на демонтаж ядерного оружия до тысячи миллиардов рублей в год. Это очень сложный и чрезвычайно ответственный технологический процесс, особенно в условиях нестабильного политического и экономического организма государства. Развивать масштабы демонтажа ядерного оружия в этих условиях чрезвычайно ответственная проблема для России,связанная с крупными инвестициями, и сегодня, подчеркиваю сегодня, ни о каком "наваре" от демонтажа здесь говорить неуместно. Что касается соглашения с США по утилизации оружейного урана в течение двадцати лет, то речь идет о частичной компенсации затрат на демонтаж ядерных арсеналов, которые мы уже сегодня несем, за счет использования этих делящихся материалов в качестве топлива для АЭС. Но и здесь Россия с пониманием относится к трудностям переходного периода в странах СНГ.

Эта работа всего ядерно-оружейного комплекса Минатома России, который сам переживает наиболее трудный финансовый кризис.

В настоящее время в ядерно-оружейном комплексе страны трудится более 100 тысяч человек. Основа его - два крупнейших национальных центра ядерного оружия: Федеральные ядерные центры в городе Арзамас-16 и в Челябинской области, на берегу озера Синары,- Челябинск-70..

Старейший из них - Всероссийский научно-исследовательский институт экспериментальной физики в Арзамасе-16. К слову, это место - Саровская обитель, известно и своим особым религиозным значением: в существовавшем здесь крупном мужском монастыре Саровской пустыни на рубеже XVIII и XIX столетий жил святой Серафим Саровский. В начале нашего века сюда приезжал император Николай Второй с женой молиться о даровании наследника. Появление последнего год спустя еще более увеличило популярность Сарова.

Увы, время чудес не возвращается: сегодня износ основных фондов оружейного комплекса составляет более 50 процентов. Даже неспециалистам должно быть ясно: требуется крупная модернизация, в том числе для демонтажа и утилизации ядерного оружия, масштабы которых до перестройки трудно было предвидеть. Для сравнения напомню, что аналогичный комплекс Министерства энергетики США предполагается обновить в ближайшие 20-25 лет с учетом современных требований по охране здоровья персонала и охране окружающей среды. Естественно, прежде всего за счет бюджетных средств государства. И это должно бы стать примером для подражания и у нас, в России. Но порой, увы, приходится иметь дело с другими подходами.

К сожалению, упомянутыми проблемами ядерно-оружейной индустрии не исчерпываются сложные стороны ситуации. В непростом положении сейчас оказался весь отечественный ядерный комплекс. Насколько естественен подобный поворот событий? Думаю, что налицо нелогичность и нерациональность происходящего, когда мощнейший потенциал нередко пробуксовывает и работает с далеко не полной отдачей по причине не только недостаточных оборотных средств и инвестиций, но и попыток поспешного внедрения тотальной "рыночности" без соответствующей правовой основы.

В короткие сроки была создана уникальная отрасль самой передовой научно-технической мысли. Ученый, конструктор, технолог и рабочий - это неразрывная цепь всегда была залогом успеха, базой которого являются единый технологический процесс и десятки тысяч разработанных отраслевых стандартов, где как в фокусе сконцентрирован научный багаж, цементирующий весь процесс творчества и созидания. Программно-целевой метод планирования научно-технического развития и целевой метод управления, естественная монополия большинства разработок и производств, когда конкуренция переносится на уровень предприятий внутри комплекса - вот основы успеха отрасли. Как же можно в одночасье оторвать часть этого комплекса, даже строительно-монтажные организации, без потери их для дальнейшего развития атомной индустрии? Для повышения эффективности работы в новых экономических условиях необходимо немалое время, в том числе для создания соответствующих государственных законов, подзаконных актов и стандартов по надежному и безопасному функционированию отдельных частей комплекса.

Многие, совершенно необходимые обществу и государству предприятия и технологии не в состоянии приносить прямой коммерческий эффект. Однако без них невозможна нормальная работа других, вполне рентабельных народнохозяйственных структур. Важное значение здесь имеет работа по созданию крупных финансово-промышленных групп с системой лицензирования от директора до мастера цеха, руководителя смены и так далее. Для этого требуется время и высокая компетентность во всем технологическом цикле, а, к сожалению, одного желания сделать это "на утро" недостаточно. Разумное сочетание вертикального управления с горизонтальными связями предприятий на основе новой законодательной базы и по стратегии "снизу - вверх" - вот на мой взгляд основа успеха перехода к новой экономической системе, к созданию крупных рыночных структур производителей товаров на основе конкуренции на мировом рынке, где уже давно нет монопольных производителей.

Экономика требует эволюционного пути развития, а не революционного. Революционный путь мы уже проходили.

В стране в первую очередь должен быть создан базис рыночных отношений - свободный рынок производителей товаров и услуг для обслуживания социально-бытовых условий жизни нашего народа. И уже этот социально-направленный свободный рынок должен определять и создавать условия для развития рынка высоких технологий, для рынка научно-технического прогресса.

Этот мировой рынок существует, однако еще со времен "холодной" войны для нас действуют такие "завалы", через которые мы сегодня с трудом пробиваемся. Проще в этом вопросе с развивающимися странами, которые тянутся к высоким технологиям, но тут выступает на сцене "большая политика"...

И здесь надо четко определить приоритет экономической выгоды, решая политические проблемы в рамках укрепления гарантий существующих международных организаций ООН.

Сегодня вся промышленность стала заложницей банковской и валютно-биржевой системы. Валютно-биржевой и банковский рынок быстро интегрируется в мировой рынок под эгидой ведущих банков мира, используя под залог по существу природные богатства нашей страны. А отечественный производитель, опутанный неплатежами и долгами, раздробленный на куски антимонопольной компанией стоит с "протянутой рукой", ищет спонсоров. Государственная система управления и регулирования налогов должна быть "спонсором" наших производителей.

Как уже было сказано, с самого начала нас отличали: закрытость и связанная с ней комплексность, универсальность отрасли. К этому надо прибавить высокий уровень все той же "бюджетности".

Тут были и сильные моменты, и слабые. Ныне закрытость уходит, и это мы приветствуем. Однако нельзя утрачивать комплексность, единое целевое управление отраслью и возможность крупных бюджетных инвестиций. Минатом России относится к тому типу структур, которые в системном отношении вполне самостоятельны. Такие структуры сегодня надо не изживать, а совершенствовать, так как они, будучи носителями передовой мысли и технологии, оказывают высокое стимулирующее воздействие на научно-технический прогресс во всех областях промышленности. В трудностях социального и политического бытия мы просто не замечаем, что окружают нас практические результаты именно научно-технических достижений физики XX столетия. А что мы оставим своим детям и внукам после себя, да нас просто "проглотят" развивающиеся страны, если не сохраним и не приумножим этот потенциал.

Официально наше министерство было создано в 1953 году как Министерство среднего машиностроения СССР (Минсредмаш). В 1989 году оно было преобразовано в Министерство атомной энергетики и промышленности, а с 1992 года существует как Министерство Российской Федерации по атомной энергии, где целевое управление отраслью осуществляется через функциональные блоки.

В состав Министерства входят десятки крупных научно-исследовательских и проектных институтов, сотни современных добывающих, перерабатывающих, машиностроительных и приборостроительных предприятий, предприятий атомно-энергетического комплекса, а также хорошо оснащенных технически и укомплектованных опытными работниками строительно-монтажных организаций.

В ведении Минатома России находятся все атомные станции на территории России, их проектирование, строительство, а после событий в Чернобыле - и эксплуатация.

Отраслевая наука - это, во многом, основа и фундаментальной отечественной науки. Причем для наших научных центров характерна многопрофильность. В них ведутся широкие исследования и прикладные работы в области физики ядра, физики высоких энергий и сверхпроводимости, атомной энергетики, термоядерного синтеза, электроники, приборостроения и автоматизации, материаловедения, прогрессивных технологий и машиностроения.

Сегодня весь этот комплекс - в сложном положении: новые разработки переплетаются с кризисными тенденциями, успехи одних предприятий - с бедственным положением других. Но не об этом хотелось бы сейчас говорить. И если я возвращаюсь к этой теме, то лишь для того, чтобы немного поразмышлять о возможности и целесообразности иностранных инвестиций в отечественную атомную отрасль. Инвестиции от тех стран, где уже давно сформировался рынок научно-технического прогресса и передовых технологий.

Думаю что наряду с крупными внутренними государственными вложениями, наше участие на рынке высоких технологий и научно-технического прогресса с привлечением в разумных и взаимовыгодных объемах иностранного капитала было бы полезно всем сторонам. У нас есть что и показать, и продать, и... И, естественно, купить. Иногда может быть эффективным внешнее финансирование каких-то разработок, проводимых на предприятиях и в научно-исследовательских институтах Министерства, а затем используемых уже совместно. Для нас сегодня это уже дает ежегодно около 80 миллионов долларов дополнительного финансирования научных и технологических разработок. К перспективам и возможным направлениям сотрудничества я еще возвращусь, а пока замечу: вздыхать по поводу трудностей - малопродуктивное занятие. Лучше смотреть в будущее, не забывая, конечно, поглядывать и под ноги.

А в будущем мы просто-таки обречены на совместную масштабную и равноправную работу с партнерами по жизни на планете.

Глобальный потенциал нашей отрасли как в капле воды зримо отражается на примере старейшего вооруженческого центра в Арзамасе-16 - ВНИИЭФ. Еще несколько лет назад этот "объект" был засекречен настолько, что на официальных картах не существовало самого названия "атомного" города. Вместо него зеленели леса Мордовского заповедника.

А сегодня во ВНИИЭФ побывали десятки иностранных делегаций из Соединенных Штатов, Англии, Германии, Китая, Франции, Норвегии и других стран. Многие специалисты, в том числе и активно работающие вооруженцы, выезжают в эти и другие страны на симпозиумы, конференции, переговоры. Заключаются договоры о совместных разработках и исследованиях. В Арзамасе-16 в конце января 1994 года состоялся уже третий российско-американский симпозиум по вопросам безопасности транспортировки опасных грузов, в том числе и содержащих радиоактивные материалы. Первый был проведен в Челябинске-70, а второй - в США, в Альбукерке в 1993 году. И это - далеко не единственный пример совместного обсуждения очень деликатных проблем.

Недавно о подобном нельзя было и помыслить как одной, так и другой стороне! Даже в самом фантастическом сне такое не могло присниться! Но оказывается, что вполне возможно находить общую почву для предметного разговора даже в такой тонкой, чувствительной сфере национальных интересов, как безопасность ядерных вооружений. Что уж тогда говорить о сотрудничестве в области мирной фундаментальной и прикладной науки? Необходимость такого сотрудничества в развитии мировой науки была всегда очевидной для наших ученых. Еще в 1956 году нами был создан Объединенный институт ядерных исследований в г.Дубне, это "окно" для мирного использования атомной энергии. В свое время этот институт посетили выдающийся датский ученый Нильс Бор, американский ученый Г. Сиборг, французский физик Ф.Жолио-Кюри. Это ли не пример международного признания успехов отечественной физики.

Международное научно-техническое и деловое сотрудничество - область человеческих отношений, давно освоенная нашей державой, однако новое, намного более широкое и значительное чем раннее, подключение к нему закрытых организаций и институтов Минатома России создает, на мой взгляд, совершенно новую и количественную и качественную ситуацию.

На карте мирового технического прогресса отсутствовали целые "материки" научной и инженерной мысли, промышленных достижений и больших возможностей. И только полностью убрав с этой карты все "белые пятна", мы обретем право на полноценную интеграцию в мировое сообщество.

И может ли быть иначе? Ведь любое крупное дело несет в себе естественный потенциал взаимного тяготения и по самой своей сути интернационально. В условиях масштабной конверсии ядерно-оружейного комплекса - это особенно важно.

мира здесь просто необходимы. Создание совместных компаний производителей научно-технической и промышленной продукции для нас основа сохранения высококвалифицированных кадров, основа перехода к более производительному труду на мировом рынке высоких технологий, А простор такого сотрудничества очень широк:

от поиска новых принципов, архитектур и новой элементно-информационной базы высокопроизводительных вычислительных систем для моделирования микро- и макромира,

от совместного использования уникальных систем, моделирующих гамма, нейтронное и лазерное излучения, для придания новых физико-химических и механических свойств материалам и веществам и для медицинских целей;

до выпуска современной техники, диагностических приборов и информационных систем с использованием новых технологий на базе сверхсильных электромагнитных полей и сверхчистых материалов, на базе широкого использования энергии химических взрывчатых веществ, сверхвысоких давлений и температур.

Одним словом на базе интеллектуального потенциала отрасли. А мозг человека не имеет цены!

Уже сегодня есть одна важная проблема, имеющая исключительно большое международное значение, на которой мне хотелось бы кратко остановиться - это ядерная энергетика. Освоение ядерной энергии для мирного созидания - одно из важнейших направлений нашей работы.

В этом году отечественная ядерная энергетика отмечает свой сорокалетний юбилей. В 1954 году 27 июня в Советском Союзе, в городе Обнинске под Москвой, была пущена первая атомная электрическая станция в мире, так что мы отмечаем одновременно юбилей и мировой ядерной энергетики. Слово "атом" в Обнинске стало символом созидания. Город мирного атома, колыбель атомной энергетики - в центре Руси на месте бывшего села Турлики, известного с XVII века. Менее чем за три года в Физико-энергетическом институте, вокруг клоторого вырос город Обнинск, была построена первая в мире атомная станция. Первая АЭС стала и экспериментальной базой по испытанию тепловыделяющих сборок с ураном-235, и новых научных и инженерных решений в атомной энергетике. По инициативе прекрасных ученых и руководителей этого института А.И.Лейпунского и Д.И.Блохинцева были начаты работы по атомным реакторам на быстрых нейтронах, где наша страна занимает ведущие позиции.

Сегодня уже 17 процентов всей электроэнергии мира вырабатывается на атомных станциях, которых в мире более четырехсот. В некоторых развитых странах доля АЭС в производстве электроэнергии составляет 50-80 процентов. В нашей стране эта доля 12 процентов, а по Европейской части России- уже около 30 процентов. Сегодня атомный реактор это источник не только тепла и электричества, но и возможность воспроизводства ядерного и термоядерного топлива, синтеза искусственных элементов, модификации вещества для придания ему необходимых качеств, наработки радиоактивных изотопов для медицины. А это все определяет перспективу электроники, медицины, металлообработки и многое другое - одним словом определяет научно-технический прогресс.

Эти сорок лет принесли нам не одни только успехи. Чернобыльская катастрофа и последующий кризис стали серьезнейшим испытанием для многих наших современников да и самой идеи использования ядерной энергии в энергетических целях. Активизировались сторонники запрета атомной энергетики и, как уже было в подобных переходных исторических эпохах, находятся инквизиторы новой науки и в XX веке. Но сегодня не конфискация имущества отдельного обвиняемого стала стимулом инквизиции, а огромные научно-технические богатства целой страны - России.

Исследования в России и за рубежом показывают, что использование разного рода альтернативных источников энергии будет возможно лишь в ограниченном объеме (не нарушая теплового и водного баланса нашей планеты на отдельных ограниченных территориях). К тому же надо добавить опасения относительно парникового эффекта и разрушения озонного слоя под влиянием выбросов в атмосферу продуктов сгорания минерального топлива. А съедание при этом кислорода!-этого источника жизни на нашей планете. А это означает, что без ядерных энергетических ресурсов человечеству не обойтись. Речь может идти только о масштабах, темпах и рентабельности, в сочетании с мерами безопасности атомной энергетики, с мерами по безопасной утилизации отходов атомных станций, и с мерами по сохранению естественного радиационного фона на нашей планете, который и определяет развитие флоры и фауны нашего мира.

Следует отметить, что каждый источник энергии связан с определенными рисками, имеет свои преимущества и недостатки.

Разработка проектов нового поколения атомных энергетических и тепловых станций основывается на естественной их безопасности, исключающей неуправляемую цепную реакцию деления ядер, на замкнутом топливном цикле с безопасной системой обезвреживания отходов, в том числе реакторы на медленных и быстрых нейтронах и с использованием МОХ топлива и уран-ториевого цикла.

Сегодня мы рассматриваем как дополнительный источник инвестиций в эту область расширение экспорта атомного оборудования и топлива для АЭС, в том числе от утилизации оружейного урана и плутония, в том числе от экспорта редкоземельных элементов, от экспорта производимых нами высококалорийных удобрений, медицинских изотопов, машиностроительной и приборостроительной продукции, и все это для стимулирования поиска решений проблем безопасности и надежности ядерных технологий. В новом году наш экспорт должен увеличиться до 1 миллиарда долларов.

В экспортной урановой продукции сегодня мы уже имеем высокую добавленную стоимость за счет своих современных технологий. Но думаю, что переход на экспорт электрической энергии от АЭС таит в себе еще большие потенциальные возможности, особенно на базе строительства современных атомных станций. А наши технологии подземного выщелачивания и выбуривания по добыче драгоценных металлов и камней, которые только пробиваются на мировую арену, имеют большие перспективы на мировом рынке.

Со всей определенностью можно сказать, что для использования экономических и экологических преимуществ ядерной энергии требуется тесное международное сотрудничество, включая мировой рынок, и взаимная поддержка национальных программ. На мой взгляд эта область совместного научного и коммерческого сотрудничества не имеет пределов.

Сегодня разработаны проекты атомных станций большой и малой мощности, обладающие естественной безопасностью с локализацией продуктов деления внутри реакторного блока. Эти проекты успешно прошли самые придирчивые международные экспертизы. В перспективе у нас - разработки, так называемых гибридных атомных станций, где внешний источник проникающих частиц инициирует деление ядер и сочетается с цепной реакцией деления подкритических масс делящихся материалов, когда в принципе исключается самопроизвольная цепная реакция деления ядер. А в дальней перспективе - это энергия термо-ядерного синтеза легких ядер.

Реализация программы развития ядерной энергетики в России непосредственно связана со стабилизацией экономики страны. В то же время стабильность атомно-энергетического комплекса является важной составной частью экономической стабилизации.

Атомная энергетика XXI века должна строиться на комплексировании усилий передовых государств с учетом интересов всех развивающихся стран нашего мира. Чтобы уменьшить издержки по созданию и строительству АЭС и АСТ (атомных станций теплоснабжения) ядерная индустрия должна разработать стандартные конструкции реакторных систем будущего века на основе блочно-модульного принципа их построения. Сегодня мы готовы приступить к таким совместным международным проектам. И ждем ответных встречных шагов.

Мы много знаем о экономическом "чуде" Японии, Франции, Германии и Южной Кореи после второй мировой войны. А все дело в промышленном освоении этими странами атомной энергии, в бурном строительстве атомных электрических станций на основе широкой кооперации.

Великий дар нашей зеленой планеты - органическое топливо необходимо не сжигать в топках печей, а сохранить нашим потомкам для более рационального и разумного использования. И все зделать для того, чтобы удовлетворение энергетических потребностей нынешнего поколения не нанесло ущерба возможностям развития будущих поколений.

А для будущих поколений развитие атомной энергетики во всех странах, как основа научно-технического прогресса, ведет нашу планету к новому пониманию мирного сотрудничества, к миру без локальных конфликтов.

Атомная отрасль Российского государства возникала и развивалась в нелегких и драматических исторических условиях. Но даже самое краткое перечисление лишь некоторых ее достижений звучит, вне сомнения, эпохально: ядерное и термоядерное оружие, ядерная энергетика, мощнейшие ускорители элементарных частиц, космические и судовые энергетические установки, ледокольный атомный флот, металлургия и производство драгоценных и редкоземельных металлов, сверхчистые материалы и сплавы и т.д., без которых сегодня не было бы впечатляющих успехов в технике, да и всего промышленного потенциала передовых стран мира, как по техническому уровню, так и по технологическим возможностям.

Но, пожалуй, главным "золотом", добытым отечественными атомщиками за уже почти полвека своей работы стали, во-первых, надежно обеспеченный национальный суверенитет и связанная с ним напрямую глобальная стабильность, а во-вторых - сам наш, некогда секретно знаменитый "Средмаш", наша отечественная ядерная индустрия и ее люди, без которых невозможны ни научный порыв, ни успехи, ни достижения- специалисты выского технического уровня и технологической дисциплины.

И это "золото", как все, добытое человечеством в глобальном движении вперед, принадлежит не одним лишь народам России, а всему миру. Это - одно из тех общечеловеческих богатств, которыми владеют отдельные народы, но принадлежат они всему человечеству на пути к современному и благополучному миру.

С надеждой на все более ясное осознание этой общей пользы, на развитие отечественных усилий по ее обретению, на расширение международного взаимовыгодного и равноправного сотрудничества мы смотрим в завтра, преодолевая сегодняшние проблемы.

Министр Российской Федерации
по атомной энергии,
п р о ф е с с о р **В.Н.Михайлов**

22.03.94

セッション1

核兵器廃絶へ向けて－平和利用からのメッセージ

＜基調講演＞

「核軍縮の歴史と未来」

今　井　隆　吉

(社)日本原子力産業会議常任顧問、元軍縮会議日本政府代表部特命全権大使

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於　広島グランドホテル２階宴会場「孔雀」

核軍縮の歴史と未来

（社）日本原子力産業会議
常任顧問　今　井　隆　吉

核軍縮が今後どのように展開するか、アメリカと旧ソ連の核兵器がどうなるか、中国とフランスの対応はどうか、イスラエル、インド、パキスタン、南アや北朝鮮（朝鮮民主主義人民共和国）をどうするか等問題は極めて流動的であり、更に１９９５年の核不拡散条約（ＮＰＴ）の延長会議の帰趨などを含めると、今は断定的に物を言うことは出来ない。国連安全保障理事会の５つの常任理事国がＮＰＴの核兵器保有５ヵ国と一致している事をそのまま放置するのかという問題もある。この講演では問題の所在と現状を描写する事を中心とし、同時に５０年近い冷戦の間を通じて核問題の姿が歪められていたと考えられる節もあり、それらについても出来るだけ触れて行きたい。

１．核兵器の概念、内容の変化

１９４５年８月に広島、長崎の攻撃に使用された核兵器から、その後の設計、製造、実験の手順を踏んで１９９１年の米ソＳＴＡＲＴ条約が禁止、削減の対象として取り上げた現代の核兵器までの間には大きな「技術進歩」がある。（これを進歩と呼ぶかどうかは既に重大な疑問であるが）。

◇　最初の二つの原子爆弾、
◇　１９５３年にビキニの実験で登場した乾式の水爆、
◇　１９５７年にスプトニークの打ち上げ以後問題になった様に長距離弾道ミサイルに積み込む可く小型軽量化の達成、
◇　ミサイルの命中精度向上に伴う弾頭のコンパクト化と多重弾頭方式（MIRV）の達成、
◇　攻撃目標の選定と作戦指揮に関わる人工衛星やレーダーなどの指揮命令系統、
◇　何万発もの核弾頭の管理にかかわる安全性と起爆管理（permissive action link)、
◇　核戦争時の弾頭の放射線影響の管理、など

現在の世界的な核不拡散論議では極めて原始的な核爆発装置からハイテクの極みである極めてソフィスティケートな弾頭システム迄が無差別に議論されているきらいがある。これらを解明する努力が核兵器国によって充分に行なわれていない。

２．核の国際管理の仕組み、目的の変化

原子力時代の最初の頃にはこの新しいエネルギーの登場によって生じる混乱を認識し、国際的な管理を早急に実施しようとする先見的な配慮が働いていた。１９４５年以後の米ソ冷戦は核の登場によって急速に加速され、同時に核の国際管理を「全人類的な思考」から「冷戦の一部」の問題へと代えてしまった。

◇　ニールス・ボーア等の心配と米当局の否定的な反応、
◇　オッペンハイマー、アチソン、リリエンソールの国際管理案が１９４６年のバルーク案として米国により国連に提案されるまでの変化、
◇　１９５３年原子力平和利用アイゼンハウアー提案と国際原子力機関（ＩＡＥＡ）、原子力の知識、特殊核分裂物質、放射線利用などの国際化、原子力平和利用国連ジュ

ネーブ会議、１９５４年アメリカ原子力法の改訂、
◇　当初のＩＡＥＡ保障措置（INFCIRC 66）と商業機密保持の議論、
◇　１９５５年ラッセル／アインスタイン宣言と PUGWASH会議、
◇　１９６８年ＮＰＴ第３条と１９７０年保障措置委員会（ INFCIRC 153）
◇　オイル・ショック後の原子力発電とプルトニュウム、ＩＮＦＣＥの意味、
◇　物的防護と共通安全基準、
◇　核兵器に関する情報の世界的広がり、その歴史、と取り扱い、（スマイス報告、自家製原爆の議論、Nuclear Weapons Databook 迄）

３．戦後の軍縮の歩み

国連憲章が書かれた時点では核兵器の存在とその潜在的な力、米ソの対立と東西冷戦の形成は意識されておらず、国際社会がこの二つの問題とその結びつきに気がついて対応を始めるまでには時間が掛かり、また幾つもの重大な間違いが犯された。議論の分岐点は百万トンのＴＮＴ火薬を爆撃機で運搬して都市や工場、軍事施設を攻撃する事は物理的に出来ないが、１メガトンの弾頭を大陸間弾道ミサイルに載せて攻撃する事は可能だという認識である。戦争の概念、軍備の内容、軍事的警戒措置などが従来とは違ったものとなり、軍縮の内容、手段も著しく変化した。

◇　米ソ核対立の形成、多量報復（massive retarlation）の始まり、
◇　当初の国連軍縮会議、包括的軍縮計画(Comprehensive Program of Disarmament)、非核兵器保有国の安全保障（Negataive Security Assurance)、核の先制不使用（Non first use)、
◇　核攻撃目標の変化と抑止力の成立、ＭＡＤ（相互確証破壊）の時代、
◇　部分核実験禁止条約（１９６３年）、
◇　核不拡散条約（１９７０年）、
◇　柔軟対応戦略(Flexible Response)、
◇　第二次ＳＡＬＴ条約、アフガン侵攻と detnete の崩壊、
◇　１９７９年ＮＡＴＯの二重決定とジュネーブ軍縮交渉、
◇　１９８５年ジュネーブ・サミット核戦争の否定、
◇　ＩＮＦ条約、ＳＴＡＲＴ条約、ソ連の崩壊と旧ソ連の核の管理、欧州在来兵器軍縮の達成（ＣＦＥ）、

４．核軍縮の見通しは依然不明

米ソ双方による核兵器の巨大な積み上げが否定されたからといって、今後の核管理の在り方について、世界的に方針が合意された訳でもなければ、新しい秩序をどのような形で実現するかの目処がついている訳でもない。以下に主立った問題点を並べて見るが、日本にとって大事な事は今までややもすると「核の廃絶」が「核の存在そのものの否定と、解決すべき問題に関しての無知」と繋がりかねなかった感触を改めて、問題の処理と解決にイニシアチブを取る姿勢が要求されている点であろう。

◇　リスボン議定書の発効：ＳＴＡＲＴ条約による核の削減をロシア、ウクライナ、ベラルシ、カザフの４共和国に及ぼし、３国が非核兵器國としてＮＰＴに加盟、

◇　紀元２００３年までに米露の核弾頭を３０００発に削減する具体的措置を定め、国際的な検証を実施する。この中には両国計２００トンの兵器級プルトニュウムの処理、貯蔵、利用など、雇用１０万人に及ぶ核兵器産業の民需転換、放射性汚染地域の除染（潜水艦など）高レベル廃棄物の処理など多様な問題が含まれる、

◇　紀元２００３年の時点で米露それぞれの３０００発の核弾頭がどのような戦略思想によって支配され、管理されているかについての納得の行く論議。軍の近代化を後回しにして戦略核を育ててきた中国、旧ソ連に届かない核ミサイルを配備して西欧に於ける安全保障の独自性を主張してきたフランスがどのような形で核軍縮に参加するか、

◇　軍事費の大幅削減をアメリカがどのような形で実現するのか。ロシア、中国を含めてハイテク通常兵器の輸出を今後どのようにして管理、縮小するのか。併せていわゆる「両用（dual use）技術」の国際移転の管理をどうするのか、COCOM, London Guide Line, MTCR（ミサイル技術）などの今後の在り方、

◇　核実験全面禁止（CTB）の今後の扱いはジュネーブの軍縮会議に一応任されているが１９９５年のＮＰＴ延長会議までにどれほどの進歩が期待出来るか。核実験をしないで核武装が可能な国がどれだけあるか。米露中国などが核兵器体系を維持しようとするとどの程度の兵器産業が必要か、新しい弾頭の開発が止まるのかどうか、

◇　ＮＡＴＯ地域、中欧地域、ロシア、中央アジア、中東、東アジア、西半球などそれぞれについて安全保障の見通しはどうか、

５．冷戦後の体制と日本の関連

この処、日本が安全保障理事会の常任理事国入りをする件が話題になっている。国連分担金が１２・５％と世界第２位を占めるようになって、具体性をおびてきた感がある。同時に国連憲章第７章による集団安全保障への貢献をどうするか、憲章に規定がない平和維持活動（特にＰＫＦ）への参加の度合いが問題視されている。従来あまり関心を持たず、態度の表明の必要も少なかった諸問題についても今後は主導性が要求される事になるであろう。例えばハイチ、アブハチ、サラエボが例である。軍縮についても従来は核廃絶の理想を掲げるだけで済んでいた処を、今後は核兵器処理の（資金、技術）分担、プルトニュウム利用と管理の具体策の提示などを含めて上記４の諸事項に積極的に参画する事が期待される時代になるであろう。日本が非核を国是としているという説明だけでは世界は最早納得しない時代になっている。

The History and Future of Nuclear Disarmament

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How will nuclear disarmament develop in future? What will happen to the nuclear weapons possessed by the United States and the former Soviet Union? How will China and France respond? How should we deal with Israel, India, Pakistan, South Africa, and North Korea (Democratic People's Republic of Korea)? These issues are extremely uncertain. In addition, there is an issue of the extension of Non-Proliferation Treaty of Nuclear Weapons (NPT), which will be discussed at the meeting to be held in 1995. It is difficult to answer these questions definitively at the moment. There is also a question of whether we can leave the present situation as it is, in the light of that the five permanent members of the U.N. Security Council represent the five nuclear powers. In my speech, I will present the problems and describe the status quo, and I would also like to refer to the nuclear issues, since it may be considered that these issues have been distorted throughout the cold war of almost 50 years.

1. Changes in Concept and Scope of Nuclear Weapons

Substantial "technical progress" has been made since nuclear weapons were first used for attacking Hiroshima and Nagasaki in August 1945 (though it is very much questionable whether this can be called "progress" or not). There are big differences between the atomic bombs dropped on Hiroshima and Nagasaki and nuclear weapons of these days which are subject to ban and reduction under the 1991 U.S.-Soviet START treaty. This is because the latter have gone through the subsequent changes in design, manufacture and experiments.

-- First two atomic bombs.

-- Dry hydrogen bomb which appeared in 1953's Bikini nuclear test.

-- Small and light nuclear bombs loaded on long-range ballistic missiles, which came to light after launching of a Sputonik in 1957.

-- Compact warheads and multiple independently targeted reentry vehicles (MIRV), by which missiles could hit targets with more accuracy.

-- Development of the command system, such as man-made satellites and radar, used for the selection of targets and strategic commands.

-- Safety and permissive action link in controlling tens of thousands of nuclear warheads.

-- Control of radiation effects of warheads in nuclear war, etc.

Today's discussions on non-proliferation of nuclear weapons tend to treat equally all the nuclear weapons, from extremely primitive nuclear explosive devices, to extremely sophisticated warhead systems which make most of high technology. Nuclear weapons nations do not make enough efforts to clarify these differences.

2. Changes in Mechanism and Aim of International Control of Nuclear Weapons

In the early stages of the nuclear age, nations recognized confusion brought by this new energy, and tried to exert an international control urgently, considering the future. The U.S.-Soviet cold war, which started in 1945, was intensified by the existence of nuclear weapons. Consequently, it changed the issue of international control of nuclear weapons from "the global matter to be addressed by the whole mankind" to "an element of the cold war".

-- Concerns of Niels Bohr, et al., and the negative response from U.S. authorities.

-- The international control proposed by Oppenheimer, Acheson and Lilienthal was presented to the United Nations as "Baruch Proposal" in 1946.

-- Proposal by Eisenhower advocating peaceful use of nuclear energy in 1953 and establishment of International Atomic Energy Agency (IAEA); internationalization of knowledge of nuclear energy, special fissionable material, utilization of radiation, etc.; U.N. Geneve Conference on peaceful use of nuclear energy; and revision of the 1954 U.S. Atomic Energy Act.

-- Initial IAEA safeguards (INFCIRC 66) and confidentiality of commercial secrets.

-- Russel/Einstein declaration in 1955 and PUGWASH conference.

-- Article 3 of 1968 NPT and 1970 Safeguards Committee (INFCIR 153).

-- Nuclear power generation after oil crises, and meaning of plutonium and INFCE.

-- Physical protection and common safety standards.

-- Global propagation of information on nuclear weapons, and the history and management of nuclear weapons (Smice Report, homemade atomic bombs, Nuclear Weapons Databook).

3. Arms Reduction after World War II

When the United Nations Charter was prepared, the nations did not recognize the existence of nuclear weapons and their potential, or U.S.-Soviet confrontation and the cold war between the East and the West. It took some time before the international community realized these two problems and a connection between them and began to take actions. During this time, a number of serious mistakes were committed. The turning point of the argument lies in the recognition that it is not physically possible to carry one million tons of TNT gunpowder with bombers and attack factories and military facilities in cities, but it is possible to attack them by loading one megaton of warheads on intercontinental ballistic missiles (ICBM). The concept of war, armaments, military guards, etc. have changed, and the scope and method for arms reduction also have undergone a great change.

-- U.S.-Soviet confrontation and beginning of the strategy of massive retaliation.

-- Initial U.N. arms reduction talks. Comprehensive Program of Disarmament. Negative Security Assurance. No first use.

-- Changes in targets for a nuclear attack and formation of deterrent, and the era of MAD (mutual assured destruction).

-- The Partial Test-Ban Treaty (1963)

-- Non-Proliferation Treaty of Nuclear Weapons (1970)

-- Flexible Response

-- SALT II, invasion into Afghanistan, collapse of detente.

-- NATO dual decision in 1970 and Geneve arms reduction talks

-- Denouncement of nuclear wars at the Geneve summit meeting in 1985

-- INF Treaty, START Treaty, collapse of the former Soviet Union, control of nuclear weapons possessed by the former Soviet Union, and reduction of conventional forces in Europe (CFE).

4. Uncertain prospects of nuclear disarmament

Even though massive expansion in armaments was denounced by both U.S. and U.S.S.R., the world has not yet reached an agreement on how to control nuclear weapons in future, or how to achieve a new order. The major problems are shown in the following list. The important task for Japan would be to take an initiative in solving those problems. In the light of the national policy of "abolishing nuclear weapons" has tended to lead to "negation of the existence of nuclear weapons altogether and ignorance of matters which need to be resolved".

-- Effectuation of Lisbon Protocol: Reduction of nuclear weapons under the START Treaty was applied to four republics: Russia, Ukraine, Belarus and Kazakhstan, and the latter three republics joined NPT as non-nuclear weapons states.

-- Specific measures will be provided to decrease the total number of nuclear warheads possessed by U.S. and Russia to 3,000 by the year 2003, and international verification will be carried out. These measures include disposal, storage and utilization of 200 tons of weapons-grade plutonium possessed by both countries, conversion into civilian industry of nuclear weapons industry covering 100,000 employment, decontamination of areas contaminated by radiation (submarines, etc.), disposal of high-level waste, etc.

-- Satisfactory explanation should be made as to what strategy will have control over each 3,000 warheads possessed by U.S. and Russia in the year 2003, and how China and France will participate in the dialogue of nuclear disarmament. China has developed strategic nuclear weapons, deferring modernization of the army. France has maintained its independent defense program in Western Europe, by deploying nuclear missiles which do not reach the former U.S.S.R.

-- In what way will the United States materialize substantial reduction of war expenditure? How will U.S., Russia and China control and curtail exports of highly developed conventional weapons?

How should we control so-called "dual use technology" on the international level? What should COCOM, London Guide Line, and MTCR (missile technology) be dealt with in future?
-- CTB (comprehensive ban on nuclear tests) will be handled by Geneve Arms Reduction Conference, but what progress can we expect to achieve by the year of 1995 when a meeting is to be held to discuss the extension of NPT? How many nations can obtain nuclear weapons without nuclear tests? What scale of weapons industry will be needed for U.S., Russia and China to maintain the nuclear weapons system? Will the development of new warheads ever stop?
-- What are the prospects of security with regard to the NATO area, Central Europe, Russia, Central Asia, the Middle East, Eastern Asia, and the western hemisphere?

5. Post-Cold War Structure and Involvement of Japan

Recently, it has been drawing people's attention whether Japan will be a permanent member of the U.N. Security Council.. This issue has begun to take a concrete form, as Japanese contributions to U.N. now account for 12.5% of the total, the second largest amount next to U.S. At the same time, the world is paying attention to how Japan will contribute to collective security under Chapter 7 of the U.N. Charter and to what extent Japan will participate in peace keeping operations not stipulated by the Charter (especially PKF). Japan will need to take a lead in dealing with issues in which Japan has not been very interested or about which Japan has not been required to express its opinion. Haiti, Abkhaz, and Sarajevo issues are some of them. Also, with regard to arms reduction, Japan has merely insisted on abolishing nuclear weapons without substantial contributions. In future, however, Japan will need to play an active role in dealing with the matters mentioned in Section 4, including disposal of nuclear weapons (contributing by way of funds and technology), and providing specific measures for utilization and control of plutonium. The era has come when the world would not be satisfied with the explanation that Japan takes a non-nuclear policy.

The 27th JAIF Annual Conference

Toward Nuclear-Weapons-Free-World -- the Role of Peaceful Utilization of Nuclear Energy

International Conference Center Hiroshima, Japan

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Facing the Reality of Ultimate Abolition of Nuclear Weapons : The Message of Peaceful Use of Nuclear Energy

Panel Discussion (Session 1)

YVES BOYER

Introduction

The awesome fate of Hiroshima and Nagasaki has stirred world demands that after making the atomic bomb and let loose the evil genius, it returns to the bottle. Since that time there has been an impressive numbers of proposals aimed at "eliminating the use of atomic energy for destructive purposes" as already proposed by Great Britain, Canada and the United States in November 15, 1945. But, was the problem really put in the right manner? Military forces are not the source or cause of tensions and hostility among nations. They are only the reflection of political disputes. Nuclear weapons reflect the same needs for protection. To attempt any control and limitations of them, separately from their underlying political causes, is to put the cart before the horses. Historical precedent of such mistake already apply in recent history : if World War I was provoked, not exclusively however, by an unlimited arms race, on the contrary World War II was partially caused by an uncontrolled race for disarmament. Therefore, any proposal intending to limit or forbid nuclear weapons shall be carefully assessed to its sheer merits and deficiencies.

1 - Is a Nuclear-Weapons Free World desirable ?

As a matter of principles, the answer to that question shall definitly be positive :

- the apocalyptic vision of a divided and fragmented mankind using the weapons of Armageddon when overcomed by its evil genius of hate and death demand a particular attention. History teaches that unpredictable events with cataclysmic effects may happen unexpectedly from a unstable situations among countries or inside a country, then escalate into armed violences and conflicts. In the nuclear era such risks are unacceptable when they reach a level where world stability is jeopardize and when concatenation of events may led to the unbridled use of mass destruction weapons.

- a positive vision of mankind, drawn from the philosophical heritage from the Enlightement period, make us believe that human behavior can be made more or less in a rationale way. Therefore international disputes shall be growingly solved by others means than war as exemplified by the increasing importance in modern history of international agreed norms aimed at reducing tensions, bringing stability and establishing confidence building measures among nations. In this framework, nuclear weapons are a useless sword of Damocles, leaving untamed the dramatic specter of the destruction of mankind and diverting ressources to the detriment of pressing needs.

Both assumptions however carry their own contradictions. The dark side of mankind should dispose to think twice before getting rid of all nuclear weapons. Armaments including nuclear weapons have not been built up entirely out of sheer cussedness. They have been built up, by the nuclear powers, in part to perform a legitimate function, that consist in trying to protect the state against infringements of its rights. Late,r legitimization of nuclear weapons was based, and continue to be based, on the fact they do contribute to assure a minimum of stability. It logically follows that we cannot merely get rid of nuclear weapons and leave a vacuum that could prove to be dangerous. The existing deterrent forces shall not be eliminated until new systems for enforcing peace have been created to insure international order under law and justice. Complete disarmament without such arrangements for security and stability would merely lead to rearmament. It is irresponsible and narrow minded to encourage the hopes of people for the sake of a still unrealistic and unreachable goal. Neither can we be satisfied with the establishment of mutual deterrence as a satisfactorily goal in the long term. Taking into account this contradiction, what shall govern the function of nuclear deterrence in the future ?

2- Is a Nuclear-Weapons Free World realistic ?

In the current international system and for the foreseable future, a nuclear-weapons free world seems more a chimera than a realistic goal. Firstly because emotional considerations whatever be their legitimacy have never made a sound policy. Indeed, the ideological principles underlying the assumption that a nuclear free world is desirable can be discussed. From an arms control perspective, one can argue that today and for an undertermined period of time, the restructuration of current nuclear arsenals towards a minimal posture will continue to offer guarantees against the worst in time of major world crisis. This can explain why even among arms-controlers, the idea of minimal deterrent forces carries its own virtues. It would be indeed irresponsible to deny the current stabilizing function of nuclear deterrence : an abolition of nuclear weapons could certainly have the potential to generate international instability. This would means a return to the pre-nuclear era, the classical age when war wasthe most common mean for conflict resolution.

Last but not least he proposals for a NWFW would required approbation by the current possessors of nuclear weapons. The flaw in those proposals is that they are short of genuine incentives for the members of the nuclear club to renounce the possesion of their arsenal. Proposals to get rid of atomic weapons have their own virtues but in no circumstances they provide for the nuclear states the sense, to paraphrase a former Scientific Advisor to the British Ministry of Defense, that "no one can afford to make them desperate".

3- A nuclear world : to make a virtue of necessity.

With the end of the Cold War, the international community faces positive perspectives to put an end to the nuclear arms race. This race had contributed to an insane spiral of building weapons for the sake of "overkill" which led the United States and the former Soviet Union to acquire 125 000 nuclear weapons, i.e. 98% of the world stockpile built between 1945 and 1993. Positive prospects do now exist to put an end to this senslessness race. Three of them are worth mentionning :

a) The 1995's NPT review and the recent opening negociations at the Conference on Disarmament in Geneva for a Comprehensive Test Ban aimed at contributing "effectively to the prevention of the proliferation of nuclear weapons in all its aspects, to the process of nuclear disarmament and therefore to the enhancement of international peace and security". This welcomed development shall not be however understood, at least seen from Paris, as the begining of a process leadind towards the total elimination of the nuclear weapons of the Five nuclear powers. France enters indeed the CTB negociation for contributing to avoid proliferation, but still with the clear will to maintain its deterrent force. For the success of the CTB negociations, the French are working to broaden the number of participants to the CTB that shall be universal in its application : nuclear states shall be signatories of the CTB as well as all states having nuclear research capabilities particularly those of the nuclear threshold. In addition, to French's officials mind, a direct link stands between progresses in the negociations for a CTB and the NPT review in April-May 1995, where a positive outcome would confirm France's desire to contribute actively to the success of those negociations. This attitude has to put into a broader perspective linking France's good will in negociating the CTB and the stability of the strategic international scene based on various arms control agrements such as the ABM treaty, the CFE agrement, the START process and of course the NPT.

b) The second positive element in limiting the risks of an unbridled nuclear arms race stems from the progresses made by the former Soviet Union and the United States in concluding START I and later START II. This provides a sound and balanced framework for defining the deterrrent posture of those countries going away from a war-fighting posture.

c) The last and probably the most promising evolution regarding the function and also understanding of the nuclear deterrence is the current shift away from this war-fighting vision towards a more existential conception of nuclear deterrence. This understanding of nuclear deterrence has always been underlying the French concept of deterrence based on the notion of "strict sufficiency". "Strict sufficiency" means having enough weapons but no more. It consits in being able to inflict any potential adversary losses cancelling out the gains his aggression could bring him. Consequently, French's vision of nuclear weapons is characterized by their double functions : in one hand a last ditch protection against the threat of annihilation but also in the other hand weapons to prove the absurdity of war. In that case the function of nuclear weapons is to make unconceivable the resort to war to settle political disputes. As a corollary, the amount of weapons is strictly limited as demonstrated by the share of French nuclear weapons in the total of warheads built between 1945-1993 : 0,8 %.

History and Prospects of the North Korean Nuclear Issues

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There would be six possible inspection formats as follows:
In the case of the IAEA inspection, IAEA could inspect the two sites and the US bases together (option A) or inspect the two sites only (option B). As for the reciprocal inspection, there are 3 options: the South inspects the two sites and the North does the two US bases (option C); only the North inspects the two US bases (option D); and no reciprocal inspection occurs at all (option E). Combining these two sets of options makes six.

Six Possible Inspection Formats

Format	North Korea	South Korea	IAEA
1. (A and C)	O	O	△
2. (A and D)	O	X	△
3. (A and E)	X	X	△
4. (B and C)	O	O	O
5. (B and D)	O	X	O
6. (B and E)	X	X	O

Format 1: (A and C)—*The IAEA inspects the two undeclared sites and US military bases and reciprocal inspections are performed on the same objects.* The two Koreas would welcome format 1 (O), but the IAEA would not be enthusiastic (△) because the two US bases are obviously not related with nuclear activities. A modified version of format 1 would let the IAEA

inspectors participate in reciprocal inspections.

Format 2: (A and D)—*The IAEA verifies the two undeclared sites and the US bases and only North Korea is allowed to inspect tow US bases.* The North would like format 2 but the South would reject it because reciprocal inspections would not be realized. The IAEA would hold the same position as in format 1.

Format 3: (A and E)—*Only IAEA inspection of the two sites and two US bases.* Pyongyang would reject format 3 since it wants to inspect US bases, and Seoul would not accept it either for the same reason as in format 2. The IAEA would take the same position as in format 1.

Format 4: (B and C)—*The two undeclared sites and two US bases are inspected through reciprocal inspections and the IAEA would inspect only the two sites at Yongbyon.* The two Koreas would welcome format 4 and the IAEA would like it as well.

Format 5: (B and D)— *The IAEA inspects the two undeclared sites and North Korea verifies two US bases.* The North would like format 5 but the South would reject it because reciprocal inspections would not be realized. The IAEA would take the same position as in format 4.

Format 6: (B and E) —*Only the IAEA inspects the two sites at Yongbyon.* As in format 3, Pyongyang and Seoul would reject format 6 but the IAEA has no reason to refuse it.

Among the six possible inspection formats, format 4 is most likely to be realized since all three parties would be satisfied. If the IAEA inspection of the two undeclared sites at Yongbyon and the first reciprocal inspection are conducted, it is thus highly probable that the IAEA will inspect the two undeclared sites while South and North Korea, through reciprocal inspections, verify the two sites and two US bases, respectively.

In principle, Pyongyang would like not only an upgraded dialogue but the establishment of full diplomatic relations with the United States. It would like the U.S. to be neutral as between North and South Korea, not siding with South Korea in every dispute. It would like the U.S. not to block other nations and international institutions, especially economic ones, from getting involved in its trade and investment activities. The North would like the United States to withdraw its forces from the South and to take other military steps including suspension of the Team Spiirit exercise to reduce pressure on the North. Pyongyang claims that all outstanding issues with Washington can be resolved through face-to-face talks. But while North Korea presses for such talks in a variety of ways, at this point its greatest concern seems to be not that the United States should go along with an easing of its terms, but rather to prevent the U.S. from actually toughening its position.

The United States is willing to improve relations with the DPRK, but only on a basis that serves its broader aims on the peninsula, in the region and globally. From Washington's perspective, the most basic requirement is to undergird peace and stability in North-South Korean relations and to gain meaningful assurances regarding long-term security and prosperity for South Korea. U.S. position would not allow the American "neutrality" between North and South Korea or compromising on the U.S. security guarantee to Seoul.

Whether the U.S.-DPRK relations develops into establishment of full diplomatic relations will depend first and foremost on inter-Korean developments. Current issues of the U.S. concern--nuclear non-proliferation, control of missile exports, and anti-terrorism--still have relevance not simply to the Korean Peninsula but to broader American concerns as well. As a result, not only the Korea-policy community but a larger set of Washington actors will need to be satisfied in order for the U.S. government to forge the necessary consensus to move ahead in its relations with the DPRK.

Regardless of the change in North Korean approaches to the United States, it is generally believed that the U.S. is not going to move toward more normal relations in the absence of an ongoing, effective North-South inspection regime alongside a continuing pattern of full North Korean cooperation with the IAEA. Even if the nuclear issue is resolved, however, and highlevel dialogue proceeds, the problems to be addressed in the course of that dialogue will not be easy. Communications with the North Koreans are by no means easy for the U.S.. The problem of speaking across significant cultural barriers is magnified by the eccentric ideology of the Kim Il Sung regime and its relative unsophistication vis-a-vis the ways of the outside world.

If Pyongyang wants to continue pushing for direct talks with the U.S., the North Korean leadership should understand that the result may be merely to harden U.S. attitudes if they only reiterate previous positions, if they seem to be seeking to go around Seoul's back, or if they lie about North Korean policies and actions (i.e. on nuclear issues or missiles)--that is what the U.S. should take into consideration in making its policy toward the DPRK.

Given complexity of the so-called "the Korean Triangle"--the United States and the two Koreas, however, it should be understood that North Korea alone cannot untie the triangular knot without help from Washington and Seoul. There is no doubt that such help can and should be prompted by a signal of serious change of the North Korean attitude.

Anyway, the "package solution" to the nuclear dispute proposed by Pyongyang on Nov. 11, 1993 envisages North Korean concessions on U.S. nuclear inspection demands synchronized with U.S. diplomatic recognition, together with the removal of restrictions on trade and investment and help in obtaining multilateral credits similar to the role being played by the United States in the case of Ukraine.

Diplomatic recognition is the top priority because the North fears that the United States wants to promote its collapse and absorption by South Korea, repeating the German unification model. In the North's perspective, the normalization of political and economic relations would signify U.S. readiness to coexist. Equally important, economic help would compensate for the crippling loss of the economic subsidies provided during the Cold War by Russia and China.

The North is also seeking a U.S. pledge not to use or deploy nuclear weapons in Korea, through a bilateral agreement with North Korea or a multilateral accord involving Russia, China, North and South Korea and Japan.

In an effort to convince Washington that it has no intention of developing nuclear weapons, Pyongyang has asked for help in shifting from its graphite-based nuclear reactors to light-water reactors, which are less easily adapted to a weapons program. This would involve an estimated $2 billion in credits over 10 years to be shared by the United States, Japan, South Korea and multilateral agencies.

Pyongyang, for its part, has signaled that it is prepared to return to full membership in the Nonproliferation Treaty and to open up its declared nuclear facilities to unimpeded, regular International Atomic Energy Agency inspections. This would include full access to the key five-megawatt reactor and reprocessing plant at Yongbyon.

A compromise formula to permit inspection of two suspected waste dumps appears increasingly likely, provided these are not designated as "special inspections," thus setting a precedent for inspection of other undeclared nuclear facilities. The North Korean armed forces fear that random access to military bases through "special inspections" could be used for espionage purposes by U.S. and South Korean intelligence agents working under IAEA cover.

Ukraine is in a stronger bargaining position than North Korea because it possesses intercontinental nuclear missiles that pose a clear threat to America. North Korea, by contrast, poses a hypothetical future threat.

Using identical evidence available to all of them, American intelligence agencies differ on whether North Korea has accumulated enough plutonium to make one or more bombs and whether it has the trigger technology necessary to detonate a nuclear weapon. Nevertheless, the United States is properly concerned that continued uncertainty over North Korean capabilities is stimulating pronuclear sentiment in Japan and South Korea.

The essence of Pyongyang's position is its insistence on simultaneous concessions. Washington has argued that the North must give in on inspections first to fulfill its obligations as a signatory of the Nuclear Nonproliferation Treaty. The tortuous preliminary negotiations during the past three months have been over how much Pyongyang would have to concede on inspection before the United States would agree to link a nuclear settlement with political and economic issues.

The Clinton administration is deeply divided over whether to engage in negotiations on a "package solution" at all and what tradeoffs to offer if it does. Hard-liners argue that giving too much would tempt Iran and other would-be nuclear powers to engage in "nuclear blackmail" of their own. But the benefits of getting North Korea to give up its nuclear option outweigh this concern.

Apart from defusing pro-nuclear sentiment in Tokyo and Seoul, resolution of the nuclear dispute with Pyongyang would remove the need for a costly conventional military buildup throughout Northeast Asia.

The Pentagon is already planning for a possible increase in U.S. capabilities in South Korea, including Patriot missiles, and for an $8 billion U.S. -Japanese Theater High-Altitude Area Defense System to counter the threat that would be posed by nuclear-capable North Korean missiles.

In its latest retort in the dispute over its nuclear program, North Korea warned on 3 February 1994 that U.S. pressure could provoke an intense response -- one that "will be carried into practical action."

In a strongly worded commentary distributed by the Korean Central News Agency, North Korea said it had an "expedient to counter any other option of the United States."

"It is not the United States alone that has the expedient," it said, "and the option is not open only for a big power."

The comments appeared as a partial response to a resolution passed earlier this week by the U.S. Senate urging Washington to prepare to return tactical nuclear weapons to South Korea if talks with North Korea remain at an impasse.

In Hong Kong, the U.S. evangelist Billy Graham said he had received a message for President Bill Clinton from President Kim Il Sung of North Korea. Mr.Graham said leaders on both sides should pray "that somebody doesn't make a mistake."

Japan and South Korea also have urged Washington to tread carefully on the issue, fearing an extreme reaction by the unpredictable North Korean leadership.

Russia's new envoy in Seoul criticized U.S. policy toward North Korea on 3 February 1994 saying that pressure tactics should not be used.

"The nuclear issue must be solved," Ambassador George Kunadze said," but not by backing North Korea up against a corner."

By the way, the only way to stop nuclear proliferation without paying off would-be nuclear powers in one form or another is to move purposefully toward a nuclear-free world.

NYT raised a "nuclear-free Korea" as follows:

It is especially important to resume regular inspections by summer, when North Korea will have to shut down its reactor and replace the fuel rods. At that time, inspectors will be able to weigh and assay the nuclear material to find out whether any of it was diverted in the past, and if so, how many bombs' worth. Special inspections of suspected North Korean nuclear waste sites might also be necessary for that purpose. Those, too, would have to be negotiated.

The Clinton administration should be prepared to pay a reasonable price to gain such access—by meeting the North's demands for improved relations, giving security assurances, providing reactors that are less proliferation-prone, and offering trade and aid.

Diplomacy will cost a lot less than confrontation, and it just might get what the world wants—nuclear-free Korea.

Now, what is more important is that the conception of a "nuclear-free world" will be also addressed in the logic of a "nuclear-free Korea".

For the logic of a "nuclear-free Korea" raised by *The New York Times'* editorial on 18 February, 1994, is closely related to "moving toward a nuclear-free world."

SOUTH AFRICA'S NUCLEAR PROGRAM

Address given at the 27th Japan Industrial Forum Conference
in Hiroshima, 13-15 April 1994

DR J W L DE VILLIERS
CHAIRMAN: ATOMIC ENERGY CORPORATION

INTRODUCTION

South Africa's nuclear development program had its origin in the occurrence of uranium in the Witwatersrand gold mines. As early as 1994, during the Manhattan Project, these uranium-bearing ores were investigated and uranium production methods developed in a joint program between South Africa, the USA and the UK. Uranium was first produced in 1952, and until the mid-1960's the total output was sold to the Combined Development Agency, the purchasing organization set up by Britain and the USA to secure adequate uranium supplies for their nuclear weapons programs.

In 1948 the Atomic Energy Board was established by Act of Parliament to control the production and sale of uranium on behalf of the Government. In 1959 the Atomic Energy Act was amended to provide for the establishment of a nuclear research and development program. This program was aimed at peaceful harnessing of nuclear energy and the development of nuclear technology for the benefit of the country. There were four major avenues of development:

- Development of the production and refining of nuclear materials, such as uranium, thorium as well as other appropriate raw materials.

- Investigation into the application of nuclear energy for electricity generation.

- Ongoing research fundamental to a nuclear energy program.

- Research into the uses of isotopes and radiation in medicine, agriculture, commerce, industry and research.

THE EARLY YEARS

The first few years, after the 1959 amendment of the Atomic Energy Act, were devoted to the selection and training of suitable staff to man the Research and Development Program. They were sent overseas for periods of up to three years to train in nuclear science and technology at various centres in Europe and the USA. Construction of research facilities was started at the Pelindaba site in 1961.

The research reactor SAFARI-1 was imported from the USA and commissioned in 1965, by which time the R&D Program had been firmly established at the National Nuclear Research Centre at Pelindaba.

During the 1960's, in view of the USA's Plowshare Program, an investigation was also launched into the feasibility of using nuclear explosives for the construction of harbours, mines and mountain passes. This program was abandoned in the late-1970s when it became clear that there was limited scope for such applications in South Africa, while the world was fast turning against the use of nuclear explosives for civil applications.

In 1969 the success achieved with the research into an indigenous uranium enrichment technology resulted in government approval for the construction of a pilot plant to prove the technology on an industrial scale and to undertake the further investigations into enrichment technology. The pilot enrichment plant was commissioned in 1977 and the first production was achieved in 1978.

The ability to enrich uranium opened new avenues for the R&D program. It also made it possible for South Africa to pursue the utilization of nuclear power reactors based on enriched fuel. A contract was concluded between FRAMATOME and ESKOM in 1974 for the construction of a nuclear power station at Koeberg. Contracts for enrichment services and fuel manufacture were concluded by ESKOM with USDOE and FRAMATOME.

However, in 1976 the USA suspended its supply of enriched fuel for the SAFARI research reactor. This fuel had already been manufactured and paid for, when an export permit was refused by the US administration.

In 1978 the Nuclear Non-Proliferation Act (NNPA) was passed by the US Congress and applied retro-actively on all previous agreements and contracts. This led to the refusal of export permits to France for the uranium already enriched by USDOE for the Koeberg Nuclear Power Station (KNPS).

These events were seen by South Africa as an unilateral breach of existing contracts and agreements for political reasons, and South Africa lost faith in the viability of international contracts to ensure the availability of fuel for its research reactor as well as for its civil nuclear power program.

It was therefore decided in 1978 "to go it alone" and to erect a semi-commercial enrichment plant to produce low enriched uranium (LEU), as well as to erect a fuel manufacturing plant to provide fuel to the Koeberg Nuclear Power Station.

THE PROGRAM FOR THE MANUFACTURE OF NUCLEAR EXPLOSIVES

The availability of enriched uranium also provided the means to develop nuclear explosives, and approval was obtained in 1971 to conduct preliminary investigations into the feasibility of producing nuclear explosives for peaceful applications. These investigations were limited to theoretical calculations as well as to preliminary investigations into the ballistics of such devices. No serious development was carried out at this stage. For example, only three engineers were involved in the ballistics research into a guntype assembly and in limited theoretical studies in implosion technology.

In 1974 the AEB reported that the development of a nuclear explosive was found to be feasible, and the Head of Government approved the development of a nuclear explosive capability, limited to peaceful applications, and approved the budget for the development of a testing site.

In August 1977 the discovery of the Kalahari testing site aroused widespread international reaction and it was realized that a nuclear device could not be tested without incurring the wrath of the international community. The site was therefore abandoned in August 1977. No nuclear explosive test whatsoever was ever conducted by South Africa.

After the discovery of the testing site, the nuclear deterrent strategy was developed and the responsibility for further development was transferred to ARMSCOR.

The reasons for this change in policy, the development of a nuclear deterrent strategy and the subsequent events leading up to the decision to abandon the nuclear explosives option in 1990, have been discussed extensively elsewhere [1)-5)], and will not be repeated here.

It must, however, be emphasized that the South African Government was throughout the program very much aware of the tremendous destructive power of nuclear explosives, and therefore also firmly convinced that South Africa could never employ such a device offensively. The final phase of the deterrent strategy therefore only included an underground test as a final step to convince the international community to intervene should South Africa be attacked.

THE FUTURE PROGRAM OF THE AEC

The abandonment of the nuclear deterrent program provided for the reassessment of the AEC's role in the nuclear development of South Africa as well as in the African region.

In the light of the changed circumstances, the Atomic Energy Corporation's mission was revised and reformulated in 1990, resulting in the so-called AEC 2000 Plus Plan. This plan has repositioned the AEC from a strategic and heavily state dependent organisation to a national asset that addresses the needs of the country by applying its vast array of high technological skills and capabilities towards:

- assisting South African industry in its movement towards greater competitiveness in exports;

- addressing the environmental needs of our country and its communities, and

- the development of the technological skills of our society.

The new domain of the AEC consists of two distinct mainstream business areas, namely:

(i) a future internationally competitive nuclear fuels business that adds significant value to our local uranium exports and

(ii) an industrial business arm of the AEC called Pelindaba Technology Products (PTP) which manages an industrial product portfolio on a strict profit basis in global market niches.

Both of these ventures are supported by a focussed Technology Development function and, in the case of industrial non-nuclear fuel products, by a Business Development Unit that is responsible for the marketing and industrialization of new commercial ventures within the AEC's core competencies.

Significant progress has already been achieved, for example:

- External income from sales of industrial products rose on average by between 25% and 35% annually over the last three financial years and is expected to exceed income from nuclear fuel related sales within the next year or two.

- Exports increased by more than 50% over the last three years and is currently representing 11% of turnover. A sharply targeted export strategy was implemented last year to increase exports to more than 50% of total sales within the next few years.

- Internationally acknowledged positive results on the well advanced Molecular Laser Isotope Separation project have been achieved recently. The demonstration of single step enrichment has now placed the objective within reach of increasing South Africa's raw uranium exports from the current approximately R150 million per annum to a figure two to three times as much by high value addition on a strict commercial basis.

- The creation of the Pelindaba Skills Institute to address the dire needs of our country in its development of technological skills amongst its broader society. These initiatives range from those of job creation through basic skills to that of actively redressing deficiencies in secondary school education through joint ventures with other industries and communities, and co-operation agreements with Technikons and Technical Colleges providing for the practical training of all their students at the AEC.

- The industrial product portfolio expanded from a very limited range of approximately 20 products in early 1990 to more than 250 products that are in various stages of market acceptance. These range from:

  - large scale radioisotope production for exports used in the medical and industrial markets for radiotherapy, radiopharmaceutical and radiation-source purposes;

  - a so-called Frothman flotation probe which measures the pulp and froth thickness in flotation processes used in the minerals industry;

  - a revolutionary air filter for passenger and industrial vehicles that has been patented world-wide;

  - a wide range of product applications in the mining, aerospace, food, agriculture and chemical markets;

  - radio luminescent (non-powered) light sources with potential application to safety signage in mines;

  - a recently patented low-cost smoke elimination device for coal-burning stoves which is now undergoing industrialisation development;

  - an easy-to-operate mobile membrane separation unit for the purification of surface water in rural areas;

- a biogas unit for obtaining methane from city refuse dumps which can be used as a 'clean' fuel for vehicles;

- an on-line coal-ash monitor developed together with the CSIR;

- the intended venture, in collaboration with the South African chemical industry, into large-scale teflon (PTFE) manufacture based on the AEC's recently patented environmentally friendly tetrafluoroethylene manufacturing process;

- involvement, through local industry, in the specialised further beneficiation of high-value small-volume minerals recovered from beach sands;

- the recernt introduction into South Africa of surface fluorination of plastic containers which render the container impervious to organic chemical seepage, making possible, amongst others, plastic fuel tanks and cheaper plastic car bumpers;

- a world leading project to develop an internationally competitive laser enrichment process for South Africa's uranium exports, thereby adding value of between 100% and 200% to foreign exchange earnings and securing employment in the mining sector.

Many of these products and processes are largely aimed at the export market and already more than 15% of the AEC's income from sales is earned in exports. Furthermore, it is the AEC's strategy to avoid the direct sale of technology to overseas partners but instead to encourage investment in local joint manufacturing ventures in order to alleviate South Africa's unemployment problem.

Significant progress in the implementation of its new policy has already placed the new AEC firmly on its way towards the creation of national wealth through the application of its vast array of technological skills and capabilities to meet the vital needs of our future South Africa.

SOUTH AFRICA AND THE NPT

South Africa has always supported the international non-proliferation policy of safeguarding the use of nuclear material and technology for peaceful purposes. It was one of the seven member countries involved in the drafting of the IAEA Statute and one of the eighteen founder members of the IAEA in 1957, and served on the Board of Governors of that body from 1957 to 1977.

When the Nuclear Non-Proliferation Treaty came into force in 1970, South Africa's nuclear research and development program was well advanced. It has already successfully developed an indigenous uranium enrichment technology on a laboratory scale, and a "zero energy critical facility", based on its sodium-cooled heavy water-moderated power reactor concept, was in operation.

When the Prime Minister informed Parliament on 20 July 1970 that a new uranium enrichment process had been developed, he stated that South Africa was prepared to collaborate in the exploitation of the process "with any non-communist country desiring to do so".

He added: "I wish to state emphatically that South Africa is prepared to subject its nuclear activities to a safeguard system including inspections, subject to the conditions that:

(a) South Africa will in no way be limited in the promotion of the peaceful application of nuclear energy;

(b) South Africa will not run the risk of details of the new process leaking out as a result of the safeguards inspection system; and

(c) the safeguards system, while efficient, is to be implemented on such a reasonable basis as to avoid interference with the normal efficient operation of the particular industries."

The Government's hopes for international nuclear collaboration were destined, for political reasons, to fail. During the 1970s certain nuclear weapon states tended to deny access to "sensitive" technology and materials to "politically unacceptable" states - a category into which South Africa increasingly fell. As a result, export permits for highly enriched fuel for SAFARI-1 were refused by the US administration in 1976, while in 1977 Congress enacted non-proliferation legislation precluding the transfer of nuclear technology to states not party to the NPT. In this political climate the search for partners to exploit South Africa's enrichment process on a commercial scale, proved futile.

The bilateral agreement on nuclear co-operation with the United States was, after the 1978 enactment of the Nuclear Non-Proliferation Act (NNPA), treated as a dead letter. South Africa was also concerned that the nuclear weapons states were exceedingly reluctant to honour their obligations in terms of Article IV, namely the parties' "inalienable right to develop research, production and use of nuclear energy without discrimination", and "to participate in the fullest possible exchange of equipment, materials and scientific and technological information"; and in terms of Article VI relating to the active pursuit of nuclear disarmament.

While its international political relations continued to deteriorate in the 1970s en 1980s, South Africa could discern no particular advantages in acceding to the NPT, but reconfirmed its adherence to non-proliferation as far as its own international nuclear relations were concerned.

In the latter part of the 1980's, far-reaching changes occurred in the international political arena, as well as in the Southern African region. South Africa's security position had improved dramatically by September 1989 and the political reforms introduced by new-elected State President, Mr F W de Klerk, paved the way for the termination of the nuclear deterrent program and South Africa's accession to the NNPT, and the resumption of its participation in the activities of the IAEA.

This also paved the way for closer participation with other African countries in the field of nuclear technology, and to unconditionally support the long-sought goal of declaring Africa a nuclear weapons free zone.

As South Africa is the first State to voluntarily give up the nuclear weapons option, the question arose: "How does a state which by the definition in NPT terms is not a nuclear weapons state, but which does possess nuclear weapons, acceed to the NPT?" For example, if such a State should accede to the NPT before it has destroyed its nuclear weapons, it would immediately be in breach of the Treaty.

One could, perhaps, as an alternative, enter into an INFCIRC-66 type Safeguard Agreement, by defining the nuclear devices as "nuclear explosives for peaceful purposes" and dismantle them under IAEA supervision. In this case only IAEA personnel from Nuclear Weapon States should be allowed to supervise the process and to prevent proliferation of weapons technology. Clearly, such an option cannot seriously be considered.

The only viable alternative is the "do-it-yourself" option, which was also the option chosen by South Africa, namely to dismantle and destroy the nuclear explosive devices completely and then acceed to the NPT as a truly non Nuclear Weapon State.

Unfortunately, as South Africa was well aware, such a State then faces the problem of convincing the IAEA and the international community of its credibility and of the so-called "completeness" of its inventory of nuclear materials and installations.

South Africa therefore offered to the Director General of the IAEA in February 1991, six months before its accession to the NPT, to make all the operating records of the enrichment plants available to the IAEA.

The only way in which the international community can be assured of such a State's credibility, is to adopt a policy of full transparency. This, in fact, entails that the IAEA should have free access to all past records of all nuclear activities and to all locations previously engaged in nuclear activities, as well as to any other location identified by the IAEA.

In practice, the IAEA inspectors were able to make use of the following in their verification exercise:

- all historical nuclear material inventories and flows for a period of more than 15 years;
- all available commissioning and operating records of both enrichment plants, spanning a period of more than 15 years for the pilot enrichment plant, where the HEU was produced, and a period of more than 6 years for the semi-commercial ennrichment plant where LEU production still takes place;
- full details of the nuclear deterrent programme;
- free access by the IAEA to numerous former facilities, now converted to commercial non-nuclear use as well as to private industrial companies, military testing sites and conventional armaments factories;
- free access to identified key individuals associated with the past deterrent programme, of whom a number had already transferred to private industry;
- free access to the independent auditor appointed by the State President to audit the dismantling process of the nuclear devices;
- permission to take as many environmental samples from any location as they wished; and
- supervision of the destruction of the two test shafts in the Kalahari.

In return, South Africa insisted on the IAEA maintaining:

(a) no political bias;

(b) continuity of, and professionalism by safeguards inspectors, and the

(c) maintenance of confidentiality of all sensitive information transferred to the IAEA.

The last requirement is for non-proliferation as well as for commercial and security reasons.

These conditions were fully met by both parties, and by September 1993 South Africa was given a "clean bill of health" by the IAEA [6)].

When the NPT was drafted in the 1960s, the world was simply divided into non-Nuclear Weapons States and Nuclear Weapons States. In the non-ideal world of the 1980s and 90s, however, a third categry, namely that of so-called 'threshold countries' has come into existence, which shows up the inadequacies of the NPT and its associated instruments for safeguards application, even if such a country exercises the roll-back option before accession to the NPT.

The experience of South Africa's journey into the NPT is that these difficulties can probably only be overcome by a conscious political decision to be fully transparent and open towards the IAEA. In return the IAEA must respect the reasonable wishes of the country acceding to the NPT, so contributing to openness and transparency. Finally, with the objective of furthering the cause of non-proliferation, the international community should take care not to impose undue political stresses and strains on an already difficult process.

THE FUTURE

South Africa's policy in the future will be directed towards supporting the nuclear non-proliferation regime and developing the peaceful uses of nuclear energy, to the benefit of all its people.

South Africa is implementing export policies commensurate with established nuclear non-proliferation guidelines, which also include dual use technologies. A new Act on the Non-proliferation of Weapons of Mass Destruction was passed by Parliament in 1993 making it illegal for any South African citizen to assist in any program related to the construction of these weapons. South Africa also intends to co-operate fully with its African neighbours in creating a climate conducive to the establishment of a NWFZ for Africa.

South Africa has also accepted membership of the Zangger Committee and has indicated its willingness to join in the activities of the Nuclear Suppliers Group. It became a member of the Missile Technology Control Regime in 1993.

As a major producer of uranium, South Africa will continue to pursue the commercial enrichment of uranium. Likewise, the fabrication of nuclear fuel will remain for as long as this activity is commercially viable.

CONCLUSION

The NPT, although severely flawed, and perhaps outdated by global developments in the past 24 years since it came into force, is still the only international treaty which has as its main goal the limitation and ultimate eradication of nuclear weapons on this planet.

Whether this treaty will be extended in 1995 in its present form or not, we sincerely hope that a way will be found, even if it entails a redrafting of the NPT or a completely new treaty, to which all countries of the world will accede, of ensuring that nuclear energy and technology shall be used solely for the benefit of all mankind and not for its destruction.

REFERENCES

1. Stumpf, W E: "South Africa's Nuclear Weapons Programme", to be published in the proceedings of a Conference on **Proliferation: A Cost/Benefit Analysis** held in New Delhi on 8 and 9 November 1993 and organised by Kathleen Bailey (Editor) of the Centre for Security and Technology Studies of the Lawrence Livermore National Laboratory, US.

2. De Villiers, J W L, Jardine, R and Reiss, M: "Why South Africa Gave up the Bomb", published in **Foreign Affairs**, Nov/Dec 1993 by the Council on Foreign Relations, Inc.

3. Shearar, J B: "Denuclearisation in Africa: The South African Dimension", published in the quarterly review **Disarmament**, by the Office for Disarmament Affairs of the United Nations, Vol XVI, No 2, 1993.

4. Stumpf, W E: Presentation at the PPNN Workshop: "Africa and Nuclear Non-Proliferation", held in Harare, Zimbabwe, on 2 to 4 April 1993 and to be published by PPNN.

5. Buys, André: "South Africa's Nuclear Weapons Capability", published in ARMSCOR's annual magazine Salvo, 2/93.

6. Report by the Director General of the IAEA: "The Agency's Verification Activities in South Africa", IAEA Document GOV/2684 of 8 September 1993.

History and Prospects for Resolution of the North Korean Nuclear Issues

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April 13, 1994

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Contents

1. Introduction

North Korea warned on 31 January 1994 that if the United States continued to demand comprehensive IAEA inspections of its nuclear facilities, it could reverse its decision to stay in the NPT.[1]

The U.S. State Department, commenting on North Korean threat to withdraw from the Nuclear Nonproliferation Treaty (NPT), reiterated on 31 January that the United States will have to refer the North Korean nuclear issue to the United Nations if there is no progress in negotiations between Pyongyang and the International Atomic Energy Agency (IAEA).[2]

A U.S. State Department spokesman noted that North Korea still has not agreed to all the inspections the IAEA is asking for.

"If this approach doesn't bring progress toward resolving this issue," the spokesman said, "we'll have no choice but to return the matter to the U.N. Security Council."[3]

Meanwhile, it was reported that South Korea and the United States have agreed to refer the North Korean nuclear issue to the U.N. Security Council if Pyongyang and the IAEA fail to make any progress in their negotiations on inspections by Feb. 21, when the IAEA is scheduled to hold a board of directors' meeting in Vienna.[4]

By the way, Foreign Minister Han Sung-joo on 2 February 1994 called on Korean diplomats to stop seeing the inter-Korean issue from a negative or confrontational perspective.

Han said South Koreans who deal with inter-Korean issues including Pyongyang's nuclear question should understand these issues are not zerosum games.

"We also gain when North Korea gains something,"

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1 *The Korea Herald*, February 2, 1994
2 *Ibid.*
3 *Ibid.*
4 *Ibid.*

he said.

Han said Seoul's short-term goal in the issue is, of course, securing transparency of North Korea's nuclear program. But what's also important is to prevent the situation from deteriorating, he said.

"We should take into account our relations with North Korea in general," Han said in a speech at the opening session of the annual conference of heads of Korean diplomatic missions.

But the minister said North Korea would not gain anything from its nuclear program, although some may say it is successfully delaying negotiations with the South and the United States and therefore has earned time to develop nuclear weapons.

"Time is on our side. North Korea cannot win anything by delaying the settlement," he said.[5]

South Korea opposition Democratic Party leader Lee Ki-taek said on 1 February that he is opposed to any international sanctions against Pyongyang to resolve the North Korean nuclear issue.

"I expect the nuclear problem on the Korean Peninsula to be settled in a peaceful way within this year," Lee said in a news conference with the Seoul Foreign Correspondents' Club held at the Press Center, downtown Seoul.[6]

Commenting on the declaration by the Seoul and Pyongyang governments on denuclearization of the peninsula in 1992, Lee said peaceful use of the nuclear energy should not be hindered.[7]

"For the same reason, I object to turning the declaration into an international treaty," Lee said.[8]

Lee reaffirmed his position on his plan to meet with North Korean President Kim Il-sung in Pyongyang.

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5 *The Korea Herald,* February 3,1994
6 *The Korea Herald,* February 1, 1994
7 *Ibid.*
8 *Ibid.*

"As soon as the special National Assembly session winds up in early March, I will file an application with the government to visit North Korea," said Lee.

"I will discuss with Kim Il-sung various pending inter-Korean issues such as the easing of tensions on the peninsula, resumption of talks, economic cooperation, and reunion of separated families," he added.[9]

Lee said a recent poll by the DP found 55 percent of the people in favor of his planned visit to Pyongyang, while just 22 percent responded negatively.

The opposition leader also urged the administration to show more independent attitude toward the negotiations to solve the North Korean nuclear problem.[10]

"The absence of Seoul negotiators in the talks to settle the nuclear issue can be serious obstacle to the national unification," Lee said.

"The government should break away from the practice of depending too much on the United States," he said.[11]

North Korea is reported to know how to process plutonium, and has achieved considerable level in means of warhead delivery, the last stage of nuclear weapon development. Nevertheless, they deny they have a nuclear weapons project and are pursuing an ambiguous policy in order to maximize the interests of the regime. Through accepting nuclear inspection and then withdrawing from the NPT, North Korea has indirectly revealed its capacity in nuclear development and at the same time has achieved military, political and diplomatic objectives, all the while denying any intention to make nuclear weapons. In consequence, North Korea has made possible bilateral talks with the U.S. through a diplomacy offensive of withdrawing from the NPT, and has succeeded in producing joint statements on some

9 *Ibid.*
10 *Ibid.*
11 *Ibid.*

crucial points towards its own advantage.

While Pyongyang is using a procedural strategy of achieving nuclear armament through this policy of *ambiguity*, the United States is making every possible effort to block it from achieving its objective. Such contrary positions of the concerned parties is indeed a deteriorating factor in their relationship. Yet North Korea is gradually inducing the U.S. into an improved relationship by taking advantage of the nuclear issue. North Korea can now control the U.S. by accepting to a limited degree the demands for inspection, while attaining political, economic and security benefits from the United States.

After the heightened three weeks, North Korea finally bows to deadline on the UN inspection of its nuclear sites.

Just days before a deadline that would have heightened its confrontation with the West, North Korea on 15 February reversed itself and told the International Atomic Energy Agency that it would permit a full inspection of its suspected nuclear sites.

The UN agency said: "Representatives of the Democratic People's Republic of Korea today informed the International Atomic Energy Agency that DPRK authorities accept the inspection activities which have been requested by the IAEA in the seven declared nuclear facilities."

North Korea sent a telegram informing the IAEA secretariat that it would issue visas for members of the IAEA inspection team after seeing the outcome of its talks with the United States, held in New York on 22 February.

North Korea and the United States may hold a working-level meeting in New York on 22 February to discuss the schedule for outside inspection of Pyongyang's nuclear facilities and a third round of high-level talks between the two countries.

It is reported that at this working-level meeting, the

U.S. and North Korea agrees to hold a third round of high-level talks between the two countries. And also it is reported·that both agrees to IAEA inspection teams' entry to Pyongyang.

South Korean President Kim Young-sam also said on 23 February that he had become "very sure that in the end North Korea will accept the nuclear inspections" that the United States and its allies have demanded for more than a year.[12]

Now I myself think that it is better for me to fix analyzing order as follows: (1)History of North Korean Nuclear Issues (2)Prospects for Resolution of the North Korean Nuclear Issues (3)Concluding Remarks.

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12 _The Korea Herald,_ February 25, 1994

2. History of the North Korean Nuclear Issues

(1) North Korea's signing of the IAEA fullscope safeguards agreement

The two Koreas signed the Joint Declaration on the Denuclearization of the Korean Peninsula on 31 December 1991. This declaration established eight principles for the denuclearization of the peninsula. Both sides would be prohibited from testing, manufacturing, producing, receiving, possessing, storing, deploying, or using nuclear weapons. The declaration also banned the operation of nuclear reprocessing and enrichment facilities and confirmed that nuclear energy would be used for peaceful purposes only. Immediately after signing the agreement, on 7 January 1992, South Korea announced that 1992 Team Spirit annual military exercises would not be conducted and simultaneously North Korea promised to sign the IAEA safeguards agreement and accept its inspections.

The North signed the IAEA fullscope safeguards agreement on 30 January 1992, and ratified it on 9 April. The IAEA carried out three ad hoc inspections of North Korean nuclear facilities in May, July, and September of 1992. Pyongyang also signed a subsidiary agreement with the IAEA on 10 July 1992. That North Korea agreed to the Denuclearization Declaration and accepted the IAEA inspections signified a retreat from previous rigid positions. The North originally wanted to turn the Korean peninsula into a nuclear-weapons-free zone that would effectively bar transit of US aircraft and ships to or through South Korea. After joining the NPT in December 1985, Pyongyang had not fulfilled its obligation to sign within the 18 months and IAEA agreement and accept inspection of its nuclear facilities. These policy changes reflect its struggle to escape economic and diplomatic difficulties. North Korea had wanted to normalize its relations with the US and Japan and get economic help from them, but to do so was obliged to reduce tensions on the peninsula by resuming dialogue with the South and removing international suspicions over nuclear activities. The changes also make it possible to presume that the reformers got the upper hand over the hard-liners in the North Korean bureaucracy.

To verify denuclearization, the two Koreas will inspect objects or sites chosen by the state conducting the inspection, but agreed upon by both sides. A Joint Nuclear Control Commission(JNCC) was established on 19 March 1992, to negotiate and implement these reciprocal inspections. Until 30 September 1992 the two Koreas held eight plenary and five working-level JNCC meetings. But the negotiations were unsuccessful because the two sides disagreed on how to choose inspection objects and methods.[13] Nevertheless, the two Koreas did have in-depth discussions on the inspection regulations and reached some consensus on the verification of nuclear materials and facilities.[14]

(2) Resumption of the 1993 Team Spirit Joint Military Exercises

Even though North Korea accepted three ad hoc inspections, South Korea and the United States believed that suspicions over the nuclear program had not been fully cleared. Seoul and Washington decided to resume the 1993 Team Spirit exercises unless meaningful progress were achieved in the JNCC negotiations on reciprocal inspections. It seems that the South Korean and US Bush administrations felt that further pressure

13 For more details on North and South Korean positions on reciprocal nuclear inspections, see Seong W.Cheon, "Verifying a Denuclearized Korean Peninsula: Current Negotiating Agenda," in Steven Mataija and J. Marshall Beier (eds.), *Multilateral Verification and The Post-Gulf Environment: Learning From the UNSCOM Experience* (Toronto: York University, 1992),pp.173-86.

14 *Hankook Ilbo,* September 20 1992.

on North Korea would be effective. According to Selig Harrison, since the first DPRK-US high-level meeting in New York on 22 January 1992, Seoul and Washington abandoned the carrot-and-stick policy, "refusing to engage in further high-level dialogue or to discuss at any level what the size and content of the carrot would be."[15]

In response, rather than yielding to pressure North Korea strongly criticized the resumption of the Team Spirit exercises and stopped all North-South Korean dialogues except the JNCC. Pyongyang rejected the establishment of a hot-line between the two Korean military authorities and revoked scheduled meetings of four Joint Commissions including the Joint Military Commission.

At the subsequent JNCC meetings, North Korea continued to demand the cancellation of the Team Spirit exercises. Five plenary and three working level JNCC meetings were held from 14 October 1992 to 25 January 1993. Pyongyang argued that it would negotiate inspection regulations on condition that the Team Spirit exercises would stop, and thus no progress was achieved at all. On 26 January 1993, Seoul and Washington issued an official announcement that the 1993 Team Spirit exercises would be carried out as planned. North Korea reacted by declaring it would close all the North-South communication channels including the JNCC.

In spite of increasing tensions between the two Koreas, however, IAEA inspections of North Korean nuclear facilities continued. Three more ad hoc inspections were carried out in November and December

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15 He further stated that "this approach has been completely insensitive to the internal debate in Pyongyang and has progressively undermined the position of the reform elements." Selig Harrison, "Korea at the Crossroads: Absorption, Confederation or Chaos?" paper presented at an international conference held by *Seoul Shinmun*, in Seoul, April 9-10 1993.

of 1992 and February of 1993.

(3) IAEA resolution demanding special inspection over the North Korea

At the initial report to the IAEA, North Korea declared that it extracted 90g of plutonium in March 1990. The IAEA is suspicious of the truthfulness of the North's report and is sure that Pyongyang extracted at least 148g of plutonium on three occasions 1989,1990,1991).[16] In order to clarify this point, the IAEA requested inspection of two undeclared facilities. North Korea rejected the demand and a controversy came about over the special inspection.

The IAEA concluded that there existed "significant inconsistencies" between what Pyongyang reported to the IAEA and what the IAEA has found. In order to resolve them the IAEA demanded special inspection of the two undeclared sites believed to be nuclear waste sites. North Korea argued that they are military sites and thus not subject to the inspections. Pyongyang also warned that it would take "self-defensive measures" if further improper actions were taken against it. The IAEA took serious note of the significant inconsistencies and adopted resolution 2636 on 25 February 1993. It called upon the DPRK to cooperate fully and accept the special inspection within a month. North Korea argued that the request of special inspection infringed on its sovereignty and the IAEA had lost its fairness, that it would not accept the demand and would take self-defensive measures to protect its sovereignty.

Pyongyang refused to accept the special inspection saying that the IAEA has no right to use intelligence provided by a third country, and that military facilities not related with nuclear activities should not be

16 Kim Hyeh-won, "P'yong agrees on IAEA examination of N-samples," *Korea Herald*, March 6 1993.

inspection objects. The North Korean argument, however, is not justified.

Firstly, there is no provision either in the NPT or in the IAEA fullscope safeguards agreement that prohibits the use of information provided by a third country. The IAEA with its lack of independent monitoring capabilities finds it essential to have nuclear-related information. For example, Hans Blix, the director general of the IAEA, said that intelligence from the member countries including the United States had been critical to find secret nuclear facilities in Iraq, and emphasized the importance of information.[17]

Secondly, it is not correct to say that the IAEA has no right to conduct inspections of military facilities not related with nuclear activities. Again, there is no provision either in the NPT or in the IAEA fullscope safeguards agreement that excludes military facilities from inspection objects. Facilities where nuclear material does not always exist can be inspected.[18]

With the IAEA adoption of the special inspection resolution, tension has greatly increased on the Korean peninsula. One day before the Team Spirit field maneuver began on 9 March 1993 North Korea proclaimed a state of semi-war.[19] Subsequently, on 10 March 1993, North Korean Minister of Foreign Affairs sent an official report to the IAEA and refused its special inspection request.

(4) North Korea's decision to withdraw from the NPT

Criticizing the Team Spirit military exercises and the IAEA's enforcing special inspection, the DPRK

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17 *Arms Control Today*, Vol. 21, No.9(November 1991), pp.3-6.

18 George Bunn, "Does the Non-Proliferation Treaty(NPT) require its non-nuclear weapon members to permit inspection by the International Atomic Energy Agency(IAEA) of nuclear activities that have not been reported to the IAEA?" *CISAC Working Paper* (Stanford: Center for International Security and Arms Control, Stanford University, May 1992), p.12.

19 Pyongyang lifted the semi-war state on March 24 1993.

government announced that it would withdraw from the NPT to protect the supreme interests of its country. North Korea also argued that it would counter any collective offensive and pressure expected from the UN Security Council.[20]

Although the decision to withdraw from the NPT was a surprise to international society, Pyongyang made it clear that it would not preclude the possibility of negotiation. In the withdrawal announcement, North Korea stated that it would not change its attitudes until the American nuclear threat ceased and the IAEA restored its impartiality. In addition, almost every statement issued by the North Korean authorities since the withdrawal announcement have emphasized settling the problem through bargaining with the United States. The North Korean ambassador in Geneva and deputy ambassador in the United Nations, for example, have listed the following conditions as quid pro quo for returning to the NPT: (1) termination of the Team Spirit exercises, (2) inspection of the US military bases in South Korea, (3) removal of the nuclear threat against North Korea, (4) no US nuclear umbrella over South Korea, (5) respect for North Korean socialism, (6) restoration of IAEA impartiality and neutrality.[21]

On the other hand, the IAEA repeatedly called for North Korea to accept the special inspections, and the North rejected the demand. Pyongyang further argued that it would take "strong self-defensive measures" if North Korea's nuclear problem were presented to the UN Security Council and pressure continued from there.[22]

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20 Press conference of the First Deputy Minister of Foreign Affairs, Choson Central News Agency(Pyongyang: March 12 1993).

21 *Segye Times,* March 16 1993; *Mainichi Shimbun,* March 17, April 21 1993.

22 A statement issued by the spokesman of the Ministry of Foreign Affairs, *Rodong Shinmun,* March 29 1993.

(5) The UN Security Council resolution

On April 1, 1993, the Board of Governors of the IAEA accused the DPRK of non-compliance and submitted the North Korean nuclear problem to the UN Security Council. In response North Korea blamed the IAEA for attempting to liquidate her socialism and declared it would take "effective and strong self-defensive" measures.[23] Even having called for UN involvement and in spite of Pyongyang's vehement criticism, the IAEA made clear its willingness to hold consultations with Pyongyang.[24]

At the United Nations, extensive consultations and negotiations were held to find an optimal solution to settle the problem peacefully, and on 12 May 1993 the Security Council adopted resolution 825. It (1)calls upon the DPRK to reconsider the announcement that it would withdraw from the NPT, (2)calls upon Pyongyang to respect its nonproliferation obligations and to comply with the IAEA safeguards agreement, (3)requests the director general of the IAEA to continue to consult with North Korea, (4)urges all member states to encourage the North to respond positively to the resolution, and (5) decides to consider further Security Council action as necessary.

(6) Pyongyang-Washington bilateral talks

After the Security Council adopted that first resolution, dialogue was activated among the concerned parties. In particular, just as North Korea had long been seeking, government-level talks were realized with the United States. A series of bilateral meetings were held in two consecutive rounds from June to July 1993.

At the first round, in New York on 2-11 June 1993,

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23 Press conference of the North Korean ambassador to Vienna, *Joong-ang Daily News*, April 2 1993.

24 Press conference of Hans Blix, *Joong-ang Daily News*, April 2 1993.

the DPRK government decided to suspend as long as it considers necessary the effectuation of its withdrawal from the NPT. And both sides agreed on the following principles:(1)assurances against the threat and use of force including nuclear weapons,(2)impartial application of fullscope safeguards,(3)mutual respect for each other's sovereignty,(4)non-interference in each other's internal affairs,(5)support for the peaceful reunification of Korea.

They also expressed their support for the Joint Declaration on the Denuclearization of the Korean Peninsula. There were divergent assessments between Washington and Seoul on the result of the first round of the talks. US President Clinton praised North Korea's decision not to leave the NPT and stated that the talks were the first and important step to resolve North Korean nuclear problem.[25] On the other hand, South Korean President Kim Young-sam repeatedly indicated that the US should make no further concessions to North Korea.[26]

The second round of the bilateral meetings was held at Geneva on 14-19 July 1993. Despite hawkish remarks on the part of President Clinton,[27] the two sides also produced some meaningful results. At the meetings, both sides agreed that full and impartial application of IAEA safeguards is essential to accomplish a strong international nuclear nonproliferation regime. They also reaffirmed the importance of the implementation of the North-South Denuclearization Declaration. North Korea promised to begin consultations with the IAEA on safeguards issues and to resume North-South talks on bilateral issues including the nuclear one. The United States specifically reaffirmed its commitment to the

25 *Joong-ang Daily News*, June 12 1993.

26 *Han-kyoreh Shinmun*, June 26 1993; *Choson Ilbo*, July 3 1993.

27 During his visit to the Demilitarized Zone near the border between North and South Korea, he warned the North Koreans that if they ever use nuclear weapons, "it would be the end of their country as they know it." Ruth Marcus, "Clinton to North Korea: Forget the Bomb," *International Herald Tribune*, July 12 1993.

principle of assurances against the threat and use of force including nuclear weapons. Washington also made clear its intention to support the conversion of the North Korean nuclear reactors from the current graphite moderated to light water moderated reactors(LWRs). The two sides agreed to meet again in the next two months. Unlike the first round of the talks, Seoul and Washington agreed that the second round made some important progress towards resolving the issue.

3. Prospects for Resolution of the North Korean Nuclear Issues

(1) DPRK-US talks

In the midst of mixed assessment of the U.S. policy circles over the North's nuclear capability, the earliest worst case scenarios positing a highly sophisticated, extensive, and advanced nuclear weapons program have been replaced by a more factual assessment.[28] Most observers expect that ongoing IAEA inspections will make it extremely difficult for the DPRK to use its Yongbyon facilities for illicit reprocessing of plutonium on a significant scale, or for other purposes related to nuclear weapons development.

This does not, however, "solve" North Korea's nuclear problem or remove the need for a separate, bilateral nuclear inspection regime between South and North. The U.S. strongly supports the ROK government's position that two Koreas must adopt a credible and effective inspection regime, allowing inspections, at short notice, of any site (so-called no sanctuary) to which

28 U.S. serious concern was raised by Bill Gates, CIA Director's testimony before the U.S. House of Representatives, Armed Services Committee on March 27, 1992 which presented "Pyongyang is close, perhaps very close to having a nuclear weapon capability." But in the process of the North's acceptance of the series of the IAEA's ad hoc inspections, such urgency seemed to be faded until recently when the IAEA's 6th round of inspection in January 1993.

suspicions are attached.

Pyongyang has tried in making efforts to shift world attention away from the nuclear issue, but finally faced the challenge of no excuse in February 1993 when it denied the access of the IAEA inspection to two undeclared sites, which are presumably containing nuclear waste. In addition, the IAEA's disclosure of the inspection results of some discrepancies between the North's reports of nuclear materials and the IAEA's findings heightened the international suspicion. In a scheduled meeting of the IAEA in February 1993, the IAEA strongly requested the North to accept the special inspections on two unreported sites and is waiting for the North's response before March 25.[29]

Even though North Korea's nuclear issue is now at the international community which seeks a strong determination to regulate proliferation of mass-destructive weapons, the issue is intrinsically the one of the Korean Triangle--two Koreas and the United States.[30] That is why North Korea is claiming that the IAEA is manipulated by the U.S. counting upon the U.S. intelligence reports on the North's nuclear program.[31]

North Korea has recently been demonstrating its eagerness to normalize its diplomatic relations with the U.S. and tended to believe that it has taken necessary steps to satisfy the U.S. demands including the improvement of inter-Korean dialogue, accepting the

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29 North Korea did not respond favorably before March 31, 1993, an extended deadline for the North's reply to the IAEA regarding acceptance of special inspection by the IAEA.

30 Sung-Joo Han, "The Korean Triangle: the United States and the Two Koreas," in Chong-Sik Lee and Se-Hee Yoo(eds.), *North Korea in Transition* (Berkeley, CA:Center for Korean Studies, Institute of East Asian Studies, University of California at Berkeley, 1991), pp.43-53.

31 Just after North Korea's announcement to withdraw from the NPT, several statements by North Korean high-ranking officials including Ambassador to Beijing Chu, Deputy Foreign Minister Kang have justified their decision by criticizing the U.S. which manipulates the IAEA to impose unfair inspections over the North.

IAEA inspections, and return of the Korean War remains. After rounds of efforts with friendly gesture, but with no substantive outcome, the North became realized that the new Clinton administration in the U.S. won't be flexible in its policy of non-proliferation and even tougher in solution of the North's nuclear weapons problem.

Despite the rhetoric of North Korean statements, the defensiveness of their position and the precariousness of their situation are all too evident. North Korea is currently grappling with several sets of conflicting goals: to guarantee its separate status while championing reunification; to severely criticize the ROK regime as an imperialist puppet while seeking to engage the South in economic enterprises in the North and mutual security assurances; to deal with its hostility toward Japan while seeking Japan's economic help; to use the United States as a whipping boy while urging improved U.S.-DPRK relations; to maintain serviceable ties with Moscow and even better relations with Beijing while smarting from those governments' movement toward Seoul; to plan for outside economic involvement in North Korea from all these sources while containing the impact of that involvement on the DPRK political and economic system; and to maintain a high level of military expenditure when the rest of the economy cries out for attention.[32]

Whatever the nature and dimensions of debate within the power structure of the DPRK over the desirability of various courses, the DPRK leadership recognizes its problems and hopefully has the capability to take at least some difficult decisions, even if within the constraint of preserving the core domestic system. This has been and still is an important factor in the growing inter-Korean dialogue and the North's relations with the

32 Alan D.Romberg, "North Korea: An American Approach," a paper prepared for Center for Strategic and International Studies Project on "Implications of Korean Peninsula Developments for U.S.-Japan Relations," January 1993, Seoul, p.5.

United States and Japan.[33]

(2) DPRK-ROK talks

During the second round of the DPRK-US negotiations in Geneva, North Korea promised it would resume dialogue with South Korea. Since Washington made progress in the second negotiation track a precondition for its own future talks with Pyongyang, Seoul-Pyongyang talks will resume in parallel with Pyongyang-IAEA talks.

The ROK Foreign Ministry stated that the second round of DPRK-US talks was important progress for the resolution of the North Korean nuclear problem.[34] The Foreign Ministry also noted that the North's recognition of the need for a non-proliferation regime and the importance of the Denuclearization Declaration as well as its willingness to begin consultations with the IAEA and South Korea are all on the right path to solve the current dilemma.

Since the North Korean NPT withdrawal announcement the two Koreas have attempted to meet and resolve the pending issues. On May 20, 1993, Seoul proposed that talks on the nuclear and other bilateral issues take place between the members of delegation of the inter-Korean High-Level Talks. North Korea, in response, came up with a counterproposal offering three stages of inter-Korean contacts:(1)working level contacts at the deputy minister level,(2)exchange of presidential emissaries to each side's capital,(3)an inter-Korean summit. South Korea accepted part of the North Korean proposal and offered to have a working-level meeting to discuss the nuclear and special-envoy issues together. North Korea insisted that at the working-level meeting, only the presidential emissary issue should be discussed

33 See Jeong Woo Kil, "Changes in U.S.-North Korean Relations," in *Seoul and Washington: New Governments, New Leadership and New Objectives* (Seoul: The Korean Council of Area Studies, 1993), pp.158~159.

34 *Han-kyoreh Shinmun, July 21 1993.*

and the nuclear issue could be an agendum for special envoys. In spite of subsequent offers and counter-offers, the two sides' positions were not narrowed. On June 26, 1993, Pyongyang unilaterally withdrew its proposal to exchange special envoys and the bilateral contacts stopped.

Since the first round of the DPRK-US talks, the ROK government's position on the North Korean nuclear problem was: (1)if North Korea accepts the inspection of the two undeclared sites, a breakthrough for the nuclear issue will be achieved and businessmen will be allowed to visit North Korea, (2) if the North-South reciprocal inspection regulations are agreed, bilateral economic exchanges can proceed fully.[35] After the DPRK-US meetings in Geneva, the ROK government seems to be cautious but willing to promote active dialogue with Pyongyang. For example, Deputy Prime Minister of Unification Han Wan-Sang remarked that ; the government puts a high value on the results of the Geneva DPRK-US negotiations by praising North Korea's staying with the NPT and her reconfirmation of the importance of implementing the Denuclearization Declaration.[36] Based on such judgments, he added, South Korea would try to resume bilateral talks soon. At the moment, the Seoul government stands by the principle that improving bilateral relations and economic exchanges and cooperation should be preceded by the resolution of the nuclear issue. South Korea would want to resume the Joint Nuclear Control Commission(JNCC) and resolve the nuclear issue at the JNCC.

The format of the future DPRK-ROK talks would depend on whether the North Korean suggestion to exchange special envoys is realized. Noting that Kang Sok-Ju, the North Korean chief delegate of the DPRK-US talks, reemphasized that the exchange of presidential emissaries for the inter-Korean summit

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35 *Choson Ilbo*, June 23 1993.
36 *Han-kyoreh Shinmun*, July 22 1993.

should be held and the nuclear issue could be discussed during the exchange,[37] Pyongyang is expected to ask Seoul formally for such an exchange. The South Korean position is yet to be decided but there seems to be more flexibility on the issue than before.[38] Even if presidential emissaries are exchanged, only guidelines or some framework for inspection provisions can probably be agreed. Therefore, follow-on negotiations on detailed inspection regulations should be held regardless of the realization of the exchange of special envoys.

It is not clear whether the North has decided to accept the inspection of the two undeclared sites. It is presumed that intensive debates are going on in the North Korean bureaucracy. There is a good chance that Pyongyang will accept a modified version of the special inspection of the sites given that it receives reasonable benefits from Washington and Seoul including its own inspection of US military bases. The US and South Korea are willing to provide some concrete compensations for the North if the two sites are inspected regardless of the name and type of the inspection. The IAEA wants its reputation not to be damaged by failing to be able to exercise its special inspection right. At the same time, the IAEA has shown flexibility to an extent that it would not stick to the name of the special inspection so long as it is allowed access to the two sites. Based on these positions, as mentioned earlier, the IAEA and North and South Korea are likely to work out compromises to allow North Korea to save face.

Under the circumstances, an optimal solution might be

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37 Kang's remarks during his press conference after the second round of the DPRK-US meetings. The Choson Central News Agency (Pyongyang: July 20 1993).

38 For example, the Deputy Prime Minister of Unification stated that the format of the bilateral negotation is a secondary issue although he viewed that the timing for an exchange of special envoys is not ripe. *Hankook Ilbo*, July 23 1993.

found by associating the IAEA inspection with the North-South reciprocal inspection. To give a face saving solution to the North, who will be embarrassed by the discovery of nuclear materials at the supposed military facilities, it is likely that the IAEA inspection and the reciprocal inspection of the two undeclared sites and the two US bases in South Korea will be conducted simultaneously.[39] In this case, the IAEA's determination to exercise its special inspection right will not be undermined. On the other hand, North Korea could argue that it had only allowed the IAEA officials for a visit[40] and could give maximum publicity to her own inspection of US bases, which it has been long wanted.[41]

According to Seong W. Cheon, there would be six possible inspection formats as follows:

In the case of the IAEA inspection, IAEA could inspect the two sites and the US bases together (option A) or inspect the two sites only (option B). As for the reciprocal inspection, there are 3 options: the South inspects the two sites and the North does the two US bases (option C); only the North inspects the two US bases (option D); and no reciprocal inspection occurs at all (option E). Combining these two sets of options

39 After meeting Choi U-jin, the chairman of the northern side of the JNCC, in November 1992, Peter Hayes revealed that North Korea determined they would limit their inspections to perhaps one or two designated sites in the South. Peter Hays, *Nuclear Inspections in Korea: Rough Waters Ahead?* (Berkeley, CA: Nautilus Pacific Research, November 1992), p. 4. Previously, the North had insisted on simultaneous inspection of all US bases in South Korea. Although this issue was not discussed in depth between the two Koreas due to the controversy surrounding the 1993 Team Spirit military exercises, there is no sign that the North altered their position. Considering that two undeclared sites are in dispute, two US bases are likely to be the objects of the first reciprocal inspection.

40 Choi U-jin distinguished on November 13 1992, the IAEA "officials' visits" from the IAEA "inspectors' inspection." Choi stated that the North had permitted visits to some of undeclared sites in order to extend a spirit of cooperation to the IAEA. Peter Hayes, Nuclear *Inspections in Korea: Rough Waters Ahead?* p.3.

41 See Seong W.Cheon, "North Korea's Nuclear Problem: Current State and Future Prospects," *The Korean Journal of National Unification*, Vol.2, 1993, pp.96~99.

makes six.[42]

Six Possible Inspection Formats

Format	North Korea	South Korea	IAEA
1. (A and C)	O	O	△
2. (A and D)	O	X	△
3. (A and E)	X	X	△
4. (B and C)	O	O	O
5. (B and D)	O	X	O
6. (B and E)	X	X	O

Format 1: (A and C)—*The IAEA inspects the two undeclared sites and US military bases and reciprocal inspections are performed on the same objects.* The two Koreas would welcome format 1 (O), but the IAEA would not be enthusiastic (△) because the two US bases are obviously not related with nuclear activities.[43] A modified version of format 1 would let the IAEA inspectors participate in reciprocal inspections.

Format 2: (A and D)—*The IAEA verifies the two undeclared sites and the US bases and only North Korea is allowed to inspect tow US bases.* The North would like format 2 but the South would reject it because reciprocal inspections would not be realized. The IAEA would hold the same position as in format 1.

Format 3: (A and E)—*Only IAEA inspection of the*

42 *Ibid.*, p.100.

43 The IAEA inspection of US bases was suggested by Leonard Spector of the Carnegie Endowment. *Choson Ilbo,* March 18 1993. The IAEA would not take to the idea, however, in consideration of these two points:it is against the IAEA's long tradition not to inspect purely military bases, and IAEA inspection of the US bases could set a bad precedent for other regions. For example, countries in the Middle East might refuse inspections until the IAEA were to inspect military bases in Israel, which is believed to possess nuclear weapons.

two sites and two US bases. Pyongyang would reject format 3 since it wants to inspect US bases, and Seoul would not accept it either for the same reason as in format 2. The IAEA would take the same position as in format 1.

Format 4: (B and C)—*The two undeclared sites and two US bases are inspected through reciprocal inspections and the IAEA would inspect only the two sites at Yongbyon.* The two Koreas would welcome format 4 and the IAEA would like it as well.

Format 5: (B and D)—*The IAEA inspects the two undeclared sites and North Korea verifies two US bases.* The North would like format 5 but the South would reject it because reciprocal inspections would not be realized. The IAEA would take the same position as in format 4.

Format 6: (B and E) —*Only the IAEA inspects the two sites at Yongbyon.* As in format 3, Pyongyang and Seoul would reject format 6 but the IAEA has no reason to refuse it.

Among the six possible inspection formats, format 4 is most likely to be realized since all three parties would be satisfied. If the IAEA inspection of the two undeclared sites at Yongbyon and the first reciprocal inspection are conducted, it is thus highly probable that the IAEA will inspect the two undeclared sites while South and North Korea, through reciprocal inspections, verify the two sites and two US bases, respectively.[44]

4. Concluding Remarks

In principle, Pyongyang would like not only an upgraded dialogue but the establishment of full diplomatic relations with the United States. It would like

44 North-South reciprocal inspections may not be as intensive as those by the IAEA, which allow inspectors to enter buildings and take samples. Until a certain level of confidence is developed between Seoul and Pyongyang, reciprocal inspections would permit mere visits of sites but not allow any buildings to be entered.

the U.S. to be neutral as between North and South Korea, not siding with South Korea in every dispute. It would like the U.S. not to block other nations and international institutions, especially economic ones, from getting involved in its trade and investment activities. The North would like the United States to withdraw its forces from the South and to take other military steps including suspension of the Team Spiirit exercise to reduce pressure on the North. Pyongyang claims that all outstanding issues with Washington can be resolved through face-to-face talks. But while North Korea presses for such talks in a variety of ways, at this point its greatest concern seems to be not that the United States should go along with an easing of its terms, but rather to prevent the U.S. from actually toughening its position.[45]

The United States is willing to improve relations with the DPRK, but only on a basis that serves its broader aims on the peninsula, in the region and globally. From Washington's perspective, the most basic requirement is to undergird peace and stability in North-South Korean relations and to gain meaningful assurances regarding long-term security and prosperity for South Korea. U.S. position would not allow the American "neutrality" between North and South Korea or compromising on the U.S. security guarantee to Seoul.

Whether the U.S.-DPRK relations develops into establishment of full diplomatic relations will depend first and foremost on inter-Korean developments. Current issues of the U.S. concern--nuclear non-proliferation, control of missile exports, and anti-terrorism--still have relevance not simply to the Korean Peninsula but to broader American concerns as well. As a result, not only the Korea-policy community but a larger set of Washington actors will need to be

45 Alan D.Romberg, "North Korea: An American Approach," a paper prepared for Center for Strategic and International Studies Project on "Implications of Korean Peninsula Developments for U.S.-Japan Relations," January 1993, Seoul, pp.15-16.

satisfied in order for the U.S. government to forge the necessary consensus to move ahead in its relations with the DPRK.

Regardless of the change in North Korean approaches to the United States, it is generally believed that the U.S. is not going to move toward more normal relations in the absence of an ongoing, effective North-South inspection regime alongside a continuing pattern of full North Korean cooperation with the IAEA. Even if the nuclear issue is resolved, however, and highlevel dialogue proceeds, the problems to be addressed in the course of that dialogue will not be easy. Communications with the North Koreans are by no means easy for the U.S.. The problem of speaking across significant cultural barriers is magnified by the eccentric ideology of the Kim Il Sung regime and its relative unsophistication vis-a-vis the ways of the outside world.[46]

If Pyongyang wants to continue pushing for direct talks with the U.S., the North Korean leadership should understand that the result may be merely to harden U.S. attitudes if they only reiterate previous positions, if they seem to be seeking to go around Seoul's back, or if they lie about North Korean policies and actions (i.e. on nuclear issues or missiles)--that is what the U.S. should take into consideration in making its policy toward the DPRK.

Given complexity of the so-called "the Korean Triangle"--the United States and the two Koreas, however, it should be understood that North Korea alone cannot untie the triangular knot without help from Washington and Seoul. There is no doubt that such help can and should be prompted by a signal of serious change of the North Korean attitude.

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46 Daniel Russel, "U.S.--North Korean Relations," in _Current Issues in Korean-U.S. Relations: Korean-American Dialogue_ (Seoul: The Institute for Far Eastern Studies, 1993), p.50.

Anyway, the "package solution" to the nuclear dispute proposed by Pyongyang on Nov. 11, 1993 envisages North Korean concessions on U.S. nuclear inspection demands synchronized with U.S. diplomatic recognition, together with the removal of restrictions on trade and investment and help in obtaining multilateral credits similar to the role being played by the United States in the case of Ukraine.

Diplomatic recognition is the top priority because the North fears that the United States wants to promote its collapse and absorption by South Korea, repeating the German unification model. In the North's perspective, the normalization of political and economic relations would signify U.S. readiness to coexist. Equally important, economic help would compensate for the crippling loss of the economic subsidies provided during the Cold War by Russia and China.

The North is also seeking a U.S. pledge not to use or deploy nuclear weapons in Korea, through a bilateral agreement with North Korea or a multilateral accord involving Russia, China, North and South Korea and Japan.

In an effort to convince Washington that it has no intention of developing nuclear weapons, Pyongyang has asked for help in shifting from its graphite-based nuclear reactors to light-water reactors, which are less easily adapted to a weapons program.[47] This would involve an estimated $2 billion in credits over 10 years to be shared by the United States, Japan, South Korea and multilateral agencies.

Pyongyang, for its part, has signaled that it is prepared to return to full membership in the Nonproliferation Treaty and to open up its declared nuclear facilities to unimpeded, regular International Atomic Energy Agency inspections. This would include

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47 Woo Chung," North Korea's Nuclear Weapons Development Program Emerges as Threat to Global Village," *EAST ASIAN REVIEW*, Vol.V.No.3 (Autumn 1993), pp.119-120.

full access to the key five-megawatt reactor and reprocessing plant at Yongbyon.

A compromise formula to permit inspection of two suspected waste dumps appears increasingly likely, provided these are not designated as "special inspections," thus setting a precedent for inspection of other undeclared nuclear facilities. The North Korean armed forces fear that random access to military bases through "special inspections" could be used for espionage purposes by U.S. and South Korean intelligence agents working under IAEA cover.

Ukraine is in a stronger bargaining position than North Korea because it possesses intercontinental nuclear missiles that pose a clear threat to America. North Korea, by contrast, poses a hypothetical future threat.

Using identical evidence available to all of them, American intelligence agencies differ on whether North Korea has accumulated enough plutonium to make one or more bombs and whether it has the trigger technology necessary to detonate a nuclear weapon. Nevertheless, the United States is properly concerned that continued uncertainty over North Korean capabilities is stimulating pronuclear sentiment in Japan[48] and South Korea.

The essence of Pyongyang's position is its insistence on simultaneous concessions. Washington has argued that the North must give in on inspections first to fulfill its obligations as a signatory of the Nuclear Nonproliferation Treaty. The tortuous preliminary negotiations during the past three months have been

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48 In testimony in Congress in November, Paul D Wolfowitz, a former Defense Department official and ambassador to Indonesia, expressed fear that North Korea would "push Japan into military programs that Japan has so far strongly resisted."

Brent Scowcroft, George Bush's national security adviser, and Arnold Kanter, who dealt with North Korean issues in the State Department, have made similar statements.

David E. Sanger, "Japan Makes It Sharp and Clear: Nuclear Arms Are Out," *International Herald Tribune*, February 2, 1994.

over how much Pyongyang would have to concede on inspection before the United States would agree to link a nuclear settlement with political and economic issues.

The Clinton administration is deeply divided over whether to engage in negotiations on a "package solution" at all and what tradeoffs to offer if it does. Hard-liners argue that giving too much would tempt Iran and other would-be nuclear powers to engage in "nuclear blackmail" of their own. But the benefits of getting North Korea to give up its nuclear option outweigh this concern.

Apart from defusing pro-nuclear sentiment in Tokyo and Seoul, resolution of the nuclear dispute with Pyongyang would remove the need for a costly conventional military buildup throughout Northeast Asia. The Pentagon is already planning for a possible increase in U.S. capabilities in South Korea, including Patriot missiles,[49] and for an $8 billion U.S. -Japanese Theater High-Altitude Area Defense System to counter the threat that would be posed by nuclear-capable North Korean missiles.[50]

In its latest retort in the dispute over its nuclear program, North Korea warned on 3 February 1994 that U.S. pressure could provoke an intense response -- one that "will be carried into practical action."

In a strongly worded commentary distributed by the Korean Central News Agency, North Korea said it had an "expedient to counter any other option of the United States."

"It is not the United States alone that has the expedient," it said, "and the option is not open only for a big power."

The comments appeared as a partial response to a

49 Mary B. Kim, "For business, politics or security," _The Korea Herald_, February 3, 1994.

50 Selig S. Harrison, "Incentives to Make Renunciation of Nuclear Arms Pay," *International Herald Tribune*, February 1, 1994

resolution passed earlier this week by the U.S. Senate urging Washington to prepare to return tactical nuclear weapons to South Korea if talks with North Korea remain at an impasse.[51]

In Hong Kong, the U.S. evangelist Billy Graham said he had received a message for President Bill Clinton from President Kim Il Sung of North Korea. Mr.Graham said leaders on both sides should pray "that somebody doesn't make a mistake."[52]

Japan and South Korea also have urged Washington to tread carefully on the issue, fearing an extreme reaction by the unpredictable North Korean leadership.

Russia's new envoy in Seoul criticized U.S. policy toward North Korea on 3 February 1994 saying that pressure tactics should not be used.

"The nuclear issue must be solved," Ambassador George Kunadze said," but not by backing North Korea up against a corner."[53]

By the way, the only way to stop nuclear proliferation without paying off would-be nuclear powers in one form or another is to move purposefully toward a nuclear-free world.

NYT raised a "nuclear-free Korea" as follows:

It is especially important to resume regular inspections by summer, when North Korea will have to shut down its reactor and replace the fuel rods. At that time, inspectors will be able to weigh and assay the nuclear material to find out whether any of it was diverted in the past, and if so, how many bombs' worth. Special inspections of suspected North Korean nuclear waste sites might also be necessary for that

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51 "North Korean Threats Mount: A Warning of 'Practial Action' Against U.S.," *International Herald Tribune*, February 4, 1994

52 *Ibid.*

53 *Ibid.*

purpose. Those, too, would have to be negotiated.

The Clinton administration should be prepared to pay a reasonable price to gain such access—by meeting the North's demands for improved relations, giving security assurances, providing reactors that are less proliferation-prone, and offering trade and aid.

Diplomacy will cost a lot less than confrontation, and it just might get what the world wants—nuclear-free Korea.[54]

Now, what is more important is that the conception of a "nuclear-free world" will be also addressed in the logic of a "nuclear-free Korea".

For the logic of a "nuclear-free Korea" raised by *The New York Times'* editorial on 18 February, 1994, is closely related to "moving toward a nuclear-free world."[55]

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54 Editorial of *The New York Times*, February 18, 1994

55 *Ibid.*

セッション2
原子力発電とプルトニウム

＜基調講演＞

「プルトニウムと文明」

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＜参加者との討論＞

Plutonium and Civilization

Address for April 14, 1994;
Hiroshima International Convention Hall
27th Annual Meeting of the Atomic Energy Industry

Yumi Akimoto
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I. Why Plutonium?

1. Gold and Plutonium (Angel or Devil?)

Since the ancient days of the Ionic States, gold has been the standard of wealth in all nations, and has been a bastion of the world economy. In search of gold, pioneers poured out their sweat and their blood to open the frontiers of the New World. It is no exaggeration to say that the enchanting power of gold has changed history and built civilization. However, I am convinced that, in the future, plutonium, an element discovered only in the middle of the 20th century, will become far more important than gold for bolstering human civilization.

Having said this, I expect some criticism for my comparison of gold, a beautiful metal that has entranced millions, with plutonium, which conversely is feared and despised by all. And, to be sure, the images our modern society holds with respect to these two elements could not be more different.

Misfortune, for plutonium, begins in the fact that the very firsts use of its enormous energy was against the people of Nagasaki. For those who believe in the potential of nuclear deterrent, plutonium remains the symbol of military force. It is understandable, thus, that for many people plutonium is tainted with the smell of blood.

Nonetheless, we must remember that the Aztec and Mayan cultures perished because of their immense stores of gold. If Marco Polo, in his journals, had not written that "in the Far East, there is a country that is made of gold," Columbus would have never set sail on his great journey. Fortunately for the people of Japan, it was not a "country in the Far East" that Columbus discovered. For after discovery of the New World, the continent of Central and South America was torn apart by a whirlwind of pillage and destruction. It is said that the native populations of Jamaica and Cuba were entirely wiped out. As the population died off, people were forcibly brought from Africa to work as slaves in the harsh labor of the gold mines. In the 16th century, gold must had been for non-Europeans a far more evil and more feared metal than plutonium today. Whatever the substance, it can be viewed as either a devil or an angel according to the uses that humans make of it.

2. The information revolution and the energy revolution
(the million-fold potential for change)

Plutonium the element is a veritable bundle of energy. Plutonium can produce several million times the energy of a lump of coal of the same weight. The difference that "several million" makes to civilization may be difficult to conceptualize, but proof in parallel already exists in information technology. One-megabyte LSIs are no longer uncommon, but consider that this tiny chip contains a million elements, each acting as a vacuum tube. Thanks to technological advances of this kind, we are able to perform the complex calculations that allow us to map the secrets of genetic structure, and information networks have been created that allow us to learn instantly about events happening around the world.

Plutonium is a material that will permit us to bring about, in the field of energy, the same kind of technological revolution that we have seen with information systems. Moreover, because energy, unlike intangible information, is directly connected to human lifestyles, it will take considerable effort and time before humanity comes to appreciate the immense paradigm shift that access to million–fold energy will occasion. The steam engine invented by James Watt produced less than a hundred times the power of a horse, and even in theory could produce no more than a thousand horsepower –– yet this was sufficient to usher in the Industrial Revolution. In the last hundred and some years, Japanese have gone from riding "kago" the carriages to jet planes, but the power differential between these two forms of transportation barely exceeds about one million.

The greater the potential, the greater the force that is brought to resist change. By the groups of people who feel that the pace of civilization today is too fast, and by the people who are still unable to extricate themselves from the thinking of the Cold War, plutonium is surrounded with malicious myths.

II. Myth and Reality

1. Is plutonium a man–made element? (its origins)

Speaking of myth, plutonium was named after Pluto, the outermost planet in the solar system. The name of Pluto reminds me the scene of famous Gluck's opera , in which Pluto is given the role of tenderhearted king of underworld, who releases Eulidice from the land of the dead, deeply been moved by tone of the harp which Orpheus, her husband, plays. Interesing enough, in Grecian mythology the underworld that Pluto reignes is the country of wealth and riches, apart from the image of gloomy Hades. In the horn which Pluto always carry on his shoulder, he puts everything he wants taken from his wealthy crop fields.

Plutonium, together with gold, came to earth 4.6 billion years ago from outer space. It is believed that the earth was formed when swirls of matter in this part of the universe condensed. Most stars, like our sun, create helium through nuclear fusion of hydrogen, emitting energy into space, but as a star reaches the end of its life, temperatures within the star rise, and progressively heavier elements are created, from helium up to iron. Elements that are heavier than iron, such as gold, silver, copper, and of course plutonium, are thought to be formed in the instant when the star becomes unable to support its own weight and collapses inwards, then explodes in a violent nuclear reaction known as a supernova.

2. Is radiation without benefit?

(Our Earth was created by "radioactive waste" of the universe)

At any rate, our Earth is, in contemporary parlance, a collection of the "radioactive wastes" of the universe. I don't like the term "radioactive wastes," because it seems to me the product of an opportunism that says, "once we've got electricity from it, the rest is garbage." In fact, it was precisely this radioactive energy that melted the "wastes of the universe" into one body of primitive earth, as the heavy metals sank to the core and the lighter ones rose to the surface, forming the crust and finally the surface of the earth as we know it.

This ball of radioactive wastes we live on continues to undergo radioactive decay. The original plutonium that came to earth 4.6 billion years has since disappeared. There are now only traces of plutonium 244, an element that cannot be produced in any normal nuclear reactor. However, the earth still contains about half of its original uranium–238, which has a half–life of 4.5 billion years. Nuclear technology performs a modern–day alchemy by taking the "wastes from the universe," which otherwise have no use, and recreating from them the precious energy source plutonium.

Life on earth thus exists surrounded by radioactivity –– the radioactivity remaining from the earth's formation, and the radioactivity that pours down on us from the universe. When life first began on earth, the level of environmental radiation was at least three times higher than it is today. The fact that life arose and evolved in such a radioactive environment is one that our modern society, which tends to treat radioactivity as a kind of horrid witch, should examine more rationally.

When living cells are irradiated, there is a certain probability that the radiation will set off chemical reactions within the cell, producing free radicals that destroy the cell or do irreparable damage to the chromosomes. This effect, along with the added risk of cancer, is what has contributed to public paranoia about radioactivity. However, there are innumerable other substances in the environment that have the same effect on cells. In fact, it is far more difficult to point out a substance that is confirmed not to increase risk for cancer. For example, oxygen, which we breathe every day, produces free radicals in the lungs at a rate 50 times greater than that of natural background radioactivity.

We know that cancer cells are cells that have lost the ability to die and proliferate without limit, and so we can appreciate that cell death is a necessary part of the program if life is to continue; thus, we cannot categorize as evil all factors that damage the cell. It is not unreasonable to say that small amounts of radiation may actually stimulate the organism and work to its benefit. The human body is made up of 50 trillion cells, 500 million of which die and are replaced every second. The free radicals produced by environmental radiation may kill 1 out of every 5000 of these cells, and the radiation from nuclear power plants, which is talked about so much, kills less than 1/1000 of the free radicals produced by environmental radiation.

I think it would be great if radiation detectors could be made smaller and more affordable, so that you could wear one as casually as you would a watch. Then we would all come to appreciate just how much radiation there is in our surroundings. When we understand that radioactivity is as much a part of our lives as the light from the sun, then we will be ready, as a society, to push ahead with truly effective policies for the use of radioactive materials.

3. Is plutonium a deadly poison?

Recently reports in the mass media have attached to plutonium the label of "deadly poison," thus amplifying fears beyond reason. The truth is that there are many, many substances in our world that are more toxic than plutonium, but which are far more difficult to detect or isolate.

Plutonium is most hazardous if you inhale a particle one micron in size, which then stays in your lungs. However, beryllium and asbestos, which pose similar risk, are used more freely despite being very hard to detect. In contrast, plutonium is isolated and rigidly controlled like no other substance on earth, and even if you did come into contact with it, the slightest amounts can be detected easily and measures taken at once.

Plutonium is normally transported and used for fuel in an oxidized form, but of all the non-soluble ceramics, plutonium is one of the most resistant to solution in water. Two years ago, there was a worldwide uproar about the shipping of plutonium, but only 10 days after that an 85,000-ton oil tanker ran aground off the Shetland Islands, covering 40 kilometers of the coast with crude oil and causing severe environmental damage. In contrast, the oxidized plutonium carried in the ship Akatsuki is less soluble in water than either earthenware or fine china, and even supposing it had been dropped into the sea without its container, it would have simply sunk to the bottom and sat there with no effect on the biosystem. (Of course, this is a completely fictitious scenario, as the Akatsuki would not travel through hazardous passages as shetland coast, and it is a double–hulled ship with negligible possibility of sinking. Moreover, plutonium is safely enclosed in a shielded container safe under pressure as deep as 1000 meters.) It had been a perplex experience to see the mass media handsomely been manipulated by the group which propagated fictious image of the "deadly poison" throughout the world. It seemed as if the mass media was bound under the spell of slogan which they easily accepted.

4. Can reactor grade plutonium be used to make nuclear weapons?
(Theory and reality)

Another myth is that, given some plutonium, even an amateur can put together a nuclear bomb. However, a nuclear bomb is a high–precision instrument that must be controlled within tolerances of one one–millionth of a second. What's more, the plutonium obtained from light–water reactors, which are designed for peaceful production of energy, is different in nature from the plutonium applied to military uses, and cannot easily be used in bombs. The former contains considerable amounts of isotopes which impairs the control of detonation and add up heat and radioactivity, to resul in manufacturing a reliable and maneuverable nuclear bomb rather difficult. There have been some 70,000 of nuclear bombs which ever since been made in the world, but there is not a single case where a weapon was made from plutonium produced in a peaceful nuclear reactor, certainly not in the mass producers like the United States and the Soviet Union, and not even in the "one–bomb shop" countries such as North Korea.

In theory, of course, it is possible to use reactor plutonium for manufacturing a nuclear bomb, and to prevent this from happening plutonium is guarded with unsurpassed vigilance. Even so, there are some people who say that all peaceful uses of plutonium should be halted at once to prevent the bad guys from possibly obtaining some for the bomb, but this argument can be compared to demanding a ban on knives because a madman might use one to kill someone. It is ironic that this argument is heard most often from a country which has no controls on guns and which is suffering from an increase in violent crime.

5. Are nuclear weapons symbolic of a country's power?

Last spring, South Africa announced that in the past it had had its own nuclear bomb program, but that it had disassembled all bombs and related production facilities. The fact that South Africa made this announcement voluntarily (that is, there was no pressure from the nuclear superpowers, nor were they "found out" through inspection by the IAEA) shows the fundamental change that has taken place in the worldwide perception of nuclear weapons. The era when having the Bomb was a symbol of "leading nation" status is over, and nuclear weapons today are considered more immoral, illogical and useless even than chemical or biological weapons. Even during the Gulf War, what Hussein had to fear most was not nuclear weapons, which if used would have exposed the user to a barrage of criticism from the rest of the world, but rather the rockets with guidance circuitry that were able to pin point and destroy military targets.

In an age when war comes into our very living rooms via the television, no country can afford to set the world against it by repeating another Hiroshima, no matter for what reason, and not even a powerful country like the nuclear weapon states. Moreover, this strong worldwide distaste for nuclear weapons can be attributed to the ceaseless efforts of Japan, which, as the only country to have suffered the effects of the nuclear bombs, early on established a policy of not making, using, or allowing the transport of nuclear weapons, and has continued from Hiroshima and Nagasaki to proclaim the immorality of nuclear weapons. Today, no self–respecting nation places any value on nuclear weapons, so that they are essentially useless as weapons. Japan deserves to be very proud of this achievement, and should intensify its push for a total ban on nuclear weapons. We should have more confidence in the potential for peaceful uses of nuclear power, so as not to be troubled by the bogeyman of possible militaristic maneuvering.

III. The Gifts of Helios and the Gifts of Pluto

(A discussion on energy and civilization)

1. Mankind in biosphere; Mankind in civilization

All creatures living on earth, regardless of their kind, are governed by certain laws. For example, the energy needed to maintain metabolism varies in proportion to body weight raised to a power of three–fourths, and the territory occupied by one animal is in [illegible] proportion to body weight. Thus, estimating mean human body weight as 60 kg, we can calculate that the optimum population density for humans is one person per 0.7 square kilometers, and the amount of energy consumed per day would be 180 watts. In actuality, the population density of Japan is a mean 230 people per 0.7 square kilometer (the world mean is 30), and the daily energy consumed is 4400 watts –– an enormous difference. It is clear from these figures that humans can no longer subsist under the same conditions as other creatures.

Although humans have emerged from the biosphere and remain a part of it, we cannot survive under the strictures of the biosphere. We can even say that civilization began when humanity stopped being subordinate to nature. So what is it in human civilization that allows us to tower above the biosphere, what is the source of our strength? Let's examine this question a bit further.

When we look back at the history of human progress, we see that progress is never smooth, but leaps ahead rapidly, then suddenly pauses again. It seems to move in stages, almost rhythmically, like a pulse. This is a feature characteristic of living systems. When we look at each of the plateaus across history, we see humanity passing through the Stone Age, Bronze Age, and Iron Age, then, in modernity, the Industrial Revolution and the age of fast transportation -- symbolized by the steam engine, the automobile, and the jet airplane -- and finally the new age of information. The Industrial Revolution was built upon coal, modern transportation upon oil, and the new age of information on the silicon diode. This shows us that, for civilization to leap ahead into a new paradigm, it is essential to find new practical uses for resources. The effective use of underground resources, which is impossible for other creatures, is the key that has allowed humanity to step beyond the bounds of the biosystem and develop civilization.
The next question, then, is why resources within the earth have such power?

2. Why are the weather forecasts usually wrong?
(Features of a non-linear system)

In the last ten years, there have been great advances in the science of complex, non-linear systems. Non-linear means that a system cannot be expressed merely as the sum of its parts. No matter how complicated a spaceship becomes, in the end you only need study the nature of its individual parts to understand the whole. Modern science has in the past attempted to perceive the world surrounding us in a linear fashion, and made great progress, as evidenced by the work of Newton and Darwin, but recently many people have come to see the enormous implications for a world that cannot be captured by this approach. For example, in the brain individual neurons do not perceive the world outside or store memories by themselves, but instead perceive the outer world in holographic manner in relation to the network which consists of huge nummbers of neurons. For this reason, it is impossible to know the totality of the brain by analyzing its parts. This applies not only to the brain, but to all living creatures, the societies that we form, the biosphere, and the entire environment of the earth. The reason that weather forecasts remain inaccurate despite all the progress of science, despite the improvements in meteorological measuring systems, is that the earth's environment is essentially a non–linear system –– so the weatherman isn't at fault.

Recently considerable attention has been given to the order that emerges in such non–linear systems under certain conditions. In this case the order does not mean the rigid order of molecules or atoms in a crystalline array, but rather the flexible, changing orders such as those of by cirrocumulus clouds, or the colonies created by ants and bees.

For these systems to maintain internal order and evolve without surrendering to the limitless chaos that surrounds them, they must ceaselessly take beneficial energy from the environment, from that extract the essence needed for ordering (in physics expressed in reciprocal of entropy, or negentropy), and release the excess energy to the environment again. Systems that create internal order through such mechanisms have been termed "dissipative structure" by Nobel Prize winning chemist Ilya Prigogene.

In order for a dissipative structure to maintain its integrity against the outside chaos, it must have within it a network of mutually responsive loops that distribute the negentropy to all parts of the system. If the loop is too simple, the system can be easily destroyed from the outside, like the clouds streaming across the sky. But when there is a appropriate balance between the mutual feedback loops and fluctuations in energy, the system begins to organize itself for still greater stability. As multiple reinforcing loops are added and diversification progresses, the stability of the system –– its homeostasis –– increases, and it becomes able to actively seek sources of fluctuating energy, to grow, to evolve. The ultimate dissipative structure network, which has acquired a high capacity for self-sustenance and propagation, is life itself.

3. The biosphere and the gift of Helios

Most of the negative entropy that is necessary for life on earth to maintain internal order, remain in homeostasis, and continue evolution comes from the sun. The sun is a source of high quality energy, the negentropy of which is converted, by photosynthesis, into organic compounds incorporated into plants. Animals eating these plants indirectly consume the sun's energy, while microorganisms in the soil take the secondary or tertiary energy of the sun from the dead bodies of plants and animals. In addition to these food chains, the biosphere has developed a variety of routes -- parasites, symbiosis, social systems of which bees and ants are typical -- to spread the negentropy derived from the sun (to save myself from stumbling over that, I'm going to resort to mythology and call this the gift of Helios) throughout the system. Thanks to these mechanisms, the stability and self-organizing properties of individual life forms are reflected throughout the system of which they are a part, and the biosphere, which is the dissipative structure that incorporates all the systems beneath it, behaves itself very much life a living system.

Lovelock was the first to observe that relationships of this kind exist not only among life forms, but among non-living systems such as the earth's environment. Plants take in carbon dioxide through photosynthesis, and release oxygen into the atmosphere. The atmosphere is indispensable for the growth of life, but obviously the atmosphere itself is not alive. Lovelock wondered why the composition of the atmosphere has not changed appreciably for a million years, and why it has fallen into balance at exactly the composition most suited to life forms. Calculations based on the theory of equilibrium in thermodynamics showed that the atmosphere of the earth should be similer to that of Mars containing almost no free oxygen.

In later research, Lovelock and others discovered further proof that the relationship between life and the earth is highly multifaceted and multi–dimensional, and that the environment of the earth self–organizes sustain homeostasisis and evolve together with the biosphere. To express in anthropomorphic terms this image of the environment as a living thing, he used the word Gaia, which is the name of the goddess of the earth. Gaia takes the gifts of Helios directly from the sun, but also absorbs them back from the various life forms on the earth, and evolves together with the biosphere. It is of vital necessity that when we interact with the environment, we be fully aware of this essential characteristic of Gaia.

4. Civilization and the gifts of Pluto

We must not forget another source of negative entropy, quite apart from the gifts of Helios, that plays an important role as Gaia goes about establishing a flexible order as a dissipative structure. The radioactive elements trapped within the earth's core from the time of its formation continue to emit radioactivity that provides energy and negentropy to many substances, and manifests itself on the earth's surface in the form of geothermal energy. I will call this the gift of Pluto, the god of the underworld in Greek mythology.

In terms of energy balance at the earth's crust, the gifts of Pluto may pale in significance beside the gifts of Helios, but they have overwhelming power within the earth. Through the formation of mountains and volcanic activity, Pluto control the long–term meteorological activity of the earth's atmosphere. Moreover, he carries an abundance of elements to the earth's surface, providing the biosystem with the means for evolution.

From this standpoint, we see that Gaia can be defined as a dissipative structure supported on two circles, the gifts of Helios and the gifts of Pluto. The biosphere, meanwhile, is a dissipative structure that relies principally on the gifts of Helios, and has had very little involvement with the gifts of Pluto, except within a limited and passive part of its mutual evolution with Gaia.

Mankind is the first creature to make active use of the gifts of Pluto for his own purposes. Heavy metals distributed throughout the earth's core are selectively carried to the surface by magma in concentrated form, where they are mined by humans. The sources of negentropy that constitute the gifts of Pluto -- metal resources -- are created this way. By taking into our hands, from Pluto, a source of negentropy unavailable to other creatures, humankind created civilization, a dissipative structure of its own, and assured itself of mutual evolution with the biosphere and with Gaia.

Nonetheless, as far as energy goes, the underground wealth that humans have traditionally sought does not represent the true, pure gifts of Pluto. Coal and petroleum in fact are derived from the energy of the sun, captured in living matter, then converted by the high temperatures and high pressures within the earth to a low entropy energy source; in that sense, these resources are actually born of Helios and only raised by Pluto. The final accounting for the fossil fuels that mankind has consumed must be made within the biosphere, where they originated; however, considering that at the present rate humans will use up in barely 200 years an energy source that took 300 million years to create, it is only natural that immense distortions should appear in both Gaia and the biosphere as a result. Global warming and acid rain, etcetera, are all problems that arise directly as a result of this mismatch between consumption and production of energy, and depending on how we handle these problems, they pose a great danger, threatening the bases of civilization.

The fact that, at this juncture, humans discovered a powerful energy source entirely independent of the gifts of Helios and began to walk the road of peaceful use of nuclear power, is for human civilization good fortune of a sort that can hardly be accidental. As I mentioned before, from uranium−235 and plutonium we can extract energy millions times that from a similarly sized piece of coal. Moreover, in contrast to fossil fuels, reserves of which will be depleted at the current rate in only a few more decades, nuclear power can sustain us for at least a thousand years on currently known stocks alone, once technology for the use of plutonium has been perfected. Thanks to the gifts of Pluto for the mankind who generate energy, we have been granted an unprecedented chance for the evolution of a new civilization.

5. The limits of renewable energy

I would like to take a minute to discuss renewable energy in terms of its role in civilization. Technologies for the use of solar power, the sun's heat, or wind power can essentially be no more than imitators of the knowledge which the biosphere has acquired. The life forms on earth have labored for billions of years to create flexible and extremely subtle mechanism whereby to capture the admittedly vast but capricious and thinly distributed light of the sun. Although the efficiency of conversion of sunlight to energy by plants does not reach even one percent, the biosystem has evolved an extremely high capacity for storing and being usedas the resource of energy; moreover, through regulation of the carbon cycle, photosynthesis also greatly contributes to the homeostasis of Gaia.

However, even if, through amazing advances in photo−conversion technology (this is impossible, but just say if), it became possible to convert 100 percent of the solar energy into electricity, this would only be a 100−fold improvement over the efficiency of plants, and nowhere near the million−fold gain in energy offered by plutonium.

Additionally, to capture the thinly spread rays of sunlight we would need an immense structure for solar collection; thus, when we subtract the energy required for installation and maintenance, we see that it would be extremely difficult to create a practical system that could deliver even 10 times the power of the biological system. Moreover, biological systems or systems that collect solar power are in direct competition for humans for the space needed to collect the energy in (excluding those areas that have already been taken over by humans).

This type of energy has some value if developed for local use, as a selective, adaptable energy source. But it is inherently inadequate as an energy source that can support our future civilization, so that one cannot possibly trade it against technologies for the peaceful use of nuclear power.

IV. Towards Completion of a System for Peaceful Use of Nuclear Power

1. Using the million–fold potential

(Improve the ratio of energy use and output)

The figure shows a comparison, drawn up by Dr. Uchiyama of the Central Research Institute for Electral Industries (CRIEPI), of the total efficiency of energy production by an electric power plant –– this includes everything from construction and operation, building materials, and the energy expended in finding and transporting resources to disposing of the wastes afterwards –– against its energy output. You can see that the total energy produced by a solar power plant is only 3–4 times the amount of energy that went into producing it.

This figure also clearly points up the current problems with the peaceful use of nuclear power. Almost all of the fuel used in Japanese reactors is based on enriched uranium produced in the U.S. or France by the gaseous diffusion method, but with these fuels the ratio between energy consumption and output is lower than even a coal–burning power plant. That is because the gaseous diffusion method was originally developed for weapons technology, with no thought of using the materials for production of electrical power.

To eliminate this paradox of expending energy only to obtain energy, a number of other methods for enriching uranium have been studied. One is the centrifugal method, which is being used at the enrichment plant in Rokkasho–mura on the Shimokita Peninsula, and which greatly reduces the amount of energy needed for enrichment. Thus, its production/consumption ratio has been increased from 16 to 55, but that still is barely three times better than a coal–burning power plant, so we are left wondering what happened to our million–fold potential.

The problem, and where the criticism should be directed, is in the basic workings of the current light–water reactor, and the fact that we have focused on the use of uranium–235, which constitutes only 0.7% of uranium in its natural state. If we take the course the United States has adopted and tried to force upon other countries, and treat spent fuels as high–level wastes, forbidding their reuse, we will end up with utilizing as little as 0.5 percent of the natural energy resource. This is not only a frivolous waste of resources, but costs society doubly because we are converting precious resources straight to waste.

2. Wastes as resources

Essentially, the distinction between "resources" and "wastes" is an artificial one, made by humans, and there can be no such distinction in nature. If human society views something as useful and tries to place a value on it, it becomes a "resource"; once we lose interest in something, it becomes "waste."

Fission products comprise only 3–4 percent of spent nuclear fuels from the light–water reactor; the remaining 96–97 percent is plutonium or uranium, both highly valuable resources. The concept when we first began to make peaceful use of nuclear energy was, quite naturally, to plan from the beginning to effectively reuse fuel resources. The light–water reactor was in effect the gateway system to peaceful use of nuclear power, and certainly was never meant to be its endpoint. The reason that policies have changed to a wasteful one, like the lord who tasted the very best portion of a complete carcass leaving the rest to be discarded, is the direct result of the American groups who put the nuclear deterrence before everything, i.e. who dont hesitate to sacrifice the peaceful uses for keeping up their nuclear weapon supremacy.

Nevertheless, the big brains from Harvard University who advised former president Carter to adopt the "no reprocessing" policy were mostly policy specialists who knew very little about nuclear energy systems. Seemingly, they believed simplistically that if they could only separate and contain plutonium, they would be able to maintain America's worldwide military dominance and it's supremacy in the field of peaceful uses, all in one stroke. However, not only did this new policy greatly detract from the international influence of the United States, which theretofore had been the world leader in nuclear power, but it instigated confusion of nuclear energy world both in the U.S. and abroad, and thus drove the U.S. into a cul–de–sac, as exemplified in the furor over the Yucca Mountain disposal site.

Our present nuclear reactors unavoidably produce plutonium at the same time as electricity. To take only the electricity and ignore the plutonium is the type of thinking that is inconceivable in an industrial system.

3. Plutonium essential for peaceful use of nuclear power

Ironically, the policies that attempted to shut out plutonium from the world of the peaceful use of nuclear energy have back to haunt the U.S. nuclear deterrence lobby, dropping their contradictions squarely on the heads of them.

Through the ending of the Cold War, numerous nuclear weapons are going to be disassembled, leaving the United States and Russia with about 200 tons of nuclear weapons grade plutonium. However, the United States no longer have any way to dispose of this plutonium. In the meantime, they have decided to take the balls of plutonium (which are called bits), alter the shape physically, and simply store them -- but who knows when the countries involved might have a change of heart and convert them back into weapons? There is no way to eliminate the possibility of military conversion except to extinguish all the plutonium. Various ways have been proposed for getting rid of it, including putting it in rockets and firing it into outer space), or confining into the form of glass and storing them in 4000-meter deep wells, but all of the proposed solutions present technical problems, and, above all, no sponsors are liklely be found to pay for such retrogressive projects. Recently, the American Academy of Science has produced a report to the US. government on this issue. The most recommendedscenario to deal with the weapon grade plutonium has been that to put into American and Canadian civilian nuclear reactors. So as to avoid contradiction to the present policy, prevarications have been made such that, it is not aimed at burning but contaminating the weapon grade plutonium in the civilian reactors with the spent fuels, or it is an exceptional treatment only applicable to the case of weapon dismantlement, but it is abundantly clear that the policy of eliminating plutonium from the peaceful uses of nuclear energy has failed utterly.

Nevertheless, even if the United States were to heed this scenario, after the witch-hunt of plutonium in the American nuclear industry, the U.S, no longer has the facilities, people or technology to handle plutonium peacefully. Even if the U.S., in its troubled state, asks for cooperation from Japan, which has pursued a policy of plutonium use for peaceful uses only, or other countries such as Great Britain or France, the request would be considered, quite frankly speaking, a great annoyance. Most countries would be willing to cooperate if it contribute to the ultimate abolition of nuclear weapons, but the honest reaction is that America should look at the realities of the post–Cold War era and devise policies that are more practical.

4. "Warming oneself with a match": The light–water reactor

To run a million–kilowatts power plant takes about 2.5 million tons of coal a year, but only 25 tons of nuclear fuel. Still, 150 tons of natural uranium are needed to create 25 tons of nuclear fuel, and some 50,000 tons of ores must be mined to collect this uranium. In practice, a good deal of earth more than this must be moved to uncover the ores, which means that the effect on nature is by no means insubstantial.

After going to all this trouble to mine uranium, only about 800 kilograms will actually be used to produce energy, which means that all we have done is increase the amount of waste products. No matter how plentiful uranium is, at this rate we will use up all available sources within a matter of decades. Such wastefulness may have been tolerated in the 'who gives a damn' milieu of the nuclear arms race, but as a method of basic industry that must sustain human civilization, it is totally unacceptable even from ethical point of view.

Uranium–238, which comprises 99.3% of all natural uranium, cannot be converted directly to energy; you might think of it as wet firewood. Just as firewood is converted in a carbon kiln to charcoal, so is uranium–238 converted in a nuclear reactor to plutonium, whereupon it first gains value as an energy source.

The concept of today's light–water reactors is similar to setting aside the wet firewood and trying to warm oneself with nature's match, uranium–235. Of course, if you keep burning enough matches you can turn a little bit of the surrounding firewood into cinder, and make it burn. In fact, when you burn fuel in a light–water reactor, at the end of its life span the amount of energy produced from plutonium which has been created within the reactor will exceed the energy originated from uranium−235. Looking across the total life cycle of nuclear fuels, we can calculate that the plutonium produces about a half as much energy as the uranium−235 that served as the original match. But in the American way, the 95% bulk of wet firewood is thrown out with the cinder as "high−level wastes."

Plutonium thermal recycling is where the cinder is retrieved and put back into the light−water reactor one more time. However, the light−water reactor was never designed to burn charcoal, and is very finicky about the kinds of fuels it can use, so repeating this cycle degrades the quality of the plutonium and increases the amount of isotopes that cannot be used for fuel (and which therefore must be treated as wastes).

5. Fast reactors change "wet firewood" to energy

Fast reactors are reactors that make most efficient use of "wet firewood." The fast reactor can even use even−numbered isotopes of plutonium that will not burn in finicky light water reactors. There is also much less deterioration of plutonium than there is in a light−water reactor, allowing us to transform the gifts of nature into energy with minimal waste. To use my earlier analogy, fast reactors produce not spent charcoal, but high−grade charcoal, and burn them with far greater efficiency.

The two−layer structure makes optimum use of the merits of the fast reactor by burning "charcoal" in the center of the reactor, and at the same time, in the outer layer, using the surplus heat to dry out the firewood and convert it into charcoal. This type of reactor, if managed well, can accomplish the amazing feat of producing more plutonium on the outside than it is using on the inside. Because the reactor is able to create more of an energy−producing resource while at the same time extracting energy from it, t is often called a fast breeder reactor, but this is only one idealized type of a fast reactor, and does not represent the totality of fast reactor types.

I think it safe to say that, on a worldwide basis, thinking about development of fast reactors has tended to concentrate on the aspect of competition with light–water reactors, and regrettably not enough has been done to place fast reactors in their proper light as complementary to light–water reactor systems. Light–water reactors are superior reactors backed by completed technology. Moreover, there are now more than 300 light–water reactors worldwide, with a growing fund of experience in construction and operation to draw on, and further improvements are being made yearly. To expect fast reactors, which are a later development, to overtake the light–water reactor technologically is like asking the Norwegian ski team to catch up to the Japanese ski team after being given a 5–minute handicap at the start: it may be possible to do it by sheer physical strength, but it will not be easy. Moreover, one type of reactor is being used to produce electricity and is steadily amassing money and experience, whereas the other still needs costly development to accumulate the experience, so the winner of the competition is clear.

The fast reactor originally was positioned as a complementary technology, not to compete with light–water reactors, but to solve some of the problems associated with the light–water reactor and coexist with it as one element in the nuclear fuel cycle. Whereas only a small fraction of the gifts of Pluto can be converted into energy in the light–water reactor, the fast reactor takes up where the light–water reactor leaves off: this is the essence of the fast reactor. The very concept of the fast reactor is predicated on the nuclear fuel cycle. Even the breeding ratio or doubling time has meaning only when we take into account the time for reprocessing and recycling. fuel. To look at breeding ratio only as a benchmark for reactor efficiency and focus on cost competition without thought for the entire cycle leaves no hope for the fast reactor.

The inherent advantage of the fast reactor is that it is a multipurpose, adaptable reactor that can moderate performance to suit the needs of the fuel cycle. It can breed plutonium, it can burn plutonium, and it can even use as fuel TRU, which in a light-water reactor is regarded only as a waste byproduct. In view of this multidimensionality, the need for fast reactors is certain to change with time. Today, when light-water reactors are still in the overwhelming majority, we have more plutonium than we need. The plutonium obtained through dismantling nuclear armaments is adding to the surplus. In this day and age, to disperse the fears of nuclear proliferation, we need to put more emphasis on the development of fast reactors, reactors that can burn plutonium and even TRU, and at the same time, I believe it is important that we press forward with research into reprocessing technology.

If fast reactors come into practical use, we may eventually find ourselves using their breeding capacity so as to eliminate delays in plant construction due to plutonium shortage. However, to avoid untoward suspicion, it is necessary that we ensure there is no excess of plutonium by carefully maintaining a balance between production and consumption. This is why it is desirable to get a clear picture of what society needs, in conjunction with the fuel cycle, when moving forward with fast reactor development.

V. Nuclear Power Plants: A Foundation for the 21st Century

In the 21st century, it is unavoidable that we will see further expansion of human civilization: witness the astonishing pace of economic development in Asian countries, and explosive population growth. However, we do not have the right to demand that the citizens of the developing countries forego the good fortune that the leading countries have enjoyed, or the right to take away the lives of the children being born. To support the burgeoning needs of civilization without losing our relationship with Gaia or the biosphere, it is essential that we implement comprehensive policies for resources, energy and recycling in society.

For people today, who are accustomed to the carefully cultivated "nature" of New Zealand or England, or to seeing the spectacles of "nature" on their television screens, it may be difficult to appreciate how people from the Middle Ages on back could have viewed nature as harsh, cruel and frightening. Today rational measures to preserve the environment and conserve resources are increasingly mixed up with emotional diatribes against civilization, with slander, and with egotism: this is where the difficulty lies in modern environmental problems. But there is not time left for humanity of the 21st century to indulge in the sentimental "back to nature" romanticism of Jean Jacques Rousseau, like the nostalgia of a youth who has run away from home, castigating civilization while being steeped in its benefits.

Securing the necessary supply of energy is a critical prerequisite if human civilization is to maintain its existence as a flexible dissipative structure, if it is to continue to evolve together with Gaia and the biosphere. And, if we are to leave to the developing nations those resources that are easier for them to use, it is important that the technologically advanced countries put all their efforts into developing a higher form of energy.

As I have said many times before, nuclear energy has incomparable potential, and is the only qualified paradigm technology in the 21st century. But even today, when nuclear power plants supply one–third of all electricity, we have only just begun to develop nuclear power as a total system. A nuclear power system that leaves aside the realities of the nuclear fuel cycle to press forward only with technology for light–water reactors is like a dilapidated mansion, of which only the front door has been kept in repair -- it's not worth living in for long. Plutonium is the key to building a solid edifice from the very start.

Whether nuclear power disappears into the ripples of history as an energy technology that left the payment to our descendants, or becomes a driving force that supports the civilization of the 21st century, whether we fall under the burden of our rapidly increasing population and economic expansion in developing nations or continue to evolve -- plutonium holds the key to all of these.

I hope that this discussion has been useful to you. Nothing could please me more than if my little talk allowed you to learn more about the true nature of plutonium, and brought you to an appreciation of the role that plutonium plays in our civilization.

プルトニウムと文明

第２７回原産年次大会
１９９４・４・１４　　広島国際会議場

三菱マテリアル（株）
秋元　勇巳

はじめに

本日は、プルトニウムがいかに人類の未来に関わってくるか、あるいは関わるべきかということを、私なりの切り口で述べさせていただきたいと思います。

話の大筋を予めご紹介致しますと、まず、「プルトニウムは２１世紀の金である」ということを導入部として、次にプルトニウムに関する様々な話題をご紹介します。次に、「エネルギー文明論」というくだりで、文明社会にとってのエネルギー問題を宇宙や地球といった視点から論じたいと思います。そして、最後に原子力平和利用について、現状の問題点と将来の展望について述べ、私の話を終らせて頂きたいと思います。

１．プルトニウムは２１世紀の金

イオニア都市国家の昔から、金は万国に通用する富の基準として、世界経済を支配してきました。人々は金を求めて新世界を開き、金のために血と汗を流しました。金の持つ魔力が歴史を作り、文明を開化させたといっても過言ではないでしょう。しかし来世紀には、２０世紀半ばに発見されたプルトニウムが、人類文明を支える金にも増して重要な元素となる事を、私は確信しています。

こう申し上げたら、万人を魅惑する金と、万人が毛嫌いするプルトニウムを一緒にするとは何事だ、とのお叱りが返ってきそうです。確かに現代社会がこの二つの元素に対し抱いているイメージは、天地の差があります。

プルトニウムの不幸は、その巨大なエネルギーの最初の向け先が、長崎の市民の殺戮であった事に始まります。核抑止力を信奉する人々にとって、プルトニウムは現在でも軍事力のシンボルであり続けています。プルトニウムに血の臭いを感じとる市民感情も、無理からぬものがあると思います。

しかしアステカやマヤの文明は、それが豊富な黄金の上に成り立っていただけの故に、あっさりと滅ぼされてしまいました。マルコ・ポーロが、その東方見聞録で、「東の果て

に黄金の国あり」と書き記さなかったら、コロンブスの大航海は実現しなかったでしょうが、日本民族にとって極めて幸いだったことに、彼が発見したのは日本ではありませんでした。コロンブスの新大陸発見以降、中南米には凄絶な収奪と殺戮の嵐が吹き荒れました。ジャマイカやキューバではそのため原住民が死に絶えたと言います。人口が不足し始めると、アフリカ大陸から黒人を移入してまで、過酷な金鉱山の奴隷労働は続けられます。16世紀の非ヨーロッパ人にとって、金は現代のプルトニウムに増して、恐るべき存在であったことになります。いかなる材料も、それを使う人間によって天使にも悪魔にもなるのではないでしょうか。

2．プルトニウムをめぐる話題

（1）100万倍のポテンシャル

先程、プルトニウムは21世紀の金と申しましたが、その理由はプルトニウムがエネルギーの塊のような元素だというところにあります。同じ重さの石炭と比べて、プルトニウムからは数百万倍のエネルギーを取り出す事が出来ます。百万倍という違いが文明に及ぼす影響のほどはなかなか見当がつけにくいのですが、情報社会では既に実証済みです。一メガのＬＳＩは、今ではあまり珍しくもなくなりましたが、この小さな部品の中には、昔の真空管に似た働きをする素子が百万個詰まっています。このような技術革新のおかげで、われわれは今日、膨大な計算量をこなして複雑な遺伝子構造の神秘に迫り、居ながらにして、しかも瞬時に世界の出来事が判る、情報ネットワークを持つことになったのです。

プルトニウムは、情報社会が成し遂げた革新を、エネルギーの分野で可能にする物質です。しかし無形の情報と異なり、人類の生活様式により直接的な関連を持つエネルギーだけに、百万倍がもたらすパラダイムの変化を世間に納得し消化してもらうには、大変な努力と時間が必要です。ワットの発明した蒸気機関は、それまでの動力源であった馬の数十倍の力を出すに過ぎず、理論的にも数千倍が精一杯といった代物でしたが、それでも産業革命の幕開けをもたらすに充分でした。ここ百数十年のあいだに、日本人の乗り物は駕篭からジェット旅客機へと大変化を遂げましたが、この二つの乗り物の動力比がようやく百万倍を越えるのです。

100万倍以上という、ポテンシャルが大きければ大きいほど、それに抵抗しようとする力も強く働きます。現代文明の進歩があまりにも速すぎると感ずる人々や、未だに冷戦構造的な考えから抜け出せない軍事力信奉派の人々によって、プルトニウムの回りには多くの悪意ある神話が張り巡らされるようになりました。

（２）プルトニウムの生い立ち、地球の生い立ち

プルトニウムという名前は、太陽系の一番外側を回る惑星の冥王星（PLUTO)にちなんで命名されました。ついでに付け加えさせて頂きますと、ウランは天王星（URANUS）、ネプチウムは海王星（NEPTUNE)にちなんで、それぞれ命名されたものです。さて、冥王とはギリシャの神プルートーの和訳で、富と豊饒の神プルトスが起源となった名前といわれています。

プルトニウムは４６億年前、金と共に宇宙からやってきました。宇宙に漂っていた破片が渦巻き凝集して、地球が誕生したと信じられています。恒星の多くは太陽とおなじく水素の核融合でヘリウムを生成しつつ、エネルギーを宇宙空間に放出していますが、その寿命が終わりに近付くと、星の温度もますます高くなって行き、核融合反応は水素から漸次重い元素へと移り、鉄にまで及びます。金、銀、銅を始めプルトニウムなど鉄より重い元素は、星が自らの重力に耐えきれなくなり、最後に激しい核反応を起こし、超新星として爆発する瞬間に生まれるものと考えられています。

いずれにせよ地球は、今様の言葉でいえば、宇宙における核反応の”放射性廃棄物”が集まって出来た事になります。“廃棄物”の出す放射線エネルギーによって原始地球は熔け始め、中心には重い元素が沈み、外側には軽い元素が浮かび上がって地核を形成し、現在の地球の原型ができあがりました。

地球なる「放射性廃棄物」は、今なお放射壊変を続けています。４６億年の間に、地球誕生時のプルトニウムは実質上消滅してしまいました。現在は通常の原子炉反応では生成する事のない、プルトニウム２４４の痕跡が残っているにすぎません。しかし半減期４５億年のウラン２３８は、誕生時の半分ほどが残っています。原子力技術は、そのままでは使いものにならないこの「宇宙の廃棄物」から、貴重なエネルギー資源であるプルトニウムを蘇らせる、現代の錬金術であると言うことが出来ましょう。

（３）プルトニウム猛毒説について

近ごろはプルトニウムに「猛毒」の枕詞をつけ、恐怖感をいやが上にも増幅させるような報道が流行のようです。しかし世の中には、プルトニウムより毒性が強く、検出技術や隔離手段の面で遥かに問題含みの物質が、これまたごまんとあるのです。

プルトニウムがもっとも危険なのは、１ミクロン程度の微粒子として吸い込まれ、肺に沈着した場合です。しかしこれに似た危険性があるベリリウムやアスベスト粉などが、世間に野放しに近い状態に置かれ、吸い込んでも検出が難しいのに比べ、プルトニウムは他の物質には例を見ないほど厳重に隔離管理されている上、万一漏れたり身体につけば極微

量でも検出出来、迅速な対応が可能なだけましと言えそうです。

プルトニウムは通常酸化物の状態で運ばれたり、燃料にされたりしますが、酸化プルトニウムは、水に溶けにくいセラミック材料の中でも、最も溶けにくい部類に属します。一昨年、プルトニウム輸送で世界中が大騒ぎをしたわずか１０日後に、８万５千トンのオイルタンカーがシェットランド諸島沖で座礁し、４０キロメートルの沿岸が重油で総なめになり、重大な被害を出しました。一方あかつき丸が運んでいた物質は、陶器や磁器よりも海水に溶けにくく、３倍も重い酸化プルトニウムで、万々一むき出しで海に投げ込まれたとしても、海底に沈積するだけで、生態系に被害を及ぼす恐れもないような代物でした。（もちろんあかつき丸はあんな危険な海域を航行しませんし、頑丈な二重船腹構造で沈没の恐れはまずありません。更にプルトニウムは１０００メートルの水深に耐える容器に密閉してありますから、あくまでも現実にはあり得ない仮定の話ですが。）作り上げられた「猛毒」のイメージと、巧みな世論操作に踊るマスコミの姿に、複雑な思いをさせられたものでした。

（４）原子炉級プルトニウムで原爆はつくれるか（理論と現実）

「素人でもプルトニウムから原爆を作る事が出来る」といった神話もあります。しかし原爆は百万分の一秒レベルの制御を必要とする超精密装置です。しかも平和利用の軽水型発電炉から得られるプルトニウムの性質は、原爆用に生産される軍事用プルトニウムと異なり、原爆製造には不向きです。世界中で今までに七万発以上の原爆が作られましたが、米ソのような量産国はもちろん、北朝鮮のような「一発屋」に至るまで、平和利用プルトニウムから原爆が作られ、あるいは作られようとした例は一つもありません。

もちろん軍事転用は理論的には可能ですから、万が一にもそのような事が起こらないよう、平和利用プルトニウムには、他の物質には例を見ない厳重な管理が施されています。それでも「”危ない国”が善からぬ企みをする恐れがあるから、プルトニウム平和利用は一切中止せよ」と言う人々が絶えませんが、これはもう「気違いに刃物を持たせては危ないから、刃物をいっさい禁止せよ」との理屈に通じはしないでしょうか。こうした議論が、国内で銃を野放しにして犯罪率増加にあえいでいる国で特に賑やかなのは、皮肉な感じさえします。

（５）もはや原爆は国力の象徴ではない

昨年春、南アフリカは、かって原爆を作っていたことを世界に告白し、既に原爆も、その製造施設も、すべて解体済みである旨公表しました。この決定が、（核大国の圧力があ

ったとか、ＩＡＥＡの核査察で秘密が暴露されたとかの理由ではなく、）全く自発的に行われたことに、原爆をめぐる世界の見方の根本的な変化を読みとることが出来ます。核兵器を持つことが一流国のシンボルであった時代はとっくに終わり、原爆は今や、化学兵器や細菌兵器以上に、非人道的で非倫理的な、無用の長物に成り下がってしまいました。湾岸戦争の時でも、フセインにとって最も脅威だったのは、正確に軍事目標を破壊する制御技術をそなえたロケットであって、使ったら最後世界世論の袋叩きにあうことがはっきりしている原爆ではなかったのです。

その日のうちに戦場の有り様が茶の間のテレビに映し出される現代では、いかなる理由であっても、またいかなる大国、強国といえども、世界世論を敵に回して「広島」を再現することはできません。そしてこの原爆を憎む強い世論は、唯一の被爆国である日本がいち早く非核三原則を確立し、広島、長崎を発信地として、機会あるごとに原爆の非道徳性を訴えてきた、たゆまぬ努力の結果なのです。原爆はもはや、まともな国が関心を持つに値しない、使えぬ武器である。日本はもっとこのことに誇りを持ち、原水爆の全面禁止に向けての働きを強めると共に、軍事利用の亡霊に煩わされることのない、真の原子力平和利用に自信を持って取り組むべきではないでしょうか。

3．エネルギー文明論

さて、しばらくはプルトニウムの話題から離れて、文明社会の直面するエネルギー問題の本質について考えてみたいと思います。

（1）生物としての人類　ＶＳ　文明社会の人類

ところで、地球上に生息している動物の生き方には、その種類を問わず当てはまる一定の法則があります。たとえば、代謝に必要なエネルギー消費は体重の４分の３乗に比例するとか、一匹あたりの生息領域は体重に逆比例するなどですが、この法則に従って、人間を体重６０キログラムの恒温動物として計算すると、適正人口密度は０．７平方キロメートルに１人、標準消費エネルギーは１日１８０ワットという数字が得られます。現実の人口密度は、日本では０．７平方キロメートル当たり２３０人、（全世界平均でも３０人）、エネルギー消費量も一日４４００ワットと桁違いの大きさです。人間がもはや生物と同条件では生きられない存在になってしまったことが、この数字からもはっきり判ります。

人類は生態系から出、生態系に属しながら、生態系に埋没しては存立できない存在です。文明は人間が自然の従属要素であることを止めた瞬間に始まった、と言ってよいのかもしれません。それでは人類の文明に、生態系から一歩抽んでるこのような力を与えている、

その源は一体何なのか。しばらくこの問題を掘り下げてみることにしましょう。

人類の文明の発達の歴史を辿ってみると、その歩みは決して漸進的ではなく、突然急激な進歩を遂げたかと思うと、暫く足踏みを続けるといった、段階的、脈動的な動きをしていることに気がつきます。これは「生きている」システムに共通の特徴なのですが、そのプラトーを一つ一つの時代として括ってゆきますと、古くは石器時代から、青銅器、鉄器、更に近代では産業革命に始まる蒸気機関時代、更に自動車、飛行機の高速交通時代、そして現代の高度情報化時代と続きます。産業革命が石炭、高速交通が石油、情報革命がシリコンダイオードの実用化によって、それぞれもたらされた事を考え合わせますと、時代が次のパラダイムに向けて飛躍するには、新しい地下資源の実用化が、その必要条件となっている事が判ります。他の生物には不可能であった地下資源の有効利用によって、人類は生態系の枠を超えて文明を発展させる鍵を手に入れたと言うことができます。

では何故地下資源にはそのような力が秘められているのでしょうか。

（２）自然のルール、非線形システム

ここ十年ばかりの間に、複雑で非線形なシステムを取り扱う科学が、急速に進歩しました。非線形とは、全体の性質がその部分の性質を足し合わせただけでは表せない、という意味です。宇宙船はいくら構造が複雑でも、全体は個々の部品から成り立っていて、部品の性質を徹底的に追及してゆけば全体の姿が判ります。近代科学は我々の周辺の世界をこのような線形のシステムと捕らえ、ニュートン、ダーウィン以来の大発展を遂げたのですが、最近になって、このようなアプローチでは捕らえられない世界が重要な意味を持っていることに、多くの人が気づくようになってきました。我々生命体、それが形作る社会、生態系、地球環境にも共通して現れる現象です。いくら科学が発達し、計測網が整備されても天気予報が当たらないのは、地球環境が非線形であるからで、予報官の腕が悪いからではないのです。

最近特に注目を浴びているのは、こうした非線形のシステムが、特定の条件下で示す秩序の問題です。それは結晶体の中の原子の配列に示されるような硬い固定的な秩序ではなくて、たとえば空に浮かぶいわし雲や、蟻や蜂の作るコロニー、更に根元的には生命現象そのものに示されるような、柔軟で生成流転する秩序です。

こうしたシステムが、無限のカオスに囲まれながらそこに落ち込むことなく、自らの中で秩序を維持し進化を遂げてゆくためには、絶えず外部から良質のエネルギーを取り込み、その中から秩序の素（物理学的にはエントロピーの逆数ネゲントロピーという言葉で表しますが）を吸収しつつ、余ったエネルギーを外界に放出してゆかねばなりません。このようなメカニズムで内部に秩序を形成してゆくシステムを、ノーベル化学賞受賞者のイリア

・プリゴジンは、散逸構造と名付けています。

散逸構造が外界からの撹乱に対抗して秩序を保ってゆくには、吸収したネゲントロピーが系内にくまなくゆきわたるよう、システム内に相互作用のループが張り巡らされている必要があります。ループが単純であれば、秩序は空のいわし雲のように、少しの外乱によっても壊れてしまいます。しかし相互作用ループとエネルギーの揺らぎとの関係が適正であれば、システムは自らの安定化に向けて自己組織を始めます。こうしてループの多重化、階層化が進めば、システムの恒常性（ホメオスタシス）は高まり、エネルギーの揺らぎを積極的に取り込んで、成長、進化する力をそなえるようになります。こうして高度の自己複製能力を獲得した、究極の散逸構造体が生命体です。

（3）ヘリオスの恵みと生態系

地球上の生命体が恒常性を保ちつつ、進化を遂げてゆくために必要な秩序の素（ネゲントロピー）は、ほとんど太陽光からもたらされます。太陽光は大層質の高いエネルギー源で、そのネゲントロピーは光同化作用により有機化合物の形で、地上の植物の体内に取り込まれます。動物はこれを食べて間接的に太陽光の恩恵に浴し、土壌内の細菌は植物や動物の死体から、二次的三次的に太陽光のネゲントロピーを取り込みます。生態系では、こうした補食関係に留まらず、寄生、共生、或いは蟻や蜂に典型的に見られる社会関係など、多彩なルートを通じて、太陽から与えられるエネルギーとネゲントロピー（舌をかまないように、これを擬神化して太陽の神ヘリオスの恵みと呼びたいのですが）が、隅々の生命体にまで満遍なく行き渡るのです。この仕掛けのおかげで、個々の生命体が持つ恒常性、自己組織能力は、その集合体である生態系に写し取られ、生態系は生命体の上部の散逸構造として、あたかも一つの生命体であるかのような振る舞いを示すようになります。

こうした関係が生物同士でなく、地球環境のような無生物界との間でも成立することに、初めて着目したのはラブロックでした。地上の植物は光同化作用で炭酸ガスを吸って、酸素を大気に放出します。動物は呼吸作用で酸素を吸い、炭酸ガスを大気に放出します。生態系が成立するために大気圏は不可欠の要素ですが、大気圏はもちろん生命体ではありません。その大気の組成がここ数百万年もの間ほとんど変化せず、しかも生態系がバランスを保つに最も都合の良い組成に落ちついているのは何故だろう、とラブロックは考えました。熱力学平衡論の立場から計算すると、地球の大気の組成は酸素がほとんど無い、火星の大気に似た組成になる筈なのです。

その後の研究で、地球と生態系の関係は極めて多面的、多層的であること、その関係を通じて地球環境自体が恒常性と自己組織性を獲得し、生態系と相互進化している証拠が、続々と見つかりました。あたかも地球環境が生きているように振る舞う有様を擬人化して、

ラブロックは大地の女神ガイアと名付けました。ガイアは、ヘリオスの恵みを直接に受け取るとともに、地上に生を営む生命体からも十分に吸収して、生態系とともに進化してゆく存在です。我々が地球環境を取り扱うとき、ガイアの持つこのような特性を根元から理解してかかることが、まず必要なことでしょう。

（4）プルートーの恵みと文明

ところで、ガイアが散逸構造としての柔軟な秩序を積み上げてゆく上で、ヘリオスの恵みとは異なるもう一つのネゲントロピー源が、重要な働きをしていることを忘れてはいけません。地球の誕生時に地核の深部に閉じこめられた放射性元素から放出される放射線は、多くの物質にエネルギーとネゲントロピーを与えながら、地熱エネルギーの形で地表に染みだしてきます。これをギリシャ神話の地下の王者にちなんで、プルートーの恵みと呼ぶことにしましょう。

プルートーの恵みは、地表の熱バランスで比較する限り、ヘリオスの恵みに比べ微々たるものですが、地核とのかかわり合いでは圧倒的な力を持ち、造山活動や火山活動を通じて、長期的に地球の気象環境を支配したり、地表に多量の物質を運んで、地上の生態系に進化の場を提供したりします。

このような観点からガイアは、ヘリオスの恵み、、プルートーの恵みの両輪の上に成立した散逸構造と定義づけることが出来ましょう。一方生態系は、ほぼヘリオスの恵みの上にのみ乗った散逸構造であり、ガイアとの相互進化関係を介した極めて受動的な範囲でしか、プルートーの恵みには関与してこなかったと言えましょう。

人類は、プルートーの恵みをその営みのために積極的に活用した最初の生物です。地球深部に広く薄く分布している重金属元素類は、マグマによる鉱床形成活動を通じて、地殻内に選別濃縮され、析出してきます。プルートーの賜物、鉱物なるネゲントロピー資源は、このようにして誕生します。人類は、他の生物が手に入れることの出来なかったネゲントロピー資源をプルートーから授かることによって、新しい散逸構造としての文明を築き上げ、ガイアや生態系と相互進化する地位を確保したのです。

しかしエネルギーに関する限り、従来人類が掘り出して来た地下資源は、純粋なプルートーの恵みではありませんでした。石炭も石油も、生態圏の生物群によって固定化された太陽エネルギーが、地殻深部の高温、高圧によって更に低エントロピー化された資源で、この意味でヘリオスが生み、プルートーが育てた恵みということが出来ます。人類が費消した化石燃料の帳尻は、その起源であった生態系で清算されねばなりませんが、なにぶん三億年かかって生産されたものをわずか二百年余りで使い尽くそうという勢いでは、生態系やガイアに大きな歪みが生まれるのは当然と言わねばなりません。地球温暖化、酸性雨

など、いずれもこのミスマッチングから生じた問題で、扱いようによっては文明の成立条件を大きく脅かしかねない、危険をはらんでいます。

このような時期に、人類がヘリオスの恵みから独立した巨大なエネルギー源を手にし、原子力平和利用の道を歩みだしたことは、人類文明にとって偶然以上の幸運というほかはありません。前にも述べたように、ウラン－２３５やプルトニウムからは、同量の石炭の数百万倍のエネルギーを取り出すことが出来ます。そのうえ化石燃料が、現在のような使い振りでは、あと数十年の命といわれているのに対し、原子力は、プルトニウム利用技術さえ確立すれば、現在確認されているだけでも千年以上の資源量を確保しているのです。有史以来初めて与えられた、プルートー起源のエネルギー資源により、文明は新しい進化を約束されたといえるのです。

（５）再生可能エネルギーの限界

ここでいわゆる「再生可能エネルギー」の文明論的役割について、触れておきたいと思います。太陽光発電、太陽熱利用、風力などの技術は、本質的に「生態系の知恵」の後追い的性格から免れることが出来ません。豊かとはいえ、気まぐれで薄く分散された太陽エネルギーを有効に取り込むため、地球上の生物群は数億年をかけて、柔軟で精巧なエネルギー捕集システムを作り上げました。緑葉植物の太陽エネルギー転換効率は１％にもなりませんが、それによって固定化されたエネルギーの保存性、資源性は極めて高く、また光合成反応は炭素サイクルを通じてガイアの恒常性保持機能に大きく貢献しています。

一方光転換素子技術の向上により、（あり得ぬことながら）仮に太陽エネルギーが１００％電気エネルギーに転換可能になったとしても、植物との効率比はたかだか百倍程度で、プルトニウムの百万倍には遠く及びません。そのうえ薄く拡がった太陽エネルギーを捕集するためには巨大な構造物が必要となりますが、その建設、保守に費やされるエネルギーを差し引けば、生物圏の十倍を越える効率のシステムを組み上げることは、現実にはかなり困難でしょう。しかも生態系と太陽光利用システムは、エネルギー取り込み面積の確保で、（既に文明が生態系から取り上げてしまったスペースを除けば）、本来的には競合関係にあるのです。

もちろんこのような技術も、局所的に利用される、小回りの利く選択肢として開発される価値は十分にあります。しかし次世代の文明を支えるポテンシャルとの立場からはいかにも不十分であり、これと原子力平和利用技術をトレードオフすることは、到底出来ないのです。

4．原子力平和利用体系の完結に向けて

さて、大分回り道をしましたが、文明を享受している人類にとって、原子力平和利用が将来にわたっての、もっとも有効なエネルギー獲得源であることがお分りと思います。

ところが、現状ではまだまだ不十分なのです。プルトニウムをフルに活用した原子力平和利用体系の完結こそが、１００万倍のインパクトを生かす手段なのです。以下に、その辺について触れてみたいと思います。

（１）百万倍を生かすために（エネルギー収支の改善）

お示しした図には、いろいろな発電プラントの、建設運転はもとより、建設資材や、エネルギー資源の採取から後始末までに投入される全エネルギーの総和と、プラントから生産されるエネルギーとの収支比について、電中研の内山さん等が計算した結果を示しました。太陽発電は、たかだか投入エネルギーの三から四倍のエネルギーしか生産できないことが判ります。

しかしこの図は同時に、現在の原子力平和利用が抱える問題点を、浮き彫りにしています。現在日本の原子炉で燃やされる燃料のほとんどは、アメリカかフランスのガス拡散濃縮工場で生産された濃縮ウランを原料にしていますが、その場合のエネルギー総合収支は、なんと石炭火力プラントより低いのです。これはガス拡散濃縮が、元々核兵器用に開発された技術であり、電気使用量には糸目をつけなかったため起きた問題です。

鯛を釣るために鯛を餌にするような矛盾を解消するため、いろいろな濃縮法が研究されましたが、下北の六ヶ所村の濃縮工場で採用されている遠心法では、ガス拡散法に比べ濃縮に使われる電気量が大幅に節減でき、収支比は１６から５５へと改善されています。それにしても石炭火力との比は三倍程度、百万倍のポテンシャルは、どこに行ってしまったのでしょう。

実は天然のウランに０．７％しか含まれていないウラン－２３５の燃焼に焦点を絞った、現在の軽水炉の仕組みに、乖離の主原因があります。現在アメリカが採用し、各国にもしつっこく押しつけようとしている、使用済み燃料をそのまま「高レベル廃棄物」として処分してしまう再処理禁止路線では、エネルギー資源の利用率はわずか０．５％程度にしかならないのです。これでは資源の無駄使いであるばかりでなく、折角の資源を廃棄物に回すことで、社会に二重の損失を強いることになってしまいます。

（２）「廃棄物」は「資源」である

元来「資源」という言葉も、「廃棄物」という言葉も、人間が勝手につくった概念で、天然にそのような区別があるわけではありません。社会が有用性を認め、その中から価値を引き出そうとすれば「資源」となり、利用する意志を失えば「廃棄物」となります。

軽水炉の中での使命を終えた原子燃料の中に含まれている燃え滓（核分裂生成物）の量は、わずか３から４％、残り９６－７％はプルトニウム、燃え残りのウランなど、立派な資源なのです。原子力平和利用が始まった頃のコンセプトには、当然の事ながら、この使い残しの資源を有効に使い尽くす計画が組み込まれていました。軽水炉発電は原子エネルギー平和利用システムの入り口であって、決して終点ではなかったのです。それが「尾頭付きの頬肉だけつつく」、お大名さながらの使い捨て路線に変わったきっかけは、軍事的な核優位性保持のためには平和利用を犠牲にする事も辞さない、アメリカの核抑止論者の圧力でした。

もっとも、時のカーター大統領に再処理放棄路線を進言したハーバード大学のブレーンたちは、原子力の現場を知らない政策屋達で、プルトニウムさえ切り放せば、アメリカの軍事的な優位性と原子力の平和利用を両立させられると、単純に信じ込んでいた節があります。しかしこの路線は、それまで原子力平和利用をリードしてきたアメリカの国際的影響力を大幅に低下させたばかりでなく、国内のみならず世界の原子力界に混迷を巻き起こし、ユッカマウンテンの廃棄物処理場問題に象徴されるような袋小路に、自らを追い込んでゆく結果を生みました。

現方式の原子力発電炉は、エネルギーと同時に不可避的にプルトニウムを生産します。エネルギーだけつまみ食いして、プルトニウムの方は頬っかむりをするような考えは、元々工業システムとして成立し得ないのです。

（３）プルトニウム無しに原子力平和利用は成立しない

皮肉なことに、平和利用からプルトニウムを閉め出そうとした政策の矛盾は、まわり回ってアメリカの核抑止力信奉派にも降り懸かってくるようになりました。冷戦時代の終結により大量の核弾頭が解体され、米ロ併せて２００トンばかりの軍事用プルトニウムが余ることになりました。ところがアメリカはこれを平和裡に処分する手段を、既に失ってしまっているのです。差しあたりは抜き出したプルトニウムの球（これをピットというそうですが）に物理的変形を加えて、貯蔵しておくのだそうですが、こんなことでは何時当事国が心変わりをして、又原爆に逆戻りさせるかわからない。その恐れを根本から断つには、プルトニウムを消滅させる以外に方法はないのです。ロケットに乗せて宇宙に放り出すと

か、ガラス固化して地下４０００メートルに埋めるとか、いろいろ議論はされていますが、皆技術的にも問題があり、そのようなことに大金を払うスポンサーもありません。

最近アメリカの科学アカデミーが政府の諮問を受けてまとめた勧告の、おすすめシナリオは、アメリカやカナダの発電用原子炉で燃やすというものでした。従来政策の面子を潰さないよう、核兵器用プルトニウムを放射性廃棄物で「汚し」て拡散抵抗性を増すために発電炉を利用するのであって、プルトニウム利用ではないのだとか、今回だけの特例だとか、いろいろ言い繕っていますが、これが平和利用からプルトニウムを閉め出すという従来方針の破綻を意味することは明白です。

しかしこの勧告を採用しようにも、プルトニウムを魔女に仕立てて追い出してしまったアメリカの平和利用界に、今更プルトニウムを扱う施設も人も技術も残っていません。苦し紛れに協力を呼びかけられても、平和利用一本にプルトニウム計画を進めてきた日本は勿論、フランス、イギリスのような国々にとっても、正直のところ迷惑千万の話です。核兵器廃絶のためになることなら応分の協力もやぶさかではないが、それにしてもアメリカが冷戦終結の現実をふまえて、もう少し整合性のある政策に切り替えて貰えないと困る、というのが率直な反応でしょう。

（４）「マッチで暖を取る」軽水炉

今百万キロワット級の発電所を運転しようとしますと、石炭では年間２５０万トン必要なところ、原子燃料なら２５トンで済みます。しかしこの燃料をつくるには１５０トンの天然ウランが必要であり、そのためには5万トンほどの鉱石を掘り出さねばなりません。通常は更に多くの覆土を取り除かねばなりませんから、自然に与える影響は決して小さいとは言えません。

これだけの思いをして掘り出しながら、そのうち本当に燃えてエネルギーになるのは、わずか８００キログラム程度ですから、残りを使い捨てたのでは廃棄物ばかりが増えてしまいます。ウラン資源もいくら豊富とはいえ、これでは数十年で使い尽くされてしまう勘定になります。このような無駄使いは、なりふりかまわぬ軍事利用の時代であればいざ知らず、いやしくも人類の文明を支えてゆく基盤産業の資源利用法としては、類例のない、産業倫理上も許されるべきでないやり方と、言わざるを得ません。

天然ウランの９９．３%を占めるウラン２３８は、そのままではエネルギーに変えることの出来ない、いわば濡れた薪のような存在です。薪が炭焼き釜の中で木炭に変わるように、ウラン２３８は原子炉の中でプルトニウムに変わる事で、初めて燃料としての価値を持つようになるのです。

現在の軽水炉は、濡れた薪はそのままにして、自然が残しておいてくれたウラン２３５なるマッチで暖をとろうとするのに似ています。勿論マッチを燃し続けていれば、まわりの薪のいくらかは消し炭に変わり、燃えるようになります。事実、軽水炉の中で燃料を燃していると、その寿命の終わり頃には、炉内で生まれたプルトニウムの燃える量の方が、最初に持ち込んだウラン２３５のそれより多くなります。原子燃料の全寿命を通じてみれば、軽水炉からはマッチ役のウラン２３５が２に対して、プルトニウムが１の割合でエネルギーが取り出されている勘定になります。しかしアメリカ流で行けば、結局濡れた薪の９５％以上が、燃え残りの消し炭とともに、「高レベル廃棄物」とされてしまうのです。

この消し炭を再処理で取り出し、もう一度軽水炉に戻してやろうというのが、いわゆるプルサーマル・リサイクルです。しかし軽水炉は元々炭焼きには適した炉でなく、燃料の選り好みも激しいので、このようなリサイクルを繰り返していると、プルトニウムは急速に劣化し、軽水炉では燃せない（従って廃棄物に回さざるを得ない）同位元素が増えてしまうのです。

（５）「濡れた薪」をエネルギーに変える高速炉

高速炉は「濡れた薪」を最も効率よく燃やしてくれる原子炉です。選り好みをする軽水炉では燃えてくれない偶数原子量のプルトニウムも、高速炉ならうまく燃やせます。それにプルトニウムの劣化も、軽水炉に比べて格段に少なく、自然からの恵みを最も無駄無くエネルギーに変える能力を備えています。いわば高速炉は「消し炭」ではなく「上質の木炭」を生産し、なおかつそれを効率よく燃やす事の出来る炉なのです。

このような高速炉の特徴をうまく利用したのが、炉の中心では「木炭」を燃やしながら、外側ではその余熱を利用して「濡れた薪」を乾かし「木炭」に変えてゆく、二重仕掛けの炉です。このタイプをうまく運転すれば、中心で燃えるプルトニウム以上の量のプルトニウムを、外側でつくるといった芸当が出来ます。エネルギーを取り出しながらプルトニウムも増やすことが出来るというので、高速増殖炉と呼ばれていますが、これは資源論的立場から見た高速炉の一理想型ではあっても、決して高速炉の総てではありません。

これは世界的に言えることですが、従来の高速炉開発路線では、軽水炉と競合する炉としての意識ばかりが前面に出て、軽水炉を補完する炉として捕らえる努力に欠ける恨みがありました。軽水炉は技術的完成度の高い立派な炉です。しかも世界で３００基以上の建設、運転経験に支えられて、その性能は年々伸びています。後発の高速炉が軽水炉に追いつき追い越そうとしても、複合スキーで日本チームに５分以上のハンディをつけられスタートしたノルウェーチームのようなもので、たとえ体力的に勝っていても、簡単に追いつくものではありません。ましてや一方は発電で収益を挙げながら着々と経験を増やせるの

に、他方はその経験を得るにも開発費がかかるのですから、勝負は明白です。

しかし元来高速炉は軽水炉と競い合い対立する存在ではなく、燃料サイクルの一要素として、軽水炉の問題点を補い軽水炉と共存する、相互補完的な存在であった筈なのです。軽水炉では僅か数パーセントしかエネルギーに変えることの出来なかったプルートーの恵みを、軽水炉からしっかり受け継ぎエネルギー化してゆく。高速炉の原点はそこにあったのです。高速炉は燃料サイクルの前提の上に成立する炉です。増殖率も、倍増時間も、再処理があって初めて意味をなす数値です。それを単に炉性能を競う指標としてしまい、サイクル不在のコスト競争を展開しても、高速炉の展望は開けてきません。

高速炉は本来燃料サイクルのニーズに応じて自在に性能を発揮できる、多面的な器用さを備えた炉です。プルトニウムを増やすことも、積極的に減らすことも、軽水炉サイクルでは廃棄物としてしか扱えないＴＲＵを燃やすこともできます。このような多面性をふまえ、時代とともに高速炉へのニーズも変わって来ます。軽水炉が圧倒的な現時点では、プルトニウムは余り気味です。核弾頭解体によって出てくるプルトニウムも、この傾向に拍車をかけます。このような時代にあっては、核拡散の懸念を払拭するためにも、プルトニウム燃焼炉や、より広くＴＲＵ燃焼炉としての高速炉開発に重点を置くとともに、これに見合った高度再処理技術の開発を並行して進めることが望ましいと、私は思います。

やがて高速炉の実用化が進んでくれば、プルトニウム不足による建設遅延などの事態が起こらないよう、増殖機能を発揮させる時代もくるでしょう。しかし無用の疑惑を招かぬ為にも、余分のプルトニウムを抱え込まぬよう、生産と消費のバランスを常に心がける必要があります。時代が要請しているものは何かしっかり見据えながら、燃料サイクルと一体になった炉開発の推進が望まれるゆえんです。

５．二十一世紀を支える原子力発電

二十一世紀、人類文明の更なる拡大は不可避です。驚異的な速度で経済成長を遂げつつあるアジア諸国、爆発にも似た人口増加。しかし先進国並の幸福を求める途上国の人々に我慢を強いる権利も、生まれ落ちる子供らの生活を奪う権利も、我々にはありません。ガイアや生態系との関係を損なわずに、膨張する文明社会を支えてゆくには、周到な資源、エネルギー計画の遂行と、リサイクル社会の実現が必要不可欠です。

ニュージーランドやイングランドの手懐けられた「自然」や、茶の間のテレビに映し出される演出された「大自然」に馴らされた現代人に、中世期以前の人類にとっての自然が、いかに苛酷で恐ろしい存在であったかを理解してもらうのは、容易なことではないようです。理性的な環境保護、資源保護と、心情的な反文明主義、感傷、エゴイズムなどが混線しているところに、現代の環境問題の困難があるようです。しかし家出少年が故郷を恋う

るような、ジャン・ジャック・ルソー以来の、情緒的自然回帰願望や、文明のなかにどっぷり浸かりながら文明を呪うような、甘えの構造に身をゆだねる暇は、二十一世紀の人々には残されていないでしょう。

適正なエネルギー量の確保は、人類文明が散逸構造としての柔軟な構造を保持しつつ、ガイアや生態系とともに進化してゆくための必要条件です。途上国が利用しやすいエネルギー資源を残しておくためにも、先進国はより高度のエネルギー資源利用技術の開発に、全力を投入しなければならないのです。

今まで縷々お話してきたように、原子力発電は、唯一無二のポテンシャルを持った、二十一世紀の為のパラダイムエネルギー技術です。しかし全電力量の三分の一を支えるようになった現在でも、トータルシステムとしての原子力はまだ緒についたばかりです。軽水炉技術ばかり進み、サイクルを積み残した原子力システムは、玄関先ばかり立派な欠陥マンションに似て、人が長く住むに値しません。これを基礎のしっかりした建築に立て直すキーワードが、プルトニウムです。

原子力が子孫に重いつけを残す束の間のエネルギー技術として、歴史の波の間に消え去るか、二十一世紀の基盤エネルギーとして文明を支える重要な役割りを担うか、その鍵はプルトニウムが握っています。そして今後文明が、急増する人口や途上国の伸張を抱えて、なお進化を遂げてゆくことが出来るか否かの鍵も、おそらくはプルトニウムが握っているのです。

今日のお話が、皆さんにプルトニウムの素顔をよりよく知っていただき、プルトニウムが文明社会に対し果たしうる役割をご理解いただく上で、少しでもお役にたったとしたら、これ以上の幸いはございません。

以上

Diffusing the fear
- Exposing the Myth

Roger Hayes
Director General
British Nuclear Industry Forum

J.A.I.F 27th
Annual Conference

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Session 2 - Nuclear Power and Plutonium

Good (time of day).

I would like first to summon-up my meagre resources of the Japanese language and say to my hosts (*IN JAPANESE*) Thank you very much for inviting me here. I feel very honoured. (*REPEAT IN ENGLISH*)

The British Nuclear Industry Forum, which I represent, fully accepts that the need for Plutonium is not, at the moment, anything like as great as it was. We also accept that there is more than one way of using, or managing the Plutonium that at present exists or is still being created. Indeed, as I am sure you all know, within the British Nuclear Industry there is extensive expertise in both reprocessing and the dry storage of high level waste.

But I do not propose in this presentation to argue the merits of either case. Today I want simply to deal with the <u>facts</u> of Plutonium, the public perception of the <u>risks</u> of Plutonium and the ways in which we can improve that perception and defuse and de-mythologise it so that rational and informed debate can take place. In other words, how we can diffuse the fear and expose the myths.

Standing in this city, above all others, no-one can deny the hellish power of plutonium when it is specifically-harnessed for destruction. Nor do I seek to do so.

Nevertheless, properly-stored and carefully-maintained Plutonium is nowhere near the hideously lethal monster which popular imagination (aided and abetted by newspapers and green groups) makes it out to be.

In general, in the United Kingdom, public attitudes towards nuclear generation are encouraging. In a series of surveys of public attitudes carried out in 1993 we revealed some very encouraging results:

For example, when 1000 adults in the UK were asked what they thought was the most important problem facing Britain today, only 1% (ten people) said "nuclear waste" - which put it at the bottom of a list of 18 other major and more popular concerns - ranging from pollution and traffic to the greenhouse effect and acid rain.

In another study in 1992 the UK nuclear generation industry Ywas rated as the one industry doing most to reduce harm to the environment.

These good figures are, I am sure, the result of a policy which has been carried-out for many years now in the UK; a policy of openness and education; a policy of presenting the facts and of inviting the public right into our generating stations and other nuclear facilities.

At the same time, public attitudes toward Plutonium are still highly anti - predictably, perhaps, because of the close connection in most people's minds between Plutonium and weapons.

It is easy for us - because we know the facts - to say that weapons-grade Plutonium and civil-grade Plutonium are two very different things. Of course they are. We can also say, with confidence, that the controls on both kinds of Plutonium are so strictly applied that there is very little risk of any of it falling into the wrong hands. This is also true.

We can go further and assert with perfect confidence that stocks of civil-grade Plutonium are monitored and inspected to the highest levels and that military-grade Plutonium has the highest-possible security classification.

We can add that we are actually destroying Plutonium in our mixed-oxide reactors.

But too many people won't believe us. Unless, that is, we say all these things in the right way.

It may be unfortunate; it may be unfair; but we must face the universal truth that perceptions are facts because people believe them - or, in other words: what people believe is as true to them as any fact. You cannot argue directly with belief - you have to approach it with skill and care and be prepared to present mind-changing arguments subtly and frequently.

This is something which we in the UK are already addressing and I like to think that, with my particular expertise in the field of public relations, I have a useful role to play.

It is, of course an international task and that is why I am so glad of this opportunity to address you all here today. To begin with we must co-ordinate our messages internationally.

Ours is a global business with global problems and global solutions.

So, a perceived problem in one part of the world reverberates across nuclear programmes in other countries. The delays in commissioning the UKAE's Thorp facility - now at last finally resolved - had an impact on nuclear plans in many regions and countries - not least here in Japan.

Eight years ago, Chernobyl was a recent and dramatic example of the way in which nuclear events reach out across national boundaries and I am presently chairing a European-wide committee - the first of its kind - to present and position the issues raised for the 10th anniversary in 1996.

This kind of international presentation of nuclear issues must continue. One assessment of the global value of nuclear business is ten billion US dollars a year and we all potentially own a share in that market.

Internationalism can have major benefits in the kind of public communication I am talking about. For example, positive messages about successfully-operated waste sites in Sweden, or the low-level waste disposal methods employed by Japan Nuclear Fuel's at Rokkasho-mura, can be employed elsewhere in the world - offering valuable synergy to the never-ending nuclear story.

I'm talking about much more than just an exchange of views; I'm talking about interactive and creative co-operation to find and use common solutions to the problems we all face. I am already working very closely with my Japanese, French, German and American counterparts , as well as co-operating with the international bodies.

Our strategy is to focus on the positives - whilst always being ready to expose and attack the negatives. Because no matter how hard we try, the negatives won't go away. There is a long term PR task for all of us there whether we like it or not.

At this point I'd like to quote briefly from some of our BNIF campaigning on behalf of the British nuclear industries. On the positive side we are currently running a press campaign which asks a series of questions such as "If a British industry proved it was worth billions, would you back it?"; "If a British industry supported 100,000 jobs, would you back it?" and "If a British industry offered real hope for the planet, would you back it?"

The industry in question, of course, as the advertisement reveals, is the Nuclear industry. And the advertisement goes on to argue the case for a government decision to press forward now with nuclear development. It is being very well received by the public at large.

At the same time, as I said just now, we must always be ready to expose and attack the negatives. And, I am bound to tell you that we found a recent Greenpeace press campaign in the UK wholly negative and grossly misleading.

Our response was a detailed seven-page letter to the UK Advertising Standards Authority. The letter contained a full rebuttal of the Greenpeace arguments and statistics and exposed their use of false and irrelevant photography. At this moment, the case is still being considered but I have high hopes that our prompt and spirited response will bring this offensive campaign to an end.

I am talking about changing public attitudes toward nuclear power in general but, of course, everything I have said goes double for the particular problems relating to public acceptability of the various Plutonium solutions.

We should not allow ourselves to be frightened by the public image of Plutonium. We should point out that the nuclear power industry can destroy military grade Plutonium safely in its mixed oxide reactors.

We can show how, by helping other countries to develop nuclear power, we are able to sign them on to the non-proliferation treaty - with all its concomitant inspections - and thus actively discourage the development of nuclear weapons.

At the same time we should be seeking to de-couple weapons-grade Plutonium from civil grade Plutonium, whilst stressing the extremely stringent controls which apply to them both.

We should go for the high moral ground, and carve out a piece of intellectual territory of our own. At the same time, I believe, we should not be over-ready to make too many public pronouncements on those matters that worry people most.

The world's airlines don't attract business by publicising their accident record.

The chemical industry doesn't focus continually on the events at Seveso or Bhopal.

And the oil industry isn't forever telling us why the Exxon Valdez disaster won't happen again.

We should learn the lesson from this.

Public exposure is important; we should not be afraid of the facts. But we should seek to give the positive the promotion it deserves.

Public education is equally important; a well-informed and educated public is, on the whole, a pro-nuclear public. But we should make sure that the education we provide places nuclear energy and the use and storage of Plutonium in context with the environmentally-damaging fossil fuels.

As an international industry - and one which will become more and more vital as the years go by - we should be positioning ourselves not as a problem, but as a <u>solution</u> to other, wider and deeper problems.

We should seek to identity issues on the move and take up a position showing how it is "on the right side" of an issue. And we should do our damnedest to do that before these issues gain too higher a profile in the public understanding.

Plutonium, of course, already has too high a profile, but, as I have indicated, there is still much we can do and say to put it into perspective.

We should not seek to do all of this by ourselves. A few words of support from trade union leaders, industrialists, politicians or academics are worth many hours of press briefing from people like me. The more independent the advocates; the greater the effect they will have.

We know, from our research, that few people can maintain a deep interest in more than three big issues. For the rest, they look for a quick off-the-shelf opinion, without ambiguity, finesse or intensive debate - they welcome the opportunity to accept a one-line opinion from someone they respect and trust. This is the power of third-party advocacy.

The images which we deal in range from, on the one hand, the concept of Plutonium as, and I quote, "the most evil element in world" and, on the other hand, the concept of a limitless source of safe, clean, non-polluting power.

We must normalise these extremes and walk down the middle in terms of imagery. We should avoid extravagant and controversial claims and look to powerful folklore imagery - building on such ideas as "Atoms for Peace", "Swords into Ploughshares" and the growing use of nuclear sources in medicine.

We should also make more use of creative imagery; employing movies and music to enhance our message. Because in many cases it's true - one picture <u>is</u> worth a thousand words.

And when we do come to use words we should choose them carefully; avoiding "loaded" words like "critical" and "contamination".

To sum up, the way people <u>feel</u> is often quite independent of what they <u>know</u>. Consequently we need to deliver our messages - both about Plutonium and about other controversial aspects of nuclear power - in ways which are not only factual, but which also feed the emotional and imaginative needs of ordinary people.

In conclusion I can only say (*IN JAPANESE FIRST AND THEN IN ENGLISH*) Ladies and gentlemen, thank you for your attention.

情報公開とパブリックデシジョン（要旨）

東京電力（株）副社長
池　亀　　亮

① 変化し得る90%の層

さまざまな世論調査をみると，原子力の開発利用について確定的な強い意見をもつ人は10%ていどで，90%は「弱い賛成」から「中立」「弱い批判」まで含めて変化し得る柔軟な意見をもった人々である。この層の存在が，まさに民主主義の強みであり，「社会的安全装置」である。

パブリックデシジョン（ＰＤ）は，この90%の人々が決定権を握っている。

② 「光」と「陰」の情報提供と総合判断

的確なＰＤがなされるためには，原子力開発利用に伴う「光」の面ー資源の保存，環境の保全，廃棄物の適切化，エネルギーの安全保障，雇傭の確保，地域振興などーと「陰」の面ー事故の可能性，廃棄物処理，核拡散の懸念，および「陰」のコントロールシステム，などについて十分な情報が提供されることが不可欠である。

国民の７０～８０%が原子力情報をマスメディアから得ていることから，メディアに対する迅速・的確な情報提供と，メディアにおける適切な報道が，ＰＤのカギを握るものとして重要である。

③ 重要な透明性

プルトニウムに即していえば，ＰＤにとって必要なことは核燃料リサイクルの計画（plan）建設・運転・保守・貯蔵・輸送（do）当事者および第三者機関による監視（check ）の各段階において，そのプロセスの透明性が確保されることである。この意味でも情報公開はＰＰ・ノウハウ等を除き全面的に推進すべきである。

現在，日本においてＩＡＥＡによる徹底的な査察が行なわれているが，この情報は必ずしも十分に伝わっていない。

今後，プルトニウム平和利用の計画・管理が国内的にも国際的にも一層目に見え，信頼されるような国際的枠組みを強化・構築することがＰＤにとっての課題である。

④ 結　び

原子力発電やＰｕ利用のＰＤは，安全・安定運転の地道な積み重ねがあるかどうか，原子力の開発利用や，核不拡散の国際的な枠組みがいかに構築されているか，それがどのていど「目に見えるか」，それが果たして信頼され安心感が得られるかどうかによって決まるものと考える。

エネルギー供給と再処理プルトニウムの位置づけ

科学技術庁原子力局核燃料課長
森口　泰孝

世界のエネルギー需要は増加の一途をたどっており、この傾向は将来にわたっても継続し、２０１０年には１９９０年の１．５倍になると見込まれている。特に、急激な人口増加や工業化による開発途上国のエネルギー需要の増大が注目されており、２０１０年までの全世界の化石燃料（石油・天然ガス・石炭など）の需要増加分のうち３分の２以上は、開発途上国によるものと考えられている。化石エネルギー資源量の制約と化石エネルギーの利用による地球環境への影響を考えあわせると、高度な技術を有する先進国が、エネルギー供給における非化石エネルギーへの依存度を増加させていくことが重要となる。

現在、世界２９ヵ国・地域で原子力発電が行われ、その総発電電力量は世界全体の発電電力量の１７％を占めている。日本においても総発電電力量の２８％を賄う基軸エネルギーとなっている。

原子力発電を行う以上、原子力発電により発生するプルトニウムをどのように取り扱うか ― 有用な資源であるプルトニウムを利用するのか、それとも、廃棄物として処分するのか ― ということが、不可避の課題となる。

使用済燃料からプルトニウムを取り出し、燃料として再利用していくことは、少量の資源から大量のエネルギーを産み出すという原子力発電の特徴をより一層活かしていくことであり、我が国は、原子力開発利用に着手して以来一貫して、プルトニウムを有用な資源として活用する「核燃料リサイクル」を基本方針としてきた。

我が国が核燃料リサイクルに取り組んでいる理由は、まず第１に、原子力発電を長期的に経済的かつ安定なエネルギー源とするというエネルギー・セキュリティの観点がある。ウランの価格が近年比較的低位で安定し、需給が緩和基調にあるという傾向が今後も当面続くと見られていることから、核燃料リサイクルの必要性と意義が薄れているとの意見もある。しかし、ウラン資源中わずか０．７％しか存在しないウラン２３５のみを用いて原子力発電を行う限り、基本的には化石燃料と同様、天然ウラン資源の有限性からくる将来的な供給不安を克服できるものではない。高速増殖炉によりウラン資源の９９．３％を占めるウラン２３８を核燃料として利用することによって、ウラン資源の利用効率が飛躍的に向上する。（核燃料の資源量としては千年以上になるとの試算もある。）また、リサイクルすることにより核燃

料は準国産の資源となり、核燃料サイクル全体の経済性が、ウラン価格のような外的要因にあまり左右されることなく、核燃料サイクル技術の成熟度に応じて向上することになる。従って、エネルギー源の約８４％を輸入に頼り、ウラン資源を１００％以上海外に依存している一方でエネルギーの多消費国でもある我が国にとって、資源制約を受けにくい核燃料リサイクルの実用化を図ることにより、エネルギーの選択肢を広げ、エネルギーセキュリティを確保していくことの重要性は今後とも変わるものではない。

第２に、原子力発電は化石燃料のように地球温暖化現象の原因の一つとされている二酸化炭素や酸性雨の原因物質を発生しないほか、使用済燃料のリサイクルを行うことにより、ウラン、プルトニウムを廃棄物とすることなくエネルギー源として利用でき、かつ、再処理した後に残る高レベルの放射性廃棄物は使用済燃料をそのまま高レベル廃棄物とする場合に比べて量は少なく、安定な形態に固化しやすくなるなど、資源と環境の保護に貢献するものである。

第３に、核燃料サイクル技術を開発し、化石エネルギー及びウランの消費を低減していくことは、長期的な世界のエネルギー需給の安定化という国際的課題に取り組むという観点からも重要である。

また、今後のプルトニウム利用を進めるにあたっては、計画に必要な量以上のプルトニウムは持たないとの原則を堅持し、プルトニウム利用の一層の透明性向上を図るなどにより核不拡散への懸念に適切に対応するとともに、核燃料リサイクルの経済性の向上、情報の公開、核燃料サイクルについての国民的合意形成の努力などに留意して着実に核燃料リサイクルを推進することが肝要である。

プルトニウム利用の諸課題と対応策

動　燃　事　業　団
中　野　啓　昌

(1)　新型原子炉の開発

①高速増殖炉の開発

プルトニウム利用によるウラン資源利用効率を増大できる炉として高速増殖炉の開発を進めており、原型炉「もんじゅ」の完成は、今後の実用化に向けた本格的な第１歩をしるすことになる。

「もんじゅ」は昭和６０年１０月に本格着工し、現在、試運転の第２段階である性能試験を実施中であり、平成６年４月５日に初臨界を達成した。

「もんじゅ」はプルトニウム利用技術を確立する上での中核的プラントとして、運転、保守を通して高速炉の安全性、信頼性を実証すると共に、新型燃料や高度な技術の開発の場として利用し、成果を実証炉に反映していく。

高速実験炉「常陽」は昭和５２年４月の初臨界以来、増殖炉心運転、照射試験を実施してきた。現在、照射能力を約４倍に向上する高度化計画を開始した。

経済性について、開発段階にある現在はコスト的には高いが革新技術の開発により経済性で軽水炉と競合しうる見通しがある。今後、高速増殖炉固有の特性を利用し、技術開発により、大幅なコスト低減が可能と考えている。
（優れた燃料利用効率，高熱効率，低圧構造，高燃焼度等）

②新型転換炉の開発

高速炉実用化までの中間的段階において、プルトニウムの燃焼を効率的に行え、天然ウラン等の多様な燃料も利用できる優れた炉として新型転換炉の開発を進めてきた。

原型炉「ふげん」は昭和５４年３月の本格運転開始以来順調に運転を継続しており、この１５年間にプルトニウム燃料を約５６０体、核分裂性プルトニウム量として約１トンを装荷した実績を有している。

(2)核燃料サイクル技術の開発

我が国では、従来よりウラン資源を有効に利用し原子力発電の供給安定性を高めるため「再処理ーリサイクル路線」を基本としている。

①再処理工場の運転、再処理技術開発

昭和５２年のホット試験開始以来、機器の故障・不具合があったがこれを解決し、年間９０トンの定格運転体制を確立しつつあり、現在までの累積処理量は約７１７トンになっている。

高速炉燃料の再処理技術開発のため、「リサイクル機器試験施設」の建設を今年より始め、2000年に完成予定。本施設では「もんじゅ」の使用済燃料を用いて連続溶解槽等の新しい機器・プロセスの試験を実施する。

ＲＥＴＦと実用プラントとを繋ぐ試験プラントでは高度化技術も取り入れつつリサイクルの実証も念頭に再処理プラントとして建設することとし、2015年頃の運転開始を目標に、2010年頃までに計画を具体化。

②プルトニウム燃料加工、燃料開発

プルトニウム燃料の製造は昭和４４年から開始し、現在まで「常陽」「ふげん」「もんじゅ」のプルトニウム燃料約１２００体、１３０トンを製造しフランスと並んで世界のトップレベルの技術を有している。

昨年６月の連続焼結炉のトラブルは「もんじゅ」臨界時期の遅れの原因となったが、これも克服し、平成６年１月「もんじゅ」初装荷燃料２０５体の製造を完了した。

基本的技術は確立しており、今後は、高速処理化、工程高度化、燃料仕様の統一等により経済性、信頼性の一層の向上を図る。

③高レベル廃棄物の処理・貯蔵・処分

我が国では再処理施設において、使用済燃料から分離される高レベル放射性廃棄物を安定な形態に固化（ガラス固化）した後、３０年から５０年間冷却のため貯蔵を行い、その後地下の深い地層中に処分することとしている。

高レベル廃棄物の処理技術については「ガラス固化技術開発施設」のホット試験を平成６年夏に開始の予定である。

地層処分の研究開発については「地層処分基盤研究施設」等での試験を実施中であり、また、地層科学研究を釜石鉱山等にて実施している。

(3)核不拡散とその対策

冷戦終結後の不安定な国際社会の中で、核拡散に対して国民が大きな関心を寄せており、国際社会が協力して核拡散の防止に向けた環境作りが重要と認識している。

原子力施設における核物質の転用は、保障措置、核物質防護で防止されている。現在、動燃には、核燃料サイクルを中心とした施設へ年間、千数百人・日のＩＡＥＡ査察官が駐在し査察を行っている。と同時に、核燃料サイクル施設には、厳格な核物質防護措置がなされていいる。

核不拡散に関しては、特に、米国でもカーター政権が出来、自らの国のPu利用政策の変更と共に、日米原子力協定の下で日本の再処理工場の設計の変更を求めて、日米再処理交渉が1977年に行われた時、再処理工場において、Puを単体で取り出すのでなく、ウランとPuを１：１の混ぜて取り出す混合転換プロセスが核不拡散上有効であることに双方が合意。以来我が国では、この方法が採用されている。更に、この時以来、日本とＩＡＥＡ、米国（エネルギー省）との保障措置技術に関する協力がスタートした。特に、エネルギー省との間では再処理、ＭＯＸ加工、炉における保障措置技術の改良、高度化の協力が進められ、大きな成果が挙げられてきた。

(4)最後に、我々はプルトニウム利用技術の開発に当たっては、

研究開発の進捗状況、環境負荷低減・経済合理性・核不拡散・プルトニウムをめぐる事情、技術継承等にも配慮しながら、新しいリサイクル技術開発にも取り組み、高速増殖炉開発開発の幅を広げながら柔軟かつ技術体系の確立を目指したいと考えている。

27th JAIF ANNUAL CONFERENCE

TOWARDS NUCLEAR-WEAPONS-FREE WORLD

THE ROLE OF PEACEFUL UTILIZATION OF NUCLEAR ENERGY

Hiroshima, Japan
April 13-15, 1994

DESTINATION OF WARHEAD PLUTONIUM : A WESTERN EUROPEAN ELECTRICAL UTILITY VIEWPOINT

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Good Morning,

First of all, I would like to say how pleased I am to attend this conference and to meet you all in this city.

My speech will be devoted to the destination of plutonium from dismantled warheads. We have, as industrialists, a day-to-day experience of managing fissile materials.

With this background, we think that the leadership that the European and Japanese industries currently enjoy in the management of *reactor plutonium* can help the governments of the United States and Russia finding the best way to dispose of their excess *warhead plutonium inventories*. Such *co-operative actions were identified* as very important at the recent (February 14-15, 1994) Tokyo Roundtable of Experts on the Current Issues of Plutonium[1].

BELGIUM'S FUEL CYCLE STRATEGY

First a few words about our own nuclear fuel cycle strategy.

My company, Synatom, is responsible for the management of the nuclear fuel cycle for the seven pressurized water reactors which provide 60 % of the electricity consumption of Belgium.

Regarding the back-end of the nuclear fuel cycle, we have a balanced viewpoint : we are not pro-reprocessing nor anti-reprocessing; we are not pro-direct disposal nor anti-direct disposal. Our principle is very simple : with due regard to assurance of supply, we aim at the safest and lowest cost operation of our nuclear plants.

Today there is an industrially proven method for spent fuel management, namely reprocessing followed by conditioning of waste of all activity levels. Hence, we have in force reprocessing contracts covering part of our back-end requirements. We have also built the necessary radioactive waste storage facilities. Since about ten years, an underground laboratory is gathering extremely valuable data on waste disposal in deep clay layers.

But we also believe it is of paramount importance to qualify the alternative : direct disposal of spent fuel, which is currently under development. For the future, i.e. after the year 2000, we think that the time is not yet ripe for us to make irreversible back-end choices. We have recently launched, in accordance with the instructions from our Parliament and our Government, a full-scale review of the two possible routes for the back-end. A full comparison is expected to be made by the end of 1998.

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1 "*Various Plutonium Problems Discussed by Experts at Tokyo Roundtable*", Atoms in Japan, February 1994, pp. 16-17.

UTILITY EXPERIENCE WITH REACTOR PLUTONIUM

The uranium and plutonium which we get from our current reprocessing contracts is committed for immediate recycling in our nuclear units.

Plutonium use as mixed oxide fuel (MOX) has been the subject of a parliamentary debate last year in Belgium. After detailed examination, the Parliament and the Government approved commercial use of our reactor plutonium as mixed oxide fuel.

Mixed oxide fuel is currently in industrial use in Switzerland, France, Germany. It is not a novelty to us. Since 1963 it has been used in a pressurized water reactor at the Belgian Nuclear Research Center. More than 300 tons of mixed oxide fuel have been fabricated to date, among which more than 200 tons in Belgium. This has permitted the recycling of more than 15 tons of reactor plutonium, which yielded, in a number of reactors in Europe, the equivalent of twice the annual electricity consumption of Belgium. Thirty pressurized and boiling water reactors are now fully licensed in Europe for mixed oxide fuel usage. There are currently fifteen reactors loaded with plutonium fuel.

European utilities have detailed knowledge and experience of plutonium and mixed oxide fuel handling, transports, physical protection and safeguarding. The European industry has first-hand information on prices and costs. Its experience is not based upon paperwork but on actual achievements[2].

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2 D. Woolf, "*Mixed Oxide Fuel - Past, Present and Future*", US Council for Energy Awareness Conference, Dallas, Texas, March 21-24, 1993.

WARHEAD PLUTONIUM : USE IT AS MIXED OXIDE FUEL

With this background, how do we see the question of destination of warhead plutonium ?

We think that the United States and Russia could and should benefit from the experience that Europe has gained with reactor plutonium management techniques.

Their governments should encourage their utilities to burn excess warhead plutonium as soon as possible, in existing light water reactors[3].

The major advantages of mixed oxide fuel use are :

- the technique is readily available and technically mature[4];
- it takes only 3 to 5 years to build the required MOX fuel factories, once they are licensed[5];
- it is the most economic solution, as I shall demonstrate in a few moments;
- it provides a high level of verifiability[6] and safety[7];
- it converts warhead plutonium into reactor plutonium contained in spent fuel, which is as proliferation resistant as standard light water reactor spent fuel[8];
- it creates no new waste management difficulty since mixed oxide spent fuel can be finally disposed of in the same way as standard light water reactor spent fuel.

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3 In order to give an appropriate incentive to the utilities, the governments could commit themselves to take back the spent mixed oxide fuel at no cost to the utilities, and be responsible for its final disposal. This could be for the governments a cheap way to dispose of excess warhead plutonium, as proposed by P. Goldschmidt, "*Corral Plutonium for Peaceful Use*", The Wall Street Journal Europe, January 14-15, 1994 (see also *"[Washington Public Power] Supply System Eyes Plutonium Stockpiles for WNP1 and 2"*, Atom vol. 432, January/ February 1994, p. 2).

4 OECD Nuclear Energy Agency, "*Plutonium Fuel : an Assessment*", report by an expert group, 1989.

5 A. Pay & A. Vandergheynst, "*MOX Fuel Fabrication Plants in Dessel-Operating Experience with PO-P1, A Second Generation Plant*"; W. Fournier & J.P. Mouroux "*MELOX Progress Status*", both papers to be presented at the 4th International Conference on Nuclear Fuel Reprocessing and Waste Management, London, United Kingdom, 24-28 April, 1994.

6 International Nuclear Fuel Cycle Evaluation, "*Reprocessing, Plutonium Handling, Recycle*", report of INFCE Working Group 4, published by IAEA, Vienna 1980, pp. 123-169.

7 OECD Nuclear Energy Agency "*The Safety of the Nuclear Fuel Cycle*", report by an expert group, 1993.

8 US National Academy of Sciences, "*Management and Disposition of Excess Weapons Plutonium*", Prepublication Copy, February 1994.

WHAT ABOUT VITRIFICATION & DISPOSAL ?

Some people consider that vitrification of plutonium oxide blended with high level radioactive waste and its final disposal would be a better solution.

A better solution ? At first glance, public opinion might indeed prefer solutions allowing final disposal of material perceived as hazardous. Nevertheless, safety authorities in Europe seem today to favour radwaste management options with as little reactor-grade plutonium remaining in the waste as possible. In such a context, would deliberately throwing-away weapons-grade plutonium in high concentrations seem rational ? Would it be acceptable from a non-proliferation standpoint ? I very much doubt it.

Further, plutonium vitrification & disposal is only conceptual at this time : it must first be established and followed by practical application at the same safety level as MOX industry. Its costs/benefits balance remains to be assessed from a number of standpoints : criticality, long-term stability, radiation protection, environmental impact, economics and non-proliferation. It will certainly reach, at a point in time, the safety standards already achieved right now in the European plutonium industry. But when ?

This will require at least a decade of R&D and major budgets[9]. Such developments should not be used as an excuse for not starting the elimination of excess warhead plutonium *as soon as possible.*

As said above, it would take only 3-5 years to build the corresponding MOX fuel fabrication plants according to industrially established techniques, provided there is no political hindrance to the siting and licensing process.

LICENSING AND PUBLIC ACCEPTANCE PROBLEMS WITH MOX FUEL ?

Some people have argued that use of warhead plutonium as mixed oxide fuels would be controversial : obtaining licenses and gaining public approval would be difficult, especially in the United States.

But why should it be so ? Would the vitrification & disposal option really be more acceptable to the public ? It is doubtful.

Let's first look at the point of licensing : the experience in Europe definitely shows that licensing the use of mixed oxide fuel in light water reactors is not that difficult.

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9 US Congress, Office of Technology Assessment, "*Dismantling the Bomb and Managing the Nuclear Materials*", OTA-O-572, September 1993, pp. 97-98.

Independent licensing authorities in Germany, France, Belgium, and Switzerland, for instance, which have built their conclusions on decades of experiments, all agree that mixed oxide fuel usage is fully acceptable. Indeed, loading, say, one third of mixed oxide fuel in a light water reactor does not notably alter the operational and safety characteristics of the reactor. Some reactors are already licensed for operating with up to 37 % or even 50 % of mixed oxide fuel in the core.

Why should it be different in the United States ? Would the opponents to MOX suggest that the licensing authorities in Europe are more accommodating or less qualified than their counterpart in the United States ? The outstanding safety record of nuclear energy in densely populated Europe[10] denies such claims.

It is true that licensing of mixed oxide fuel fabrication plants has not been easy in Europe, to say the least. But it must be stressed that those difficulties arose from actions by certain political circles and anti-nuclear activists. None of them was technical.

Turning now to public acceptance, the argument seems equally wrong. Everyone everywhere would be very satisfied if valuable material previously destined to destructive aims, such as highly enriched uranium and warhead plutonium, would be used for peaceful purposes. A recent opinion poll in my country, Belgium, has shown that twice as many people would favour recycling warhead plutonium in civilian nuclear reactors rather than oppose it.

A real problem one is facing in the United States (I should perhaps say in Washington) might well be the disproportionate influence of pressure groups which are dogmatically opposing *anything* connected with nuclear energy.

The attention of policy makers in the United States should be drawn, as did Gerald Holton in his recent penetrating book "Science & Anti-Science" published by the Harvard University Press, at (quote) "*the type of pseudo-scientific nonsense that manages to pass itself off as an 'alternative science' and does so in the service of political ambition*" (unquote). One must be prudent and watch carefully at the reasons of some benevolent advisers' positions.

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[10] There might be a need to remind that in the United States the average capacity factor of the nuclear power plants only reached 70 % for the first time in 1993. By comparison all seven Belgian nuclear power plants have reached a *cumulative* load factor of 80 % from their first commissioning date nineteen years ago (Nuclear Engineering International, "*Load Factors : 1993 Annual Review*", April 1994, pp 16-21).

ECONOMIC ANALYSIS

It has been said that revenues from power sales from MOX fuel would not be enough to offset the costs of destroying surplus warhead plutonium.

Let me demonstrate that this is wrong.

Our calculations are not based upon theoretical cost assumptions but, when available, on actual prices and offers made by industrial companies striving not only for cost recovery but also for profit, while keeping outstanding safety records. Our experience with economic calculations for reactor plutonium can be easily extended to warhead plutonium.

Let's compare the two main destination options :

- MOX scenario : use of plutonium as mixed oxide in current light water reactors;
- V&D scenario : plutonium Vitrification with high level waste followed by Disposal of glass canisters.

The economic assessment of the two options request consideration of the following main items :

- to compare the energy production costs in both cases : i.e. the fuel cycle costs with mixed oxide fuel and the fuel cycle cost with standard uranium fuel;
- to assess in both cases the costs of plutonium storage, depending on their respective duration;
- to estimate the vitrification & disposal costs of unrecycled plutonium.

Let us look at those items in sequence.

- ***Energy production costs***

Warhead plutonium procurement costs, under oxide form, can be considered nil for the purpose of this exercise, since they are the same in both cases. Thus, in the MOX scenario, the energy production costs are limited to the mixed oxide fuel fabrication price[11], the mixed oxide spent fuel management and the operation of the nuclear station. In the V&D scenario, the replacement power is supplied by standard enriched uranium fuel. In that case, the energy production costs comprise uranium purchase, conversion into hexa-fluoride, enrichment and fuel manufacturing prices, as well as spent fuel management costs and operation costs of the nuclear station.

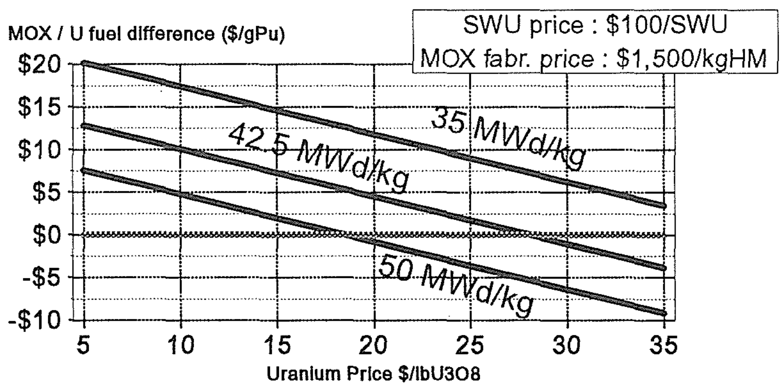
When comparing the two cases, the two latter items, spent fuel management and reactor operation costs, are equal and thus cancel out, leaving only the costs associated with the "front-end" of the nuclear fuel cycle. We use the following reference values and a very wide sensitivity range for market values :

	Reference	Range
Average burnup	42.5 MWd/kg	35-50 MWd/kg
Uranium purchase	20 $/lbU_3O_8$	5-35 $/lbU_3O_8$
Conversion	6.5 $/kg U	
Enrichment	100 $/SWU	75-125 $/SWU
U fuel fabrication	275 $/kg Ue	
MOX fuel fabrication	1,500 $/kgHM	

The range of cost differential between MOX fuel and standard uranium fuel is shown on the following graph, covering a rather wide range of uranium prices :

Figure 1

Energy Production Costs Differential (in $/gPu)



11 The MOX fuel fabrication price includes the conversion of depleted uranium hexafluoride into oxide and its use as matrix for the plutonium oxide.

The calculations show, in the reference case, that MOX fuel costs are about 12 % more than standard fuel. This, translated in dollars per gramme of warhead plutonium, represents $ 4/g plutonium. This value depends on the market assumptions as well as on burnup. With higher burnups, such as the 48 or 50 MWd/kg currently achieved in Europe, there is a break-even : in other words, there is equivalence between MOX fuel and standard enriched uranium fuel.

This graph shows that, except in extremely improbable scenarios (very low burnups, very low uranium and enrichment prices), the cost differential between MOX fuel and standard enriched uranium fuel costs ranges between ***- $ 5 and + $ 10 per gramme plutonium***, with the equivalence being quite likely.

Warhead plutonium recycling will take place on a time span of a decade or so, i.e. equivalent to the duration of standard long term uranium and enrichment purchase contracts. Hence, in these calculations, one needs to consider as market indicators the *long term* prices, namely today about $ 15/lbU_3O_8 and $ 100/SWU or more. Looking at the graph above, we get rather close to the economic equivalence between energy production costs with MOX fuel and standard fuel[12].

12 This graph also suggests a very interesting conclusion. Since warhead plutonium would *replace* uranium, its use will decrease uranium demand and thus have a depressing effect on uranium market prices. This pure market effect may significantly benefit the global fuel cycle costs. Let us assume that one-third of a given nuclear park uses MOX fuel and the two remaining thirds standard uranium fuel. Further, assume that MOX, when used, represents 30 % of the corresponding core. Now, what does this yield for the economics of plutonium recycle ? The calculations show that if such plutonium recycle has the indirect effect of decreasing the average uranium market price by, say, *1 $/lb*$U_3O_8$ (for illustration), the money saved on uranium purchase is equivalent to an additional plutonium credit as high as *3.5 $/gramme plutonium*. This side-effect (which could also apply to enrichment) might well turn out to be more important in practice than any direct effect such as calculated above. But its level cannot be demonstrated now.

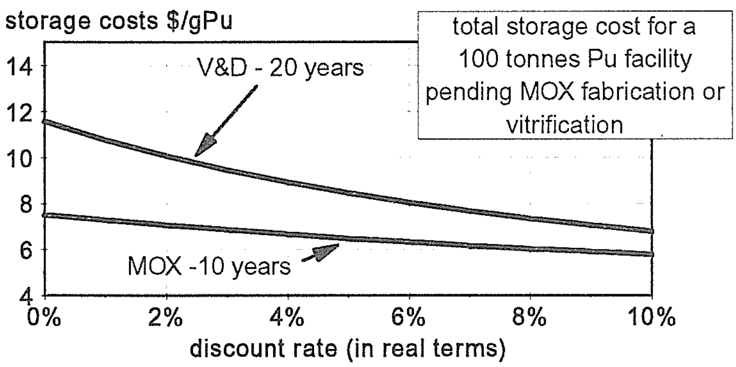
- ***Plutonium storage costs***[13]

The plutonium oxide storage costs (investment and operating costs) mainly depend on the size of storage facilities and on the duration of storage. Regarding the size, we assume that individual storage facilities would contain 100 tons warhead plutonium[14]. The duration of storage is dependent on the route selected. Since MOX fuel factories can be built in 3-5 years one can take 10 years storage of plutonium oxide as conservative in this option, when accounting for licensing processes[15]. In the V&D scenario, R&D will take about one decade, during which storage shall be needed. To those years, one should add approximately 10 years assumed to be needed for licensing and building the vitrification and disposal facilities[16]. Hence, in this case, storage can be reasonably estimated to last 20 years.

The following graph compares the storage costs in $ per gramme plutonium for a number of discount rates (in real terms)[17] :

Figure 2

Plutonium storage costs



This graph shows that in realistic circumstances (discount rate 5 % in real terms), the plutonium storage costs are about ***$ 2 per gramme*** lower with the MOX scenario than with the V&D scenario.

[13] For a discussion of the need for storage, see e.g. A. Jaumotte & A. Michel, "*Recycling also Military Plutonium : Time has Come to Act*", International Amaldi Conference of Academies of Sciences and National Scientific Societies, Heidelberg, July 1992; see also, more recently, the consensus on this point at the International Policy Forum : "*Management & Disposition of Nuclear Weapons Materials*", Leesburg-Va, 8-11 March 1994.

[14] It is assumed, for this exercise, that Russia and the United States shall each recover about 100 tonnes plutonium from their dismantled warheads (cf. Uranium Institute, "*Disarmament and Nuclear Fuel", UI Briefing n° 93/4, April 1993)..*

[15] US National Academy of Sciences, op. cit. (1994).

[16] US Congress, Office of Technology Assessment, op. cit. (1993).

[17] Assuming a capital cost of $ 300 million for a 100 tonnes plutonium storage facility and annual operating costs of $ 45 million, all in constant money (B.G. Chow & K.A. Solomon, "*Limiting the Spread of Weapon-Usable Fissile Materials*", RAND's National Defence Research Institute, Santa Monica -CA, 1993, pp. 67-69).

- ***Plutonium vitrification costs***

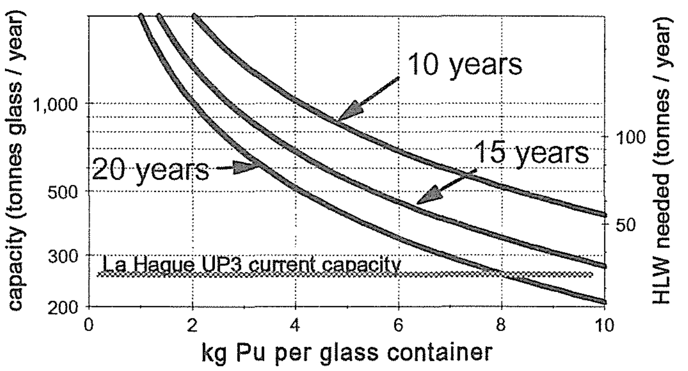
The European reprocessing industry has a long experience in vitrifying fission products and minor actinides. This experience can serve to estimate roughly the costs to be borne if such high level radioactive waste would be blended with plutonium and then vitrified, although many difficult technicalities remain to be solved.

Those costs will mainly depend on the technically allowable plutonium content in the final glass, on the absolute size of the vitrification facility and on the availability rate of high level radwaste quantities for blending.

Figure 3 below shows schematically the annual capacity required to vitrify 100 tons of warhead plutonium within 10, 15 and 20 years respectively, as a function of plutonium content in the final glass products[18]. One can notice that, for such 100 tons and reasonable time frames, one would need a capacity equal to at least two vitrification plants of the size of the Cogema industrial facility associated with UP3-La Hague.

Figure 3

Plutonium Vitrification Capacities for 100 tonnes Pu



The plutonium content of glass canisters will be limited by a number of factors, such as: solubility[19], criticality[20] and non-proliferation resistance. In the latter instance, one will have to very carefully weight the proliferation risk arising from the concentration, within a single glass block, of amounts of weapon-grade plutonium large enough in principle for explosive uses.

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[18] In this graph, 4 kg plutonium per canister is equivalent roughly to 1 % plutonium assay in the glass. For reference, the maximum allowed content in each glass canister produced at reprocessing plants in Europe is 110 grammes of plutonium-239 per canister (see R. Odoj, "*Plutonium in Betriebsabfällen*", Mensch+Umwelt, Magazin der Gesellschaft für Strahlen-und Umweltforschung München, 6. Ausgabe, September 1989, pp. 25-26).

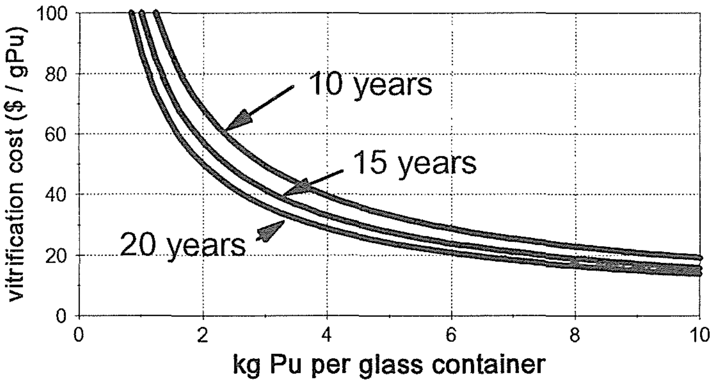
[19] And other technical factors, such as glass cracking by helium production (alpha particles) and alpha radiation embritlement.

[20] H. P. Berg et al., "*Criticality Considerations of the Final Disposal of Alpha-Bearing Waste*", International Symposium on Geological Disposal of Spent Fuel, High-Level and Alpha-Bearing Wastes, Antwerp, Belgium 19-23 October 1992 (IAEA-SM-326/17).

Figure 4 below gives rough estimates of the warhead plutonium vitrification costs in $ per gramme plutonium (discounted at the time of first operation of the vitrification plant[21]), as a function of the plutonium content of the glass product[22], for different operating lives of the relevant facility, always for a total of 100 tons plutonium :

Figure 4

Plutonium Vitrification Costs for 100 tonnes Pu



It appears that, with a cost equal to or higher than $ 20/g in practical cases (yet unproven), vitrification is a costly process.

To be fully consistent in our comparison of plutonium destination options, we must now discount those vitrification costs to a common base date. This base date might be set at the time of MOX fuel fabrication (i.e. after 10 years storage in our example). This vitrification costs should be discounted 20 - 10 = 10 years. With a 5 % discount rate this results in vitrification costs equal to or higher than ***$ 10 per gramme plutonium*** in real terms.

[21] We assumed $ 1 billion investment cost (including R&D) for a 300 tonnes glass per annum capacity (*"DOE Considers Using French Process for HLW Vitrification at Hanford"*, Nucleonics Week, March 17, 1994, pp. 7-8) and appropriate scale effects for other vitrification plant sizes. It should be noted that, for high capacities, the results shown on Figure 4 may be too optimistic since only "smaller" units (similar in size to the current vitrification plant associated with UP3-La Hague) might be technically feasible. Operation costs are estimated at $ 230,000 per ton of glass. Discounting is done at 5 % per year in constant money.

[22] In this graph, 4 kg per canister is equivalent roughly to 1 % plutonium assay in the glass (see note 18 above).

- ***Vitrified plutonium final disposal costs***

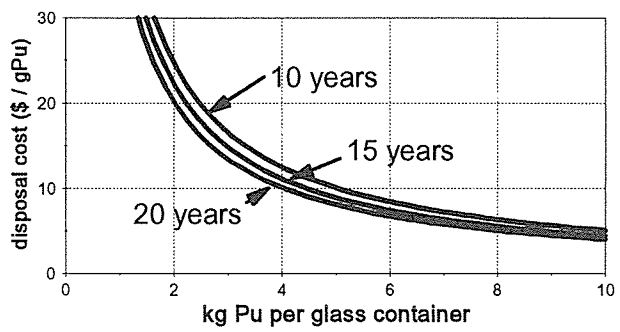
I now turn to the storage and final disposal of glass canisters. Here too, European experience can help assessing the costs, since a number of interim storage facilities of glass canisters produced at civilian reprocessing plants are in industrial use in Europe and large R&D programmes on disposal in many types of host rocks are currently underway.

We have disregarded the interim storage costs in our study on warhead plutonium. Indeed, we may assume that, by the time such glass canisters would be produced, the final disposal site shall already have been selected, that the licence will have been granted, and that the installations needed will have been built. This assumption might look a bit optimistic, especially in the United States' case, knowing how slowly the Yucca Mountain spent fuel disposal project is proceeding. Nevertheless, one can be sure that when there will be a real political will to expedite those matters, solutions will be available rather quickly.

The cost of final disposal of vitrified waste mainly depends on the waste volume and thus, again, on the plutonium assay in the glass. Our estimates are shown in the following graph, in a now familiar format[23]. The costs are discounted (5 % p.y.) at the time of first operation of the disposal facility, assumed to be at the same time as the vitrification plant startup.

Figure 5

Plutonium Disposal Costs for 100 tonnes Pu



According to these calculations, final disposal of vitrified plutonium may be estimated to cost about $ 10 per gramme plutonium or more. After discounting to the base date discussed above, i.e. the time of MOX fuel fabrication, this yields disposal costs equal to or higher than ***$ 5 per gramme plutonium*** in real terms.

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23 Our estimates are based upon final disposal costs of canisters containing vitrified high-level waste from reprocessing, i.e. about $ 65,000 per glass canister. For a discussion of the uncertainties in those costs : OECD Nuclear Energy Agency, "*The Costs High-Level Waste Disposal in Geological Repositories, an Analysis of Factors Affecting Cost Estimates*", report by an expert group, 1993.

- ***Summary of the cost analysis : MOX scenario versus V&D scenario***

Let me now summarize briefly the costs calculations on the main items involved in the economic comparison between use of warhead plutonium as MOX fuel for reactors and its vitrification & disposal as a waste :

- *energy production* : the MOX scenario may bring an additional cost of up to $ 10 per gramme plutonium or may save up to $ 5 per gramme, depending on the uranium and enrichment market conditions. The equality between the MOX scenario and the V&D scenario is quite likely;

- *plutonium storage* costs are $ 2 per gramme plutonium lower in the MOX scenario than in the V&D scenario;

- *plutonium vitrification* leads to costs only in the V&D scenario, which can be estimated equal to or higher than $ 10 per gramme plutonium;

- *plutonium final disposal* as vitrified product increases the costs of the V&D scenario by at least $ 5 per gramme.

The conclusion is clear enough : warhead plutonium recycling in light water reactors makes economic sense[24]. It should be stressed, again, that these results are based upon first-hand commercial information on prices and costs. Many other studies in this domain are based upon paperwork; ours are rooted in actual achievements.

The money saved in this option, compared with the V&D scenario, ranges between $ 10 and $ 20 per gramme plutonium.

For 100 tons warhead plutonium, this means savings of $ 1 to $ 2 billion.

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24 Even without taking into account the possible indirect impact on the uranium and enrichment supply markets.

GENERAL CONCLUSION

- Assuming that the *superpowers* really have the intention to de-militarize their warhead plutonium inventories, the fastest, safest and most economical currently available way for disposing such plutonium is to use it as MOX fuel in existing light water reactors[25].

- Reloading one-third of the nuclear reactors presently in operation in the United States with 1/3 of MOX fuel would use 100 tons of warhead plutonium over ten years. This would generate 750 billion kWh, i.e. as much as the total electricity consumption of the State of New York during five years[26].

- This approach does not preclude burning plutonium in fast neutron reactors, nor further technological developments currently underway to optimize the destruction rate of plutonium in new types of reactors[27]. But these developments will only bear fruit decades from now. This should not be used as an excuse for not starting the elimination of excess warhead plutonium as soon as possible.

- The civilian nuclear industry, especially in Europe and Japan, is well equipped to help the United States and Russia achieving this aim safely.

- The MOX route is fully proven on an industrial scale, as opposed to other techniques such as vitrification & disposal. Such alternative techniques are at very early stages of development and there is no guarantee that they will attain the same proliferation resistance as irradiated MOX fuel (i.e. the "spent fuel standard" set by the US National Academy of Sciences)[28].

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25 Similar conclusions may be drawn from recent independent research reports, such as : the United States Department of Energy Technical Review Committee, "*Plutonium Disposition Study*", July 2, 1993; US Congress, Office of Technology Assessment, "*Dismantling the Bomb and Managing the Nuclear Materials*", OTA-O-572, September 1993; N.J. Numark & T. Suzuki, "*Spoils of Peace, What To Do With US Warhead Plutonium*", Nuclear Engineering International, January 1994, pp. 43-46; US National Academy of Sciences, "*Management and Disposition of Excess Weapons Plutonium*", Prepublication Copy, February 1994; H. von Hardung, "*Options for the Limitation of Undesirable Access to Plutonium*", Atomwirtschaft, Februar 1994, pp. 142-145; G. Clark (Uranium Institute), "*Uranium to 2010*", paper to be presented at the 9th Pacific Basin Nuclear Conference, Sydney, Australia, 1-6 may 1994.

26 Cf. P. Goldschmidt, "*Corral Plutonium for Peaceful Use*", The Wall Street Journal Europe, January 14-15, 1994.

27 See e.g., two review articles in Proceeding of the International Conference SAFEWASTE '93, ENS, ANS, OECD, IAEA, CEC, SFEN, 13-18 June 1993, Avignon, vol. 1 : A. Suzuki, "*Japan's Strategy on High-level Radioactive Waste Management*" (pp. 408-415); J. Lefèvre *et al.*, "*Partitioning and Transmutation of Long-lived Radionuclides*" (pp. 416-429).

28 US National Academy of Sciences, op. cit.

- To consider as a waste a material with large energy content like plutonium would be irresponsible in a world with finite resources[29].

I will end my talk with a word of concern.

If no practical step is taken in the United States and Russia within the next two years for the destination of excess weapons plutonium, by starting the construction either of MOX fuel fabrication plant or of a plutonium vitrification facility, the world might question that there is a real desire in the United States and Russia to solve this problem. Such a suspicion might complicate the discussions on the extension of the Non-Proliferation Treaty.

And a word of hope.

The use of warhead plutonium for electricity production could become the symbol of real efforts towards a safer and more peaceful world. Being gathered here, in Hiroshima, we all feel strongly about this ultimate goal. Let us not waste this chance.

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[29] See e.g. World Bank, "*World Development Report 1992, Development and the Environment*", Oxford University Press, 1992 : "Policies that encourage efficiency lead to less waste, less consumption of raw materials, and more technological innovation".

SIX REASONS FOR DEFERRING THE USE OF SEPARATED PLUTONIUM IN THE CIVIL NUCLEAR FUEL CYCLE

1. IMPROVE CHANCES FOR HUMAN SURVIVAL

- Small quantities of reactor and fuel-grade plutonium can be used to make efficient, powerful nuclear bombs as well as inefficient crude bombs and terrorist explosive devices.

2. LIMIT SPREAD OF NUCLEAR EXPLOSIVE MATERIAL

- National separation, recycle, and breeding of plutonium on a commercial scale place an impossible burden on the current capabilities of the IAEA safeguards system to detect promptly thefts or diversions of Pu-bomb quantities from peaceful use.

3. PREVENT ABUSE OF NUCLEAR TECHNOLOGY

- "Civil" plutonium programs provide a legitimate civilian cover for any country to acquire a stockpile of nuclear explosive materials, while sustaining a global technology base in chemical separation, processing, and metallurgy that has been -- and will continue to be -- applied to clandestine military programs.

4. REDUCE POTENTIAL FOR NPT "BREAKOUT"

- The JAEC vision of a future plutonium economy ignores the problem of future "break-out" from the NPT by nations that have "legally" acquired a stockpile of separated plutonium under safeguards, but then undergo political upheaval and emerge as nations determined to build nuclear arsenals.

5. ENCOURAGE DESTRUCTION OF WEAPON STOCKS

- Stockpiles of separated "civil" plutonium and operational Pu-production facilities will act as a barrier to deep reductions and eventual elimination of nuclear weapons held by declared and undeclared nuclear weapon states.

6. ENSURE EFFICIENT ALLOCATION OF CAPITAL RESOURCES

- Separation and use of Pu in the civil nuclear fuel cycle is not justified now by current or foreseeable energy market conditions, which favor investments in conservation, efficiency, and a range of competing power sources, including safer, more reliable and efficient advanced LWR technology.

1. Small Quantities of Reactor or Fuel-Grade Plutonium Can be Used to Make Nuclear Bombs.

- Regardless of the fuel burnup level, the critical mass of plutonium separated from spent fuel will be between that of Pu-239 and U-235, the most favorable isotopes for making weapons.

- Recent reviews by J. Carson Mark, Director of the Theoretical Division, Los Alamos 1947-72, and the U.S. National Academy of Sciences show that:

-- a basic fission weapon with a probable yield in the vicinity of 5 kilotons, having a radius of destruction two-thirds that of the Hiroshima bomb, can be made from as little as 4 kg of plutonium recovered from high burn-up fuel.

- MODERN EFFICIENT HIGH YIELD WEAPONS USING REACTOR-PLUTONIUM ARE POSSIBLE:

-- The threshold for initiating fusion reactions in the fissioning core is reached at about 300 tons.

-- This is less than the worst expected ("fizzle") yield of 700 tons expected from maximum "preinitiation" of the original Nagasaki-type bomb by spontaneous neutron emission in the weapon material.

-- The National Academy Report notes: "Regardless of how high the concentration of troublesome isotopes is, the yield would not be less [than one kiloton]" for "a relatively simple device."

-- Therefore, a few grams of a deuterium-tritium mixture present in the fissioning core will increase the yield of a reactor-grade bomb by a <u>factor of 5</u> or more.

-- The NAS Report notes: "With a more sophisticated design [than the original Nagasaki weapon], weapons could be built with reactor-grade plutonium that would be <u>assured</u> of having higher yields."

- HOW MUCH HIGHER CAN THE YIELD GO??

-- Unfortunately, reactor-PU fission weapons with yields of a few to tens of kilotons can produce the X-ray energy needed to compress and ignite fission or thermonuclear "secondary" stages with yields of hundreds of kilotons to megatons.

-- Three decades ago, Chinese scientists successfully tested a 3 megaton thermonuclear weapon only 32 months after their first atomic test.

- CONCLUSION -- Production or acquisition of HEU, or separated Pu without regard to isotopic composition, by any competent industrial state carries with it the potential to develop not only "crude" fission bombs of the Nagasaki type, but also weapons of even greater destructive potential.

POINT ONE DISCUSSION: Requirements for a Bomb - Any "Grade" of Plutonium Will Do the Job.

Plutonium can vary widely in its isotopic composition, and can exist in six metallic forms corresponding to six different arrangements of its crystal structure. The two forms most often associated with weapons are the most dense "alpha-phase," and the more stable "delta-phase."

The plutonium in U.S. nuclear weapons is "weapon-grade" (less than 7% Pu-240) in the form of delta-phase metal (density = 15.7 g/cc). The bare critical mass of delta-phase plutonium metal is dependent on the concentrations of the various plutonium isotopes, and varies from about 16 kg for plutonium with 6% Pu-240, to about 22 kg for plutonium with 30% Pu-240, reactor-grade plutonium from high burn-up fuel.[1]

The less stable, more brittle alpha-phase plutonium metal has smaller critical mass values ranging from about 10 kg for plutonium with 6% Pu-240 to about 15 kg for plutonium with 30% Pu-240.[2]

Thus, regardless of the fuel burnup level, the critical mass of the extracted plutonium will be between that of Pu-239 and U-235. The Trinity device (and the Nagasaki bomb) used 6.1 kg of weapon-grade plutonium, and modern compact fission warheads require as little as 3 kg of weapon-grade plutonium. As shown below, a basic fission weapon with a yield in the vicinity of 5 kilotons could be made from as little as 3 kg (alpha-phase) to 6 kg (delta-phase) plutonium recovered from high burnup fuel.

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[1] The bare critical masses for plutonium in the delta-phase (density = 15.6 g/cc) range from about 16 kg for Pu-238 and -239, to 19 Kg for Pu-241, to 63 Kg for Pu-240. All the various isotopic combinations fall within this range.

[2] The bare critical mass for plutonium in the alpha-phase (density = 19.6 g/cc) are about 10 kg for Pu-238 and -239, 12 kg for Pu-241, and 40 kg for Pu-240.

TABLE 1A: ROUGH DESIGN CRITERIA FOR A WEAPON

Critical mass M_c = amount needed to sustain fission chain reaction.

The assembled weapon system needs to contain about 2 "crits" (two critical masses) or more. For example:

No. of Crits	Explosive Yield (KT)
1.5	0.6
2.0	4.6
2.5	15.0 (Hiroshima)
	←— 20.0 (Nagasaki)
3.0	34.0

The mass required for criticality (M_c) can be greatly reduced by use of a neutron reflector (e.g. beryllium, tungsten, U-238) and compression.

Example (Alpha-phase Pu):

M_c = 10 kg at normal density, unreflected
M_c = 6 kg at normal density, reflected
$M_c = 6/x^2$ kg with x-fold uniform compression

Therefore, if an assembled weapon system requires at least two crits, with uniform 2-fold compression an alpha-phase Pu weapon could be made with $2 \times (6/2^2) = 3$ kg.

TABLE 1B: NOMINAL TWO CRITICAL MASS REQUIREMENT FOR WEAPONS
(Kilograms)*

Nuclear explosive material	Bare No reflector	With moderate reflector	Compressed 2-fold
U-235 (93.7%)	105	52.4	13.1
Alpha Pu-240	80	42	10.5
Delta Pu MOX-Grade (32.1% Pu-240)	48	24	6.0
Delta Pu "Reactor-Grade" (24.3 % Pu-240)	42	21	5.3
Delta Pu "Weapon-Grade" (6% Pu-240)	34	17	4.2
U-233 (98.11%)	33	16.5	4.1
Delta FBR blanket (4.0% Pu-240)	32	16.2	4.1
Delta Pu-239	32	16	4.0
Delta Pu-238	32	16	4.0
Alpha Pu MOX-grade (32.1% Pu-240)	31	15	3.8
Alpha Pu "Reactor-Grade") (24.3% Pu-240)	26	13	3.2
Alpha FBR Blanket Pu-239 (4.0% Pu-240)	21	10.5	2.6

* Uncompressed values for plutonium are mainly hypothetical, as the high spontaneous fission rate of plutonium severely complicates assembly of an explosive "supercritical" mass at normal density by means of the "gun-assembly" technique used in the Hiroshima uranium bomb. However, a "Little Boy" gun assembly of "2.5 crits" (32 kg) of reactor-grade plutonium could produce an explosion with a yield on the order of 10-20 tons of TNT equivalent, enough to knock down a very large building, seriously contaminate a downtown district, and cause thousands of prompt fatalities and later cancer deaths from Pu-inhalation.

Pure PuO_2 as well as MOX blends with PuO_2 concentrations greater than about 20-30% appear to be directly usable in an illicit nuclear device.[3] However, the material requirements are substantially larger and the explosive yields of such devices would be substantially less than if plutonium metal were used, other design factors being the same.[4]

Plutonium with a high Pu-240 content is less desirable for weapons purposes than weapon-grade plutonium, because for low-technology weapons designs the neutrons generated by the high rate of spontaneous fission of Pu-240 can increase the statistical uncertainty of the yield by "pre-initiating" the chain reaction before the desired compression of the plutonium core has been achieved. In spite of this difficulty, *militarily useful weapons, with predictable yields in the kiloton range can be constructed based on low technology designs with reactor-grade plutonium.* According to the conclusions of a recent study by the National Academy of Sciences in the United States, based in part on a classified 1994 study by scientists at the Lawrence Livermore National Laboratory:

> even if pre-initiation occurs at the worst possible moment (when the material first becomes compressed enough to sustain a chain reaction), the explosive yield of even a relatively simple device similar to the Nagasaki bomb would be on the order of one or a few kilotons. *While this yield is referred to as the "fizzle yield," a one kiloton bomb would still have a destruction radius roughly one third that of the Hiroshima weapon, making it a potentially fearsome explosive. Regardless of how high the concentration of troublesome isotopes is, the yield would not be less.* With a more sophisticated design, weapons could be built with reactor-grade plutonium that would be assured of having higher yields.[5]

The same conclusions can be drawn from a recent unclassified review of this subject by J. Carson Mark, director of the Theoretical Division, Los Alamos National Laboratory, 1947-1972. Based on the now unclassified probabilities of preinitiation estimated for the original Trinity test device -- built with very low Pu-240 content delta-phase plutonium to

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[3] U.S. Nuclear Regulatory Commission, *Safeguarding a Domestic Mixed Oxide Industry Against a Hypothetical Subnational Threat*, NUREG-0414, May 1978, p. 6-9.

[4] The bare critical mass for reactor-grade plutonium oxide (PuO_2) varies from 30 to 70 kg. Bare critical masses for MOX at 30 and 10 percent PuO_2 concentrations vary between 250 and 600 kg and 3,000 to 10,000 kg, respectively; ibid.

[5] *Management and Disposition of Excess Weapons Plutonium*, Committee on International Security and Arms Control, National Academy of Sciences, National Academy Press, Washington, D.C. 1994, (Prepublication Copy) p.37.

achieve a nominal yield of 20 kt and a "fizzle" yield of about 700 tons (i.e. the "worst-case" yield obtainable short of mechanical component failure) -- Mark then estimates the probability of achieving a given yield with higher levels of spontaneous neutron emissions. Assuming the Trinity device used super-grade material, the neutron source level corresponding to reactor-grade material would be some 20 times larger, resulting in a 67% probability of achieving a yield in excess of one kiloton, a 29% probability of achieving a yield in excess of 5 kilotons, and an 8% probability of achieving a yield in excess of 20 kt.

Assuming a more modern implosion system that assembles twice as rapidly as the Trinity device, the corresponding probabilities are 82% above one kiloton, 54% above 5 kilotons, and 28% above 20 kiloton. Of course, improving the speed of assembly can also increase compression of the core and hence the nominal yield. The United States, for example, twice tested a "levitated core" version of the Nagasaki "Fat Man" bomb during Operation Sandstone in April-May 1948 that took advantage of the increased momentum obtained from propelling a outer metal shell through free space before striking the plutonium core. These tests achieved yields of 37 kt and 49 kt compared to the 20 kt yield of "Fat Man." Thus if this improved but still relatively "primitive" design were built today with reactor-grade plutonium, it would have a better than even chance of producing an explosion greater than 11 kilotons.[6]

That is far from the end of the story, however. The threshold for initiating fusion reactions in the fissioning core -- to provide additional free neutrons to accelerate ("boost") the fission reaction -- corresponds to an energy release in the vicinity of three hundred tons, *less than the fizzile yield* of the original Trinity device. This means that a few grams of a deuterium-tritium mixture present in the fissioning core can increase the fission yield by a factor of 5 or more, virtually guaranteeing that even a severely preinitiated reactor-grade Pu weapon will provide a yield of several to tens of kilotons.

Unfortunately, fission weapons with yields of a few to tens of kilotons can produce the x-ray energy needed to act as the "primary" or triggering stages for thermonuclear "secondary" stages with yields in the hundreds of kilotons to megatons. Four decades ago, U.S. and Soviet scientists designed two-stage thermonuclear devices, without the assistance of high-speed computers, that worked the first time they were tested.

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[6] For further discussion see, J. Carson Mark, *Reactor-Grade Plutonium's Explosive Properties*, Nuclear Control Institute, August 1990, and a revised version of this paper published as "Explosive Properties of Reactor Grade Plutonium, Science and Global Security, 1993, Volume 4, pp. 111-128; Thomas B. Cochran, et al., *Nuclear Weapons Databook, Volume I, U.S. Forces and Capabilities*, (Boston: Ballinger Publishing Company, 1984), p. 24, footnote 17; T.B. Cochran, "Hydronuclear Testing or a Comprehensive Test Ban, NRDC draft report, April 10, 1994, p. 12.

A decade later, Chinese scientists likewise exploded a thermonuclear weapon on their first attempt, only 32 months after their first *atomic* test.[7] Clearly, the production or acquisition of separated plutonium or highly enriched uranium by any reasonably competent industrial state today means an inherent potential to develop not only fission bombs of the Nagasaki type, but also thermonuclear weapons of even more horrendous destructive potential.

[7] Robert S. Norris, et. al., *Nuclear Weapons Databook, Volume 5, British French and Chinese Nuclear Weapons*, Westview Press, 1994, p.420.

2. National separation, recycle, and breeding of plutonium places an impossible burden on the current capabilities of the IAEA safeguards system to detect promptly small diversions of material from peaceful use.

- To reliably detect theft/diversion of one bomb's worth of Pu (i.e. half the IAEA's current 8 kg "significant quantity") above measurement "noise" with 95% confidence, 3.3 times the uncertainty in the Inventory Difference (σ_{ID}) must be less than 4 kgs. The value of σ_{ID} is dominated by the error in measuring plutonium input into the plant, usually about one percent of throughput.

-- For Tokai Mura: Avg. throughput = 90 MTHM/y
Avg. Pu content = .09%
Input error = 1.0%

Therefore:

3.3 (ID) ~ 3.3 x (.009 x 90 x .01) = 27 kg/yr
(27 kg/4) = 6.75 x "bomb quantity"

-- For Mayak Combine
(Chelyabinsk-65): Avg. throughput = 200 MTHM/y
Avg. Pu content = .09%
Input error = 1.7% per campaign
campaigns = 2/y

-- Therefore:

(ID) = (.009 x 100 x .017) = 15.3 kg/campaign
3.3 (ID) = 50.49 kg/campaign
50.49/4 = 12.6 x "bomb quantity"

- CONCLUSION: Reprocessing safeguards need to be improved by a factor of 6 to 12 above present performance levels to provide the international community with confident detection of stolen or diverted material.

- QUESTION: Can this be done in a way which meets the requirement that safeguards provide "timely warning" of diversion or theft?

  -- Detection time should be $\leq$ "conversion time" to weapon component

  -- For metallic Pu and HEU, conversion time is 7 -10 days; For other materials, 1-3 weeks.

  -- These times are much shorter than the period between inventories at any fuel reprocessing plant operating today.

  -- Implementing more effective safeguards would require frequent shutdowns, further driving-up the cost of reprocessing.

- CONCLUSION: No assurance that primary objective of safeguards -- timely detection of missing significant quantities of Pu -- is now being met, or will be met in the future.

  -- Near Real Time Accountancy (NRTA), involving frequent on-line measurements without shutting down the facility, would improve sensitivity and timeliness of safeguards; BUT

  -- practical implementation of a commercially viable and effective NRTA system is an open question.

POINT 2 DISCUSSION: Do IAEA Safeguards and Physical Security Measures Provide Sufficient Insurance Against Proliferation?

Adequate physical security is essential to prevent the theft of any quantity of material, even as little as one bomb's worth. Highly accurate material accounting and control measures are essential to determine whether a theft has taken place, and to provide timely warning to prevent the material from being used for illicit purposes. It is well established -- from experience at existing civil and military chemical separation (reprocessing) plants, naval fuel facilities, and mixed-oxide fuel facilities -- that it is extremely difficult (some would argue impossible) to provide in practice a sufficient level of physical security and material accounting and control, at bulk handling facilities that process large amounts of nuclear weapons-usable material.

The difficulty in providing adequate physical security is that theft of materials can involve a collusion of individuals, including the head of the guard force, or even the head of the company. Despite having guards at every bank, employees at the Bank of Credit and Commerce, Inc. (BCCI) were able to steal millions of dollars from bank customers because the thieves were running the bank -- the collusion was at the top. If the threat includes the potential for collusion involving the guard force and facility directors, providing adequate physical security in the West would require turning the facility into a heavily armed site occupied by an independent military force. In Russia physical security has relied on heavily guarding not only the facilities, but also the towns where the work force resides. These closed cities are anathema to a democratic society.

Of course the principal role of physical security is completely reversed when the collusion involves elements of the government itself. In this case the primary mission of the security apparatus is to hide the program from outside scrutiny. It is now known that at various times in the past, the governments of the United States, Japan (during World War II), Soviet Union, United Kingdom, France, China, Israel, India, South Africa, Sweden, Argentina, Brazil, Taiwan, Pakistan, North Korea, South Korea, and Iraq have had secret nuclear weapons development programs. *In light of this history, combatting the "norm of secrecy" surrounding the operations of nuclear research and development complexes can be seen as an integral part of any serious nuclear nonproliferation strategy.*

The international community's principal tool for penetrating the secrecy of nuclear facilities is the power of the International Atomic Energy Agency to conduct inspections and require adherence to strict material accounting and control procedures, collectively referred to as "safeguards." These are meant to provide timely detection of the diversion of significant quantities of weapons-usable material. The IAEA's Standing Advisory Group on

Safeguards Implementation (SAGSI) in 1977 defined a significant quantity of plutonium as 8 kg. Depending on the type of plutonium metal used, the thickness of neutron reflectors, and the compression achieved by chemical explosives assembly mechanism, the true significant quantity can be considerably less -- on the order of 3 kilograms.

To provide assurance that a significant quantity of fissile material has not been diverted, the uncertainty in the inventory accounting must be small compared to the quantity of fissile material considered significant, e.g., compared to 8 kg of plutonium or less. At a bank each deposit and withdrawal has a precise numerical value which, if accurately recorded, permits a precise daily balancing of the books. At a bulk handling facility the books never balance because of inherent limitations in the ability to measure the material quantities entering the plant.

In the parlance of nuclear material accounting the inventory difference (ID) is defined as

$$ID = BI + I - R - EI,$$

where BI is the beginning inventory, EI is the ending inventory, and I and R are, respectively, the material added and removed during the inventory period.[8] For the minimum amount of diverted plutonium (assumed here to be 8 kg) to be distinguished from measurement noise with detection and false alarm probabilities of 95% and 5%, respectively, it can be shown that 3.3 σ_{ID} must be less than 8 kg, where σ_{ID} is the uncertainty in the inventory difference.[9]

At existing reprocessing plants in the West that handle tons of weapons-usable plutonium, σ_{ID} is dominated by the error in measuring the plutonium input into the plant, which is about one percent of the throughput. The Japanese Tokai Mura plant, one of the smallest plants in the West, has an average output of about 90 Metric Tons of Heavy Metal per year (MTHM/y), and the LWR spent fuel processed has an average total plutonium content of about 0.9 percent. Thus, 3.3 σ_{ID} for Tokai Mura is about 27 kg of plutonium per annual inventory. Even if inventories were taken every six months, 3.3 σ_{ID} would be about 14 kg, which is still greater than 8 kg. One simply cannot detect the diversion of several bombs' worth of plutonium annually from Tokai Mura.

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[8] In the literature "inventory difference" (ID) is sometimes called "material unaccounted for" (MUF).

[9] Marvin Miller, "Are Safeguards at Bulk-Handling Facilities Effective?, Nuclear Control Institute, Washington, D.C., August 1990.

We are told that material accounting and control at Russian plants handling nuclear fuel in bulk form is rudimentary at best. The RT-1 chemical separation plant at Chelyabinsk-65 has a capacity of about 400 MTHM/y, and until 1991 had been operating at about 200 MTHM/y. Therefore, the situation at RT-1 would be two to six times worse than at Tokai Mura, even if it were brought up to current western standards.[10] It is difficult to imagine running a bank in which you counted the money only a few times a year, and then only counted the notes larger than 10,000 rubles. Yet the Russian nuclear establishment sanctions the commercial use of nuclear weapons-usable material under safeguards that are no better.

Detection time (the maximum time that should elapse between diversion and detection of a significant quantity) should be in the same range as the conversion time, defined as the time required to convert different forms of nuclear material into components of nuclear weapons. For metallic plutonium and HEU, the conversion time is 7-10 days; for other compounds of these materials, 1-3 weeks. These times are already much shorter than the period between inventories at any fuel reprocessing plant operating today. Thus, there can be no assurance that the primary objective of safeguards - the timely detection of significant quantities of plutonium - is now being, or can be, met.

To meet the timely detection criteria reprocessing plants would have to undergo clean-out inventories every few days, or weeks. But this would reduce their annual throughput -- and utility -- practically to zero. It would also drive up the cost of reprocessing. Plutonium recycle, the use of MOX fuel in standard commercial light-water reactors (LWRs), is already uneconomical due to the high costs of reprocessing and fuel fabrication even when conducted without a technically adequate level of safeguards. Similarly, the cost of the fast

[10] According to Evgeni Dzekun, chief engineer of the Mayak civil reprocessing plant at Chelyabinsk-65, a plutonium input-output balance for the plant is calculated every 3-4 months when the plant is cleaned out between reprocessing campaigns. About one percent of the plutonium is lost to waste streams, and a lesser amount to plateout in the plant's plumbing. The ID is typically 15 kilograms of Pu per campaign, amounting to a total ID of about 3% percent of throughput. In other words, the ID is almost twice the IAEA's significant quantity for plutonium. According to Dzekun, if the ID in a given campaign is larger than can be explained by measurement errors, a "special investigation" is carried out, but what this consists of is not known. To assure detection of an 8 kg. diversion at this plant with 95% confidence and a 5% false alarm rate, 3.3 x ID must be less than 8 kg., so this plant apparently falls short of the minimum IAEA standard by a factor of six. If 4 kilograms is regarded as the amount needed for a weapon, then the "safeguards" at Mayak need to be improved by a factor of twelve in order to provide confident detection of diverted material. See "Report on an International Workshop on the Future of Reprocessing, and Arrangements for the Storage and Disposition of Already-Separated Plutonium (Moscow, 14-16 December 1992) by F.v.Hippel, Princeton University, and T.B. Cochran, C.E. Paine, Natural Resources Defense Council, 10 January, 1993, p. 5.

Similarly, the cost of the fast breeder fuel cycle is greater than that of the LWR operating on the once-through cycle without plutonium recycle.

In Western Europe and Japan, consideration is being given to Near-Real-Time Accountancy (NRTA) as a means of improving the sensitivity and timeliness of detection. NRTA involves taking inventories at frequent intervals, typically once a week, without shutting down the facility. It and similar concepts are likely to be opposed by operators due to the added costs that would be imposed. In any case the methods and adequacy of practical NRTA system implementation are open questions.

3. Use of plutonium in civil power programs provides any country with a legitimate civilian cover for acquiring a stockpile of weapons-usable nuclear material, while sustaining a global technology base in chemical separation, Pu-processing, and Pu-metallurgy that can be acquired for "peaceful uses" and applied to clandestine military programs.

- The plutonium inventory needed to support a single commercial-size 1000 MW breeder is staggering -- 11-22 METRIC TONS -- depending on the fraction of the core replaced annually (.33 - .5) and the reprocessing/fuel fabrication interval (3.5 - 7 years)

- 10 gigawatts of electric capacity supplied by breeders -- hardly enough to justify an R&D program -- means a plutonium inventory of 100-200 MT, enough for 25,000-50,000 bombs.

- India recovered the plutonium for its first nuclear explosive device in a reprocessing plant developed as part of its national breeder program

- Sufficient plutonium has already been separated worldwide to support any rational scale of breeder R&D effort. There is no requirement to continue separating Pu for this purpose.

- There is no need to separate plutonium today to insure a stockpile for starting breeders in the future. Should that day ever arrive, commercial deployment can begin with cores of about 20% enriched uranium, making commercial deployment of the breeder relatively independent of the accumulated stock of separated plutonium.

POINT 3 DISCUSSION: Deferring the Use of Separated Plutonium in the Civil Nuclear Fuel Cycle.

Deployment of plutonium fast breeders would entail staggering amounts of nuclear weapons-usable plutonium in the reactors and the supporting fuel cycle.[11] There is no adequate means of safeguarding this material to prevent some of it from being used for nuclear weapons.

The continued development of plutonium breeders in the few remaining countries that have strong breeder research and development programs will continue to legitimize breeder programs and plutonium stockpiles in non-nuclear weapons states that may use these programs to cover the development of a weapons option. India recovered the plutonium for its first nuclear device in a reprocessing plant that was ostensibly developed as part of its national breeder program.

Consequently, breeder research and development programs should be limited to conceptual design efforts only, with an emphasis on advanced proliferation resistant fuel cycles that do not require mastery of the technology for isolating and fabricating weapons-usable nuclear materials. To the extent that this is politically impossible, sufficient plutonium has already been separated to meet the needs of R&D programs, so at a minimum there is no requirement to continue separating plutonium for this purpose. In this connection it should be noted if plutonium breeders some day prove to be economically competitive, and if the breeder fuel cycle can be safeguarded with high confidence under stringent international controls, then commercial deployment could begin with cores of non-weapons usable 20% enriched uranium. *In other words, there is no need to accumulate a stockpile of separated plutonium today to insure the possibility of deploying breeders at some point in the future.*

By giving sanction to reprocessing the world is confronted with large flows of recovered plutonium and plutonium stockpiles. If only 10 gigawatts of electric capacity were supplied by breeders - hardly enough to justify the R&D effort in any country even if the economics were otherwise favorable - the plutonium inventory in the reactors and their supporting fuel

[11] With a plutonium breeder economy the quantity of plutonium involved would be enormous. The plutonium inventory in a commercial-size breeder is about 5 MT, of which 3.5 MT is fissile - about 600 atomic bombs worth. A Russian BN-800 breeder reactor would require over 4 MT. Although the net amount of plutonium produced in a fast breeder reactor annually is generally less than that produced in a conventional thermal power reactor of the same size, one-third to one-half of the FBR fuel must be removed annually for reprocessing, plutonium recovery, and remanufacture into fresh fuel. Since the fuel will be outside of the reactor for 3.5 to 7 years the plutonium inventory needed to support a single commercial-size plutonium breeder is 11-22 MT, about 1400 to 3700 bombs worth.

cycle would be on the order of 100-200 MT, or about 25,000-50,000 bombs' worth. By comparison, U.S. nuclear weapons stockpiles in 1987 consisted of 23,400 warheads, and the weapon-grade plutonium inventory, most of which was in weapons, was about 90 MT. The Russian warhead plutonium stockpile consists of an estimated 135-170 MT of plutonium in a total stockpile which peaked in 1985 at about 45,000 warheads.

About one half of the plutonium created in a breeder reactor is bred in the blanket rods. The burnup of the blanket material is low. Consequently, the resulting plutonium is weapon-grade, with a Pu-240 concentration lower than that used in U.S. and Russian weapons. Thus, any non-weapons country that has large stocks of breeder fuel, has the capacity to produce a ready stock of weapon-grade plutonium. It only has to segregate and reprocess the blanket assemblies separately from the core assemblies.

4. The JAEC vision of a future plutonium economy does not take into account the problem of "break-out" from the NPT by a nation that has "legally" acquired a stockpile of separated plutonium under safeguards, but then undergoes political upheaval and emerges as a nation determined to build a nuclear arsenal.

- Nations and their motivations can change dramatically, as do the relationships between nations.

  -- Compare today's relationship between the U.S., Germany, and Japan with that of 50 years ago.

  -- Compare China's shifting relations with Russia over the same period.

  -- Compare the U.S. relationship with Iraq in 1985 - 89 with 1990-94.

- The JAEC, MINATOM, BNFL, and CEA programs offer a justification, and serve to encourage, Pu stockpiling and technology acquisition by other countries.

- Without violating safeguards agreements, these countries can design and fabricate non-nuclear weapons components. From a technical perspective, they can move within hours or days of having nuclear weapons without other states being able to draw the firm conclusion that these countries have violated the NPT's prohibition on the "manufacture" of nuclear weapons.

- Absent urgent and compelling energy short term needs that cannot reasonably be met in any other way, no country should unilaterally resort to the use of technologies that pose a significant risk of seriously destabilizing relations between nation states.

  -- National energy independence must not be pursued at the expense of international security.

- To limit the likelihood of "break-outs" from the NPT, any use of nuclear explosive material in the future nuclear fuel cycle must be managed on supra-national basis:

  -- national control over Pu exchanged for access to energy service.

  -- Any other approach to nuclear explosive materials in the fuel cycle is just tickling the dragon of proliferation.

POINT 4 DISCUSSION: The Risk of Breakout

Reprocessing of spent fuel and the recycling of plutonium[12] into fresh fuel for reactors permit non-nuclear weapons states to justify the acquisition and stockpiling of nuclear weapons-usable material -- ostensibly for peaceful purposes. At the same time, without violating any international safeguards agreements, these countries can design and fabricate non-nuclear weapon components. By moving to a point of being within hours of having nuclear weapons - perhaps needing only to introduce the fissile material into the weapons -- a nascent weapons state would have all of its options open. Under these conditions, international safeguards agreements can serve as a cover by concealing the signs of critical change until it is too late for diplomacy to reverse a decision to "go nuclear."

Likewise, acceptance of the plutonium breeder as an energy option provides the justification for the early development of a reprocessing capability by any country. A non-nuclear weapons country would always have the option to shift its "peaceful" nuclear program to a weapons program, but this would require the politically difficult decision to attempt evasion or overtly abrogate IAEA safeguards. Without national reprocessing facilities and breeder reactors, countries wishing to develop nuclear weapons capacity face very considerable political problems and cost. Obtaining large quantities of weapon-usable plutonium requires that they build one or more specialized production reactors and chemical separation facilities. By establishing their nuclear weapons option through a plutonium-using nuclear electric generation program, they can circumvent these obstacles.

[12] Or any other weapons material, such as highly enriched uranium or uranium-233.

5. Stockpiles of separated plutonium in civil programs will act as a barrier to deep reductions and eventual elimination of nuclear weapons held by declared and undeclared nuclear weapon states.

- How far is China likely to go toward eliminating its nuclear arsenal if Japan accumulates an inventory of nuclear explosive materials in pursuit of a civil plutonium program with no obvious commercial justification.

- Likewise, how deep will the cuts be in the U.S. nuclear weapons stockpile if Russia proceeds to large-scale deployment of the breeder fuel cycle, with its inventories of hundreds of tons of separated plutonium and inherent capacity for creating super-grade blanket material, or if Russia maintains "civil" reprocessing plants while the U.S. reprocessing plants are shut-down?

- A failure to proceed to very deep cuts and international monitoring of residual weapons stocks -- as the prelude to ultimate abolition -- could lead to further erosion of the nonproliferation regime.

- Hence there is a serious need to review the mistaken legitimacy afforded civil plutonium programs under the current loose system of international controls

POINT 5 DISCUSSION: Toward "Virtual Abolition" as the Interim "End State" of the Nuclear Arms Reduction Process

As deep nuclear and further conventional force reductions proceed, and international control mechanisms are built-up, it should become both possible and desirable to shift the international security role of nuclear weapons from "active" day-to-day deterrence of nuclear and large-scale conventional attacks to the largely "passive" role of "discouraging" potential proliferant nations who might be motivated by the prospect of a regional or global nuclear monopoly. This shift can be achieved initially through international commitments to "no-first-use" of nuclear weapons, and through the retention of modest internationally-monitored residual nuclear forces, the size and combat readiness of which are steadily diminished over time.

Over the long term, as greater confidence is achieved in an international control regime and capabilities for prompt nuclear attack are eliminated, this proliferation "discouragement" mission could be performed by secure deep underground storage of residual nuclear warhead inventories -- under international monitoring -- that would be remated with their delivery systems only in the event a serious nuclear threat to international security emerged that justified redeployment of a nuclear deterrent force.

However, this denuclearizing vision is threatened by, among other difficulties, the accumulation of large stockpiles of separated plutonium in nominally civil programs. One need only ask how far China, for example, might be willing to go in accepting limits on, or reductions in its nuclear weapons stockpile if Japan is poised to accumulate an even larger inventory of weapons usable fissile materials in pursuit of a civil plutonium program with no clear commercial rationale.

Likewise, Russia's continued operation of reprocessing plants and potentially large-scale commitment to the breeder reactor fuel cycle could abort U.S. political support for continuing toward very deep reductions and ultimate abolition of nuclear weapons stockpiles. The lack of such a commitment by the U.S. and other nuclear weapons states, could, in turn, lead to continued erosion of the nonproliferation regime. Hence the need to forthrightly address the (in our view) mistaken legitimacy afforded civil plutonium programs under the current system of international controls.

6. Separation and use of Pu in the civil nuclear fuel cycle is not justified now by current or foreseeable energy market conditions, which favor investments in conservation, efficiency, and a range of competing power sources, including safer, more reliable and efficient advanced LWR technology.

- Investing in plutonium recycle today ignores three fundamental laws of economics:

  -- (1) money has "time value," i.e. never invest capital or accumulate inventory until you need to do so to satisfy market demand;

  -- (2) every capital investment has an "opportunity cost" equal to the most productive alternative use of the invested capital;

  -- (3) future improvements in technology can reduce capital costs at the time the investment is actually required.

- Accumulating a Pu-inventory in the current and projected energy market is a poor investment of resources.

  -- RAND STUDY: At the current cost for reprocessing services, the price of uranium feedstock for enrichment would have to increase by a factor of 16 before Pu recycle in LWRs becomes competitive.

  -- At current reprocessing costs and an FBR/LWR capital cost ratio of 1.5, the yellowcake price would have to increase by a factor of 45 before the breeder becomes competitive. When might this happen?

  -- The earliest date, based on the most optimistic assumptions about nuclear energy growth, reprocessing costs, and breeder capital costs, is at least 50 years away, and the more likely case is 100 years away.

- A period of 50 -100 years is a long time, during which more efficient fission options may emerge, not to mention advanced solar and new technologies not yet invented.

- Accumulating a Pu-inventory today is not required to insure a sufficient start-up fuel supply for breeders. If the time ever comes when Pu-breeders are economically competitive and proliferation resistant, startup cores can be made from reserves of uranium enriched to about 20% U-235.

- To make a bomb out of 20% enriched material would require the theft or diversion of at least 125 kilograms of material, compared to 3.2 kilograms of reactor-grade alpha Pu.

- BOTTOM LINE: Plutonium separation and thermal recycle is a bad investment in today's energy market, and a separated Pu-inventory larger than that needed for R&D is not required to preserve the Pu breeder option for the future.

POINT 6 DISCUSSION: Pu Economics

Development efforts worldwide have demonstrated that plutonium fast breeders are uneconomical -- unable to compete with thermal reactors operating on a once through uranium cycle -- and that breeders will remain uneconomical for the foreseeable future. The putative benefits of the plutonium breeder, associated with its ability to more efficiently utilize uranium resources, are not diminished if commercial breeder development is postponed for decades, and the spent fuel from existing conventional reactors is stored in the interim. As thoroughly documented by Paul Leventhal and Steve Dolley of the Nuclear Control Institute in the U.S., energy security in the nuclear sector can be achieved more cheaply and more quickly by stockpiling uranium.[13]

The use of plutonium in the form of mixed-oxide (MOX) fuel in conventional power ("thermal") reactors is likewise uneconomical, because the costs of using MOX fuel cannot compete with those of enriched fresh uranium fuel for the foreseeable future. A recent study by the RAND Corp. in the United States estimates that, at the current cost for reprocessing services, the price of uranium feedstock for enrichment would have to increase by a factor of 16 before Pu recycle in LWRs becomes competitive.[14]

At current reprocessing costs and an FBR/LWR capital cost ratio of 1.5, the yellowcake price would have to increase by a factor of 45 before the breeder becomes competitive. When might this happen? The earliest date, based on the most optimistic assumptions about nuclear energy growth, reprocessing costs, and breeder capital costs, is at least 50 years away, and the more likely case is 100 years away. On the timescale for technology development, a period of 50 -100 years is a very long time, during which more efficient fission options may emerge, to say nothing of advanced solar and new energy technologies not yet invented.

Accumulating a Pu-inventory today is not required to insure a sufficient start-up fuel supply for breeders. If the time ever comes when Pu-breeders are economically competitive and proliferation resistant, startup cores can be made from reserves of uranium enriched to about 20% U-235 (to make a bomb out of 20% enriched uranium metal would require the theft or diversion of at least 125 kilograms of this material, compared to 3.2 kilograms of

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[13] See, for example, P. Leventhal and Steven Dolley, "A Japanese Strategic Uranium Reserve: A Safe and Economic Alternative to Plutonium," Nuclear Control Institute, Washington D.C., January 14, 1994.

[14] Brian G. Chow and Kenneth A. Solomon, *Limiting the Spread of Weapon-Usable Fissile Materials*, RAND National Defense Research Institute, Santa Monica, CA, 1993, p.36-38.

reactor-grade Alpha Pu). *Consequently, there is no sound economic or energy security justification for continued commercial reprocessing.*

Despite these realities, however, by the end of the decade France, the U.K and Japan alone will have separated an additional 120 metric tons, more plutonium than in the U.S. nuclear weapons stockpile. The global inventory of surplus separated civil plutonium (i.e. not fabricated into fuel or in use in reactors) will rise to an estimated 180 metric tonnes, a figure about twice the size of the U.S. weapons plutonium stockpile at its peak.[15] This amount would be in addition to more than 100 MT of plutonium likely to be removed from retired US and former Soviet weapons.

[15] Capacity data and production estimates are from F. Berkhout, et al., "Disposition of Separated Plutonium," Center for Energy and Environmental Studies, Princeton University, July 8, 1992, Appendix A.

CONCLUSION

At the dawn of the nuclear age, the authors of the famous Acheson-Lilienthal plan for international control of atomic energy clearly recognized the inherent military potential of fissile materials used for ostensibly peaceful purposes. Indeed, they believed that no widespread use of nuclear energy for civil purposes was possible or desirable without international ownership and control of the full nuclear fuel cycle.

Today it remains the unanimous opinion of the weapons design and arms control communities that the pacing consideration in a country's acquisition of a nuclear weapon is not the capability to design a nuclear device, but the availability of fissile materials which can be turned to weapons purposes. Ending -- as opposed to "managing" -- nuclear weapons proliferation will likely prove impossible as long as: production of highly enriched uranium (HEU) and chemical separation of plutonium for national security needs remain legitimate activities in a particular class of "nuclear weapon states," and; the international control regime permits civil nuclear fuel reprocessing in any state that asserts a peaceful interest in plutonium recycle and future deployment of plutonium breeder reactors for energy production.

With the end of the cold war, and the reductions in the superpower arsenals, the United States and Russia have huge surpluses of weapon-grade plutonium and highly-enriched uranium. Undoubtedly, there is no need for additional weapons plutonium production in other declared weapons states. *By completely renouncing the production, separation, and isotopic enrichment of weapons-usable nuclear materials, declared weapons states can put pressure on undeclared weapons states to do the same.* Weapon-usable fissile materials have no legitimate application in today's energy marketplace, and can always be produced in the future should the appropriate market and international security conditions emerge.

Despite the fact that all types of plutonium in relatively small quantities, irrespective of their designation as civil or military, have an inherent capability to be used in weapons, the current nonproliferation regime allows national separation and acquisition of plutonium (and highly-enriched uranium) under an internationally monitored commitment of peaceful use. A more effective nonproliferation approach would be a global ban on the production, transfer, acquisition, or isotopic enrichment of separated plutonium, and on the isotopic enrichment of uranium to greater than 20% U-235.

The heavy commitment of Japan and other countries to spent fuel reprocessing and recycle of plutonium, and the lingering hopes of a future revival of the plutonium fast breeder program in the United States and abroad, have effectively barred consideration of such a simple and direct step as outlawing production and acquisition of weapons-usable fissile materials on a global basis.

While there are obvious technical advantages in such a comprehensive approach, tangible political progress will more likely be achieved in the near term by adopting parallel approaches that seek separate controls -- in the initial stages at least -- on the military and civil applications of weapon-usable fissile materials.

THE CASE FOR DEFERRING
THE USE OF SEPARATED PLUTONIUM
IN THE CIVIL NUCLEAR FUEL CYCLE

Presentation
of
Christopher E. Paine

to

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ABSTRACT

Small quantities of reactor and fuel grade plutonium can be used to make efficient, powerful nuclear bombs as well as crude bombs and terrorist devices.

National separation, LWR recycle, and breeding of plutonium on a commercial scale place an impossible burden on the IAEA safeguards system to detect promptly the theft or diversion of Pu-bomb quantities from peaceful use.

The vision of a future "plutonium economy" provides a legitimate civilian cover for any country to acquire a stockpile of nuclear explosive materials, while ignoring the problem of future "break-out" from the NPT by countries that have "legally" acquired a plutonium stockpile under safeguards, but then decide to build nuclear arsenals.

Stockpiles of separated "civil" plutonium will act as a barrier to deep reductions and eventual elimination of nuclear weapons held by declared and undeclared weapon states.

Separation and use of plutonium in the civil nuclear fuel cycle is not justified by current or foreseeable energy market conditions, which strongly favor other fuels for generating electric power, and represents a grossly inefficient allocation of capital resources.

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セッション３

科学技術教育と日本の将来

＜基調講演＞

「科学技術教育の現状と課題」

福　井　謙　一

基礎化学研究所所長、京都大学名誉教授

＜パネル討論＞

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＜参加者との討論＞

科学技術教育の現状と課題

福井　謙一

科学は、「自然」と人間の本性とのかかわりから生じ、それが欲望と結びついて技術を生んだ。科学と技術は、相互に相手の進歩を加速しあい、未曽有の「科学技術化社会」を招来した。そのもたらした利便安楽、病気や飢えの減少など、人類の蒙った恩恵を評価しない者はいないであろう。このような社会の実現に、大きな影響をもったのは、教育であり、しかもその教育の趣旨と程度が、自然の謎を解き明かしたい人間の本性に概ね合致するものであったため、内部に秘められた困難がそれほど顕在化しないまま、今日を迎えたといい得る。

ところが、科学技術化社会における教育には、もともと本質的な不安定要素が存在したのである。これらは、地球の有限性と自然の特殊性に基ずく種々の制約に起因する。科学と技術の相互加速性は、資源・エネルギーの消費と人類の欲望の加速をもたらしたが、明かにこれは地球の有限性とあい容れない。加速する人類の欲求を満たし、また、それに伴って生じた天然資源の枯渇や自然環境の変化などの諸問題を解決するのには、きわめて高度の科学技術が要求される。そのためには、きわめて高度な教育が必要となり、科学志向の若人に対して従前に比し格段に苛酷な重荷を背負わせる結果になる。そのうえ、今世紀の科学は、量子論、相対論、生命論の発見により、自然がいかに特殊な性格を持つものであるかを明らかにした。その結果、今世紀の科学技術の先端分野は、ほとんどすべてその三大原理に代表される自然の特殊性に負っていると言っても過言ではない。さらに、今後の地球人類の抱える困難な諸問題に寄与すべき科学は、上記三大原理に基礎をおくのはもちろん、その三大原理から論理的に演繹される範囲を超え、自然の特殊性の深奥に迫るものであることが、しだいに明かとなりつつある。このような情勢は、若い学徒を鼓舞激励する材料にもなるが、時としては彼らを辟易させ、科学の道に飛び込むのをためらわせることにもなりかねない。

人間も生物の一つであり、遺伝的進化をするが、その科学的能力を遺伝的に進化させるほど、人間の科学とのつきあいはまだ長くない。したがって、人間がその生物的能力にお構いなく展開する科学技術の進歩についていくためには、格別の努力を必要とする。また、人間は、科学技術のもたらす地球環境の悪化に反撥する生物的側面をも持つ。これらは、

いずれも、科学技術を意図的に推進しようとするに際し抑制的に働く。したがって、今後の科学技術教育においては、もはや人間の自然探求の本性に頼りすぎるわけにはいかなくなると同時に、科学技術推進の新たな動機づけが必要となってくる。

従来、科学技術の普遍的価値を信じ、その推進は人類に無條件に恩恵をもたらすものとされ、また、国としてもその経済的効果を期待して「科学技術立国」などという標語が掲げられてきた。しかし、科学と技術の相互加速性は、地球上に科学文明の偏在をもたらし、その是正がいまだできていないまま、人類は、自然環境の悪化や資源・食糧の不足、人口爆発などの諸問題に対処せねばならなくなった。科学技術推進の動機づけの重心は、しだいにこのようなグローバルな視点へと移っていかざるを得ないことは明かであり、もはや一国が科学技術で世界を制覇しようとする時代ではない。科学技術に関係する価値観も、たとえば利便安楽から地球守護の目標へ、延命術から健康医学へ、経済万能の考えから心の安らぎなどの精神性重視へというふうに変っていくならば、科学技術に志す若人にも、時代の変化に即した適切な動機を与えることになろう。

今後の科学技術教育が成果をもたらすには、このような文明論的考察の上に立ち、それを取り巻く間接的な環境を整えることが肝要である。月並ではあるが、待遇や研究費など、科学技術者の活動する環境が良いことが前提となる。そのうえで、止めどもなく高度化する科学技術に敢えて挑戦し、そのひずみを正し、時には地球守護の戦士となろうとする若人を、社会を挙げて評価し、勇気づけていかねばならない。そのような若人の育成に当たっては、人間の個性の多様性を活用し、それを一層拡大するような教育によるのでなければ、その成功は覚束ないであろう。たとえば、直観や論理的思考の力に富むものは、ますますそれを伸ばすことを心掛けるべきである。知識の詰め込みに過ぎないような一律の理工科教育を、いくら強化拡充しても、それは、単に科学文明社会の構成員としてそれに適応し、あるいはそれを維持するには役立つかも知れないが、地球人類の守り手のような科学技術者の養成には、あまり有効ではなかろう。いうまでもないが、今後は、科学技術教育を、常にこのように少くも二様に分けて考え、論じていかざるを得ないであろう。

Current Status of Education in Science and Technology: A Problem

Kenichi Fukui

Science was born in the interface of "nature" and "human nature," to provide the technology that satisfies desires. Science and technology have stimulated each other, causing each to accelerate its development, and have led to a science-and-technology society unprecedented in its sophistication. No one would deny the benefits -- comfort and convenience, the elimination of hunger and disease -- that human beings have enjoyed. Education had played a major role in the realization of such a society; yet, because the motives and objectives of the educational effort have corresponded in the main with the human wish to clarify natural mysteries, difficulties hidden in the educational process have not been clearly revealed.

There is, however, an inherent instability attached to education in the advanced science-and-technology society, caused by various restrictions stemming from the finiteness of the earth and the uniqueness of nature. Accelerated developments in science and technology have also accelerated the consumption of natural resources and energy -- and human desires -- which are not consistent with the finiteness of the earth. A very high level of science and technology is required to solve associated problems, including exhaustion of natural resources and environmental deterioration, while still meeting accelerating human demand. This will, in turn, require a very high level of education, imposing a much heavier burden on science-minded young people than ever before. In addition, during this century, scientific studies have revealed essential features of nature through discovery of the principles of quantum theory, relativity and life. As a result, it is no exaggeration to say that most work in advanced scientific and technological fields in this century is dependent on the special features of nature represented by those three concepts. It is also becoming clear that science, which must contribute to solutions to the difficult problems human beings will have to face, should be based on those three concepts as well as enter more deeply into the fundamental questions posed in nature, beyond the range to be logically deduced from those concepts. The realization of this will be helpful in inspiring and encouraging young students, but, sometimes, could also make them hesitate to leap into careers in science and technology.

As living creatures, human beings evolve hereditarily, but scientific history is not yet long enough to encompass a genetically engineered acceleration of human scientific ability. Accordingly, in order for human beings to keep pace with technological developments, which occur irrespective of the biological ability to assimilate them, extraordinary effort is required. Human beings also have the biological capacity to react negatively to a worsening of the global environment by technology. This aspect works as a restrictive factor in the irresponsible promotion of technological development. In the future, therefore, scientific and technological education cannot be driven only by humanity's instinctive tendencies toward nature, but will require new motivation for the promotion of scientific and technological development.

Human beings have believed in the universal value of science and technology, and that development would unconditionally bring benefits to themselves. The government has bannered the theme of "Establishing a nation on a scientific and technological base," with the expectation of economic returns from scientific and technological endeavors. Accelerated developments in science and technology have, however, brought a non-uniformity of civilization to the earth. Before being able to correct that, human beings have to deal with other problems, such as environmental deterioration, shortages of resources and foods, and the explosive increase in population. It is now clear that the direction of scientific and technological promotion should be changed to encompass a more global view. We are beyond the time when a nation should seek to dominate the world through its scientific and technological power. Values in science must also change, from convenience and comfort to global protection; from the prolongation of life to the prevention of disease for keeping health; and from "economics almighty" to spiritual fulfillment -- all of which will provide young people interested in scientific careers with motivation appropriate and responsive of the changes of the times.

In order for humanity to enjoy the fruits of future scientific education, it is important that the cultural aspects of the indirect educational environment be fostered -- commonly, the working conditions, both physical and financial, of the scientists and engineers. Then, it is necessary that the whole of society appreciate and encourage those young people brave enough to undertake the challenges of science and technology, which are becoming ever more difficult and advanced; who wish to correct the imbalances and strains; and who will become fighters for the protection of the earth. In nurturing such important human resources -- in order to educate them effectively -- it is necessary to fully utilize their individuality. Those, for example, who possess sufficient intuition, or a logical way of thinking, should be led to develop those abilities. Continuing, strengthening, even expanding current uniform methods of scientific and technological education, which tend only to fill students with knowledge, will merely make them components of the science-and-technology society at its present level, serving to maintain that, but will not be effective in producing scientists and engineers who will be the protectors of the earth, or the benefactors of humanity.

It should go without saying that scientific and technological education must be addressed in at least the foregoing two respects in the future.

広島市民と語る夕べ－ヒロシマの意味と役割
於：広島国際会議場地下２階ヒマワリ

＜パネル討論＞
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庄野　直美
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他

セッション４

アジアの原子力開発と日本の役割

＜基調講演＞

「国際貢献におけるわが国の役割とこれまでの実績」

林　暘

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＜パネル討論＞

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Peaceful Utilization
of
Nuclear Energy For Benefit of Mankind

Li Yulun
Vice Chairman/Vice Minister
China Atomic Energy Authority
Vice President
China National Nuclear Corporation (CNNC)
April, 1994.

Abstract

The discovery of natural radiation in 1896 marked a new milestone in modern science and technology. Since then, great development has been achieved in nuclear science, technology and industry. Nowadays the electricity supplied by nuclear power plants accounts for 17% of the total electricity generated in the world.

China started to develop its nuclear industry in 1955. Today, a fairly complete system of nuclear scientific and technical industry has been established. China attaches great importance to the position and role of nuclear power as an alternative power source in China's energy infrastructure. The first nuclear power plant--Qinshan NPP with 300 MW(e) designed and constructed by self-reliance reached full load in July 1992. Its operation marked the ending of the history without nuclear power in China. The booming economy of China provides a huge marked for nuclear power. Most provinces in coastal areas show strong interests in building NPPs.

China is one of the nuclear weapon possessive countries. However, It consistently stands for a complete prohibition and thorough destruction of nuclear weapons. During the past decades, great efforts have been made by China to assume its responsibility and obligation of non-proliferation of the nuclear weapons, as well as promotion of nuclear disarmament.

China is a peace loving country, pursuing an independent policy for peace and is making every endeavor to create and maintain a peaceful environment. For this purpose, China attaches a great importance to strengthen international cooperation with foreign countries in the field of nuclear energy and safety.

CNNC, the former Ministry of Nuclear Industry, is an economic entity and a nationwide industrial conglomerate. It was also authorized by Chinese State Council as " China Atomic Energy Authority" performing certain administrative functions entrusted by the government.

NUCLEAR POWER DEVELOPMENT IN THAILAND

by

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Abstract

In the last 10 years (1984 - 1993) electricity demand in Thailand has actually tripled due to very rapid economic and industrial expansion of the Country. An everage increase of about 13.1% per year was experienced during this period and the peak demand in November 1993 was at 9839 MW. The total electric energy consumption in 1993 was 56,094 millions kwh. This trend is expected to continue in the next 2 decades and about 1000MW of new generation capacity would be required per year.

At present, electricity is generated by various sources. The installed capacity is roughly: lignite 17.4%, thermal 35.0%, combined cycle 24.6%, gas turbine 2.0%, diesel 0.2%, hydro 20.8%. In the future the indigeneous sources will be exausted and new sources have to be imported. The possible candidates for this purpose are imported coal, liquid fuel such as liquid natural gas, and nuclear.

Nuclear power is an interesting option for Thailand. It can lessen the problem of air pollution associated with coal-fired power plants and lessen the problem of large areas flooded by construction of dams for hydroelectric power stations. The problems associated with the adoption of nuclear power are mainly public acceptance, decision making process and uncertainty about comparative costings done by diverse agencies. There is a growing trend of acceptance among informed and educated citizens. But the word "nuclear" is still causing spectral images among the uninformed and less educated population and sometimes wrongly associated with the unhappy event at Hiroshima in World War II and the accident at Chernobyl. There is also apprehension about the danger and the management of nuclear

waste. These concerns are legitimate and public education programs are necessary. There is also concern about the ability of the Thai technical personnel to evaluate and to eventually operate nuclear power plants safely. The Thais can operate and have operated successfully many complex systems but suitable human resource development program in nuclear power is still needed. And Thailand must look to other experienced countries like, Canada, France, Germany, Korea, Japan, USA etc. for help in developing her nuclear human resources. The decision process in also very important and Thailand has to improve her decision process for large and long-term projects like this one.

In conclusion, nuclear power is an option for Thailand but extensive programs for public education and human resources development have to be undertaken before the project can become a reality.

セッション5

放射線の影響－研究成果と今後の課題

＜基調講演＞

「放射線影響評価一広島、長崎の調査結果より」

重　松　逸　造

(財)放射線影響研究所理事長

＜パネル討論＞

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フェアウェル・パーティ

於　広島国際会議場地下2階ダリア

第27回原産年次大会セッション５基調講演
1994年４月15日（金）14:10-14:40，広島

放射線影響評価ー広島・長崎の調査結果より

（財）放射線影響研究所　理事長　重松逸造

1.原爆と放射線

1945年８月、広島と長崎に投下された原子爆弾（原爆）は、いうまでもなく人類史上最初のもので、その爆発力はＴＮＴ火薬に換算して、広島型のウラニウム爆弾は15Kt（ｷﾛﾄﾝ）、長崎型のプルトニウム爆弾は21Ktといわれている。ＴＮＴ１トン爆弾のそれぞれ１万５千個分と２万１千個分ということになるが、原爆の特徴は強烈な爆風のほかに高温の熱線と大量の放射線を放出することにある。すなわち、原爆は瞬間的な殺傷力や破壊力が強大なだけではなく、放射線による長期的な健康影響や環境汚染をもたらす点が問題である。

もともと、人類が放射線の存在に気付くのは、ドイツの物理学者Wilhelm Konrad Röntgenが1895年にＸ線を発見したことにはじまるが、その後1945年までの50年間に得られた放射線の健康影響に関する知識は、放射線取扱い事故などによる急性影響が中心で、長期的な影響については殆ど知られていなかったといっても過言ではない。この点、広島・長崎の原爆被爆者は老若男女を問わず大量の放射線に曝露したわけで、これはまさに人類最初の経験であった。それだけに、未知の放射線影響に対する被爆者の人たちの不安は想像を絶するものがあり、この不安は遺伝的影響の問題を含めて今日もなお続いていることを忘れてはならない。

2.急性影響

原爆放射線の急性影響については、上述した原爆の爆風と熱線の影響にカバーされて正確な把握は困難であるが、1945年９月に発足した日米合同調査団の報告などによると、主に１Gy（ｸﾞﾚｲ）以上の被曝者（爆心地より約1.5Km以内の被爆者）については、被爆当日より２～３日の間に悪心、嘔吐、食欲不振とこれに続く血便と発熱がみられ、脱毛は被爆２週間後位から現われた。皮膚の出血と口腔、咽頭の潰瘍はそれぞれ第３週目と第４週目にピークとなり、急性影響による死亡の発生は遅くとも４か月以内に終了した。

人間が放射線の被曝によって60日以内に半数の人が死亡する線量（半数致死量LD50）は従来４～６Gy程度といわれていたが、広島の被爆者について再検討した最近の成績では半数致死量が３Gy以下となっていた。放射線は以前考えられていたよりは、より危険ということになるが、当時の被爆者の栄養状態や火傷の影響なども考慮する必要があろう。1986年４月に起ったチェルノブイリ事故の場合は、４～６Gyの被曝でも死亡者は１／３以下であった。

3.長期影響

3.1　調査体制　原爆被爆者の長期的な健康影響を調査する目的で、米国政府は1947年と1948年にそれぞれ広島と長崎に原爆傷害調査委員会（略称ABCC）を設立した。また、1948年には日本の国立予防衛生研究所支所が両市のABCCに併設されて日米共同研究の形となったが、実際は予算の95％が米国側の負担であった。しかし、1975年よりは日米両国政府が均等負担する現在の放射線影響研究所（略称RERF）がABCCの事業を引き継いで現在に至っている。

なお、原爆被爆者に関する調査研究は、連合軍の占領下時代、日本の研究者にとって多くの制約が存在したが、1952年の講和条約発効後は自由となり、広島、長崎の地元大学をはじめとして、いくつもの施設で活発に実施されるようになった。その成果は、1959年以来毎年開催されている原爆後障害研究会などで発表されているが、ここでは主としてABCC－RERFの調査研究について述べる。

3.2　調査対象　原爆放射線の健康影響を追跡するような調査を疫学調査と呼ぶが、これを実施するためには、被爆者の正確な把握が必要である。しかし、戦後の混乱のためにその把握が遅れていた。1950年になって、日本では戦後はじめての国勢調査が実施されたが、その際ABCCの要請により、被爆状況の調査が付帯的に行われた。

その結果、全国で284,000人が広島か長崎での被爆者と申告した。このうち、広島、長崎両市在住の195,000人については被爆状況を確認するための面接調査が行われ、確実な被爆者93,000人と非被爆者27,000人の計120,000人が寿命調査の対象に選ばれた。この調査は、現在も60％に近い生存者について継続されているが、日本の戸籍制度のお蔭で死亡状況の把握は100％に近い。ただし、この寿命調査の開始時期は国勢調査時の1950年であって、被爆後の５年間がブランクになっている点を念頭に置く必要がある。

寿命調査対象のうち、70,000人は病理学的調査の対象として死亡時の剖検などが行われた。日本では困難視されている病理解剖が、広島、長崎では特に1960年代に活発に実施されたことは、被爆者と家族の方々の深い御理解によるもので、特記されるべきことであろう。

また、寿命調査対象者より抽出された成人約20,000人については、1958年を出発点に２年に１回の健康診断が実施されてきた。この成人健康調査は、現在１８サイクル目を終えようとしているが、30数年間に及ぶ長い期間、80％以上という高率の受診率が維持されていることは、いかに被爆者の方々の協力が大きいかを示している。

その他、胎内被爆者の調査や被爆者の子供についての遺伝調査も実施されてきた。また、がんや循環器疾患の特別調査や免疫学的研究なども行われている。

3.3　被曝線量　ABCC－RERFの時代を通じて、今日までに最も力が注がれてきた仕事の一つが、被爆者各人の被曝放射線量を推定することである。これには、かつて米国がネバダ砂漠で行った大がかりな被曝実験や日米科学者による多くの共同研究が含まれる。その結果、1986年には現在用いられているDS86（1986年線量体系）と呼ぶ被爆者各人の被曝線量を推計するシステムが完成した。

3.4　調査成績　今までに得られた原爆放射線被曝者の追跡調査成績を総括すると、図１に示すように数Gy以上の大量被曝による急性死亡は被曝後４か月以内に終了した。その後、２、３年の潜伏期間を置いて白血病（慢性リンパ性を除く）といった血液のがんによる死亡が増えはじめ、６年後位にピークとなったが、最近は非被曝者群と同じレベル近くにまで低下している。

甲状腺がん、乳がん、肺がん、大腸がん、胃がんなどの固形がんは10年後位より過剰死亡がみられ、過剰の程度は減少したものの被曝後50年近い現在もこの傾向は継続している。なお、がん、特に白血病の場合は0.2Gy程度の被曝から、非被曝群との間で死亡の発生に有意差が認められた。

最近判明した新しい事実は、1.5Gy以上の高線量被曝者に心臓病などで過剰死亡の発生が示唆されることである。がんの場合に比べて過剰の程度は少ないが、被曝後30年以前から増加の傾向がはじまったものと推定されている。いずれにしても、以上は大量１回被曝の場合で、チェルノブイリのように継続被曝が予想される例では、図１のカーブも右の方へずれて、より長い潜伏期間となることが考えられる。

図２は、原爆放射線の被曝者中、主な死因による死亡者の何％が放射線に起因しているかという寄与率を示している。３５年間の観察で、全死亡の３％、がん死亡の１０％が放射線によっていることが分かる。図３は、がん死亡の場合についての内訳で、例えば白血病では死亡の絶対数は少ないが放射線の寄与率は55.4％もある。逆に、死亡数の多い胃がんではこの率が6.3％と低率であった。図４は、１Gyの被曝者が非被曝者に比べて何倍位死亡率が高いかという相対リスクを主要死因別にみたものであるが、がんが1.4倍と他の死因に比べてリスクが最も高くなっている。図５はがんの部位別に相対リスクをみたものである。白血病の相対リスクが５と最も高くなっている。

上記の死亡以外で被曝に関連すると思われる健康異常を表１でみると、白内障、副甲状腺機能亢進症、染色体異常、体細胞突然変異、幼少期被曝者の成長・発育遅延などがあり、胎内被曝者では小頭症、精神遅滞（主として受胎後８～15週に被曝の場合）がみられる。

一方、表２によると、慢性リンパ性白血病、子宮がん、骨肉腫、不妊などについては被曝、非被曝の両群間で有意差は認められていない。また、被爆者の子供については、現在までのところ先天異常、白血病、染色体異常などを含めて遺伝的影響は発見されていない。

4.問題点

もともと疫学調査とは、分母となる被曝人口をできれば被曝線量別に明確にして、分子となる健康異常者を識別することである。広島、長崎の場合は、戦後の混乱で分母の把握が被爆時の5年後と遅れたが、チェルノブイリでは既にそれ以上の遅れを示していて、分子のみが強調されているのは、正しい被曝者対策のためにも残念なことである。

被爆者の多くが高齢化しつつある現在、放射線の影響を他の要因によるものから区別することはますます困難となっているが、従来知られなかった健康影響が老化現象とともに表面化する可能性も否定できない。一方、若年被爆者の場合はこれからがんなどの好発年齢を迎えることを思えば、今後とも被爆者の健康管理を怠るべきではない。さらにいえば、遺伝影響についても今日までの結果に満足することなく、より精密な手技を用いて追求を続けるべきであろう。被爆者の健康後影響調査では、異常の存在を示す陽性所見だけでなく、異常が存在しないという陰性所見を明らかにすることも重要である。

最近は放射線被曝の問題が世界的な規模で拡大しつつあるが、特にチェルノブイリ事故を契機に被曝者対策のノウハウを広島、長崎に求める例が急増してきた。広島、長崎のような悲劇を二度と繰返してはならないが、今日までに蓄積された放射線の健康影響に関する知識を世界に役立てることは被爆者の方々の意向にも添うものと信じている。そのため、広島と長崎の研究者は既に多くの国際協力を行ってきているが、今後一層の拡充ができるよう各位の御支援をお願いする次第である。

終りに、長年にわたるABCC-RERFの調査研究に対して被爆者ならびに御家族の方々からいただいた御協力に感謝するとともに、広島、長崎の両地元をはじめとする日米関係諸機関の御援助に謝意を表する。

図1

EXCESS DEATH DUE TO A-BOMB RADIATION

原爆放射線による過剰死亡

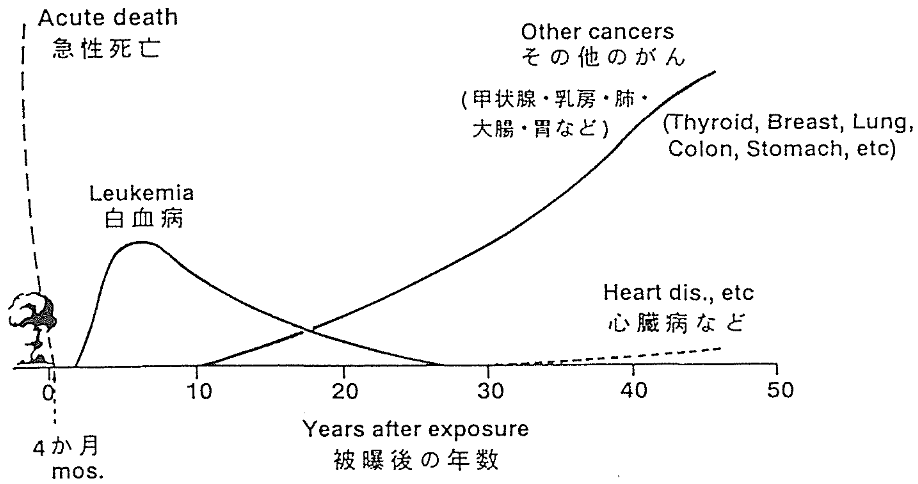

図2

ATTRIBUTABLE RISK OF RADIATION FOR DEATHS OF A-BOMB SURVIVORS (35 YRS)

原爆被爆者死亡中に占める放射線の寄与率 (35年間)

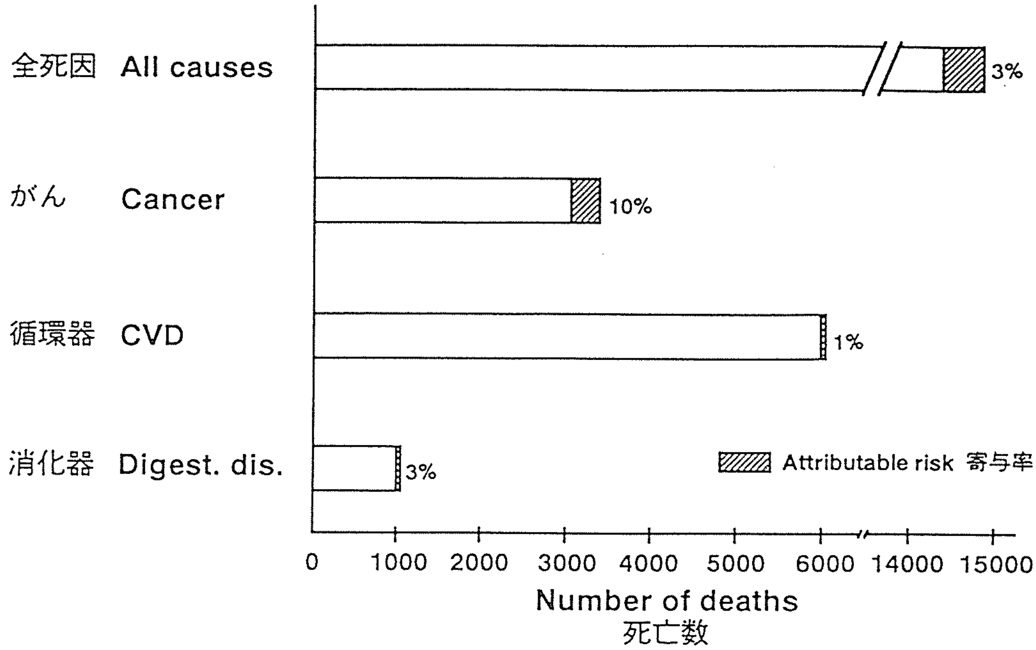

図3

ATTRIBUTABLE RISK OF RADIATION FOR CANCER DEATHS OF A-BOMB SURVIVORS (35 YRS)

原爆被爆者がん死亡中に占める放射線の寄与率 (35年間)

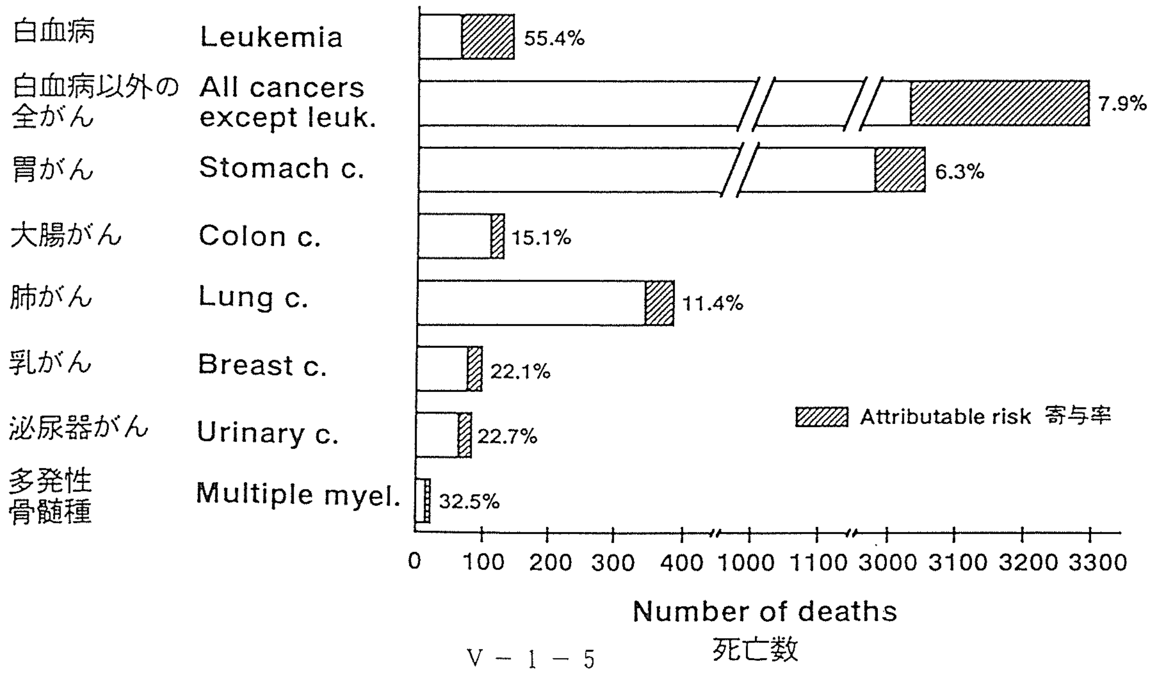

図 4

RELATIVE RISK FOR MAJOR CAUSES OF DEATH AT 1 GRAY

1グレイ被曝者の主要死因別リスク
(非被曝死亡者と比べて)

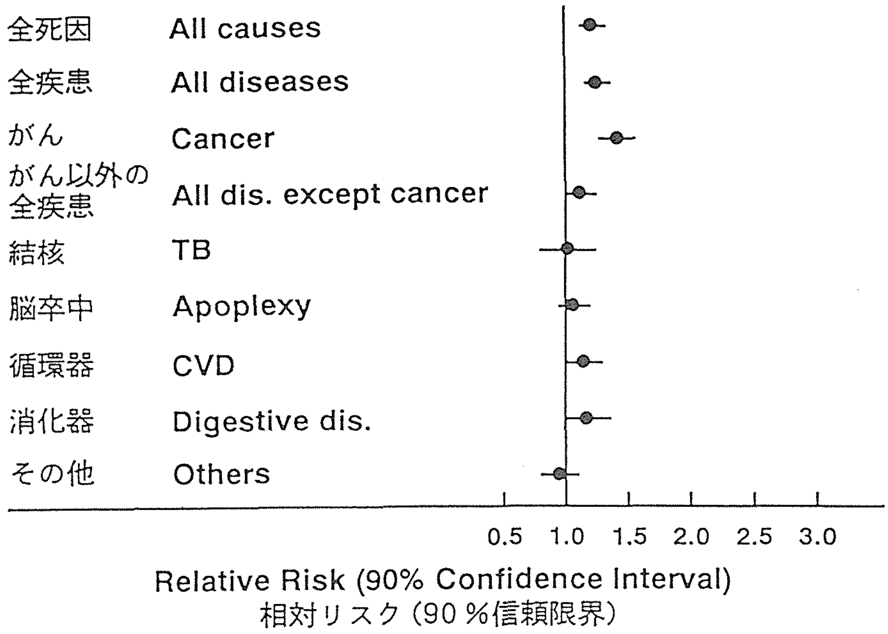

図 5

RELATIVE RISK FOR MAJOR SITES OF CANCER DEATH AT 1 GRAY

1グレイ被曝者の部位別がん死亡リスク
(非被曝死亡者と比べて)

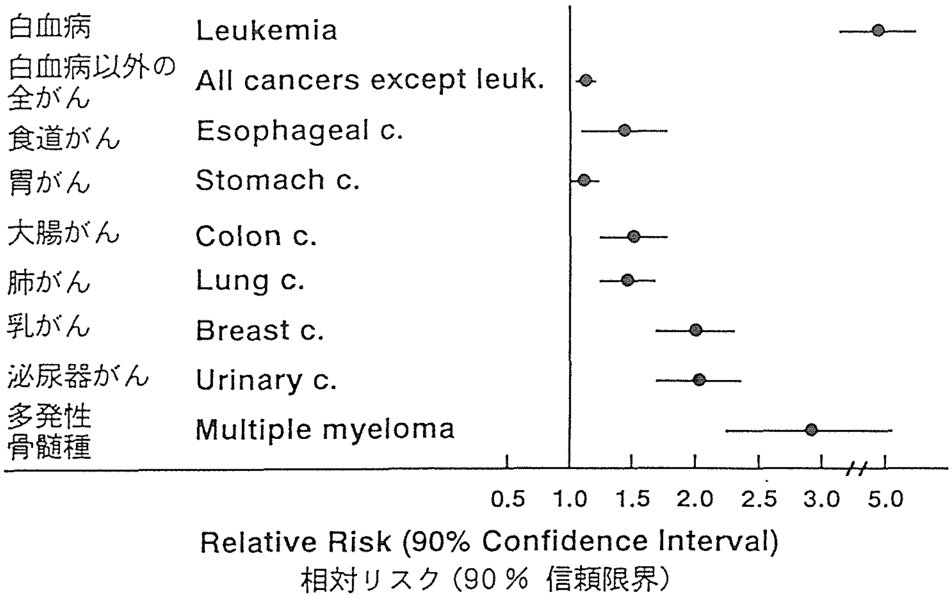

表1

放射線と関連あり	ASSOCIATED WITH RADIATION
白血病・その他のがん	Leukemia・Other cancers
白内障・副甲状腺機能亢進症	Cataract・Hyperparathyroidism
染色体異常・体細胞突然変異	Chromosomal abberation・Somatic cell mutation
成長・発育の遅延(幼少時被曝)	Delayed growth & development (Exposure at young age)
小頭症・精神遅滞(胎内被曝)	Microcephaly・Mental retardation (In utero exposed)

表2

放射線と関連なし	NOT ASSOCIATED WITH RADIATION
慢性リンパ性白血病・子宮がん・骨肉腫	Chronic lymphocytic leukemia・Uterine Ca.・Osteosarcoma
加齢促進	Acceleration of aging
不　妊	Infertility
先天異常・白血病・染色体異常・その他の遺伝影響(被爆二世)	Congenital anomaly・Leukemia・Chrom. abb. & Other genetic effects (Children of A-bomb survivors)

EFFECTS OF RADIATION: STUDY RESULTS AND FUTURE ISSUES

Seymour Jablon

It is a privilege to talk about radiation effects on human health in Hiroshima, the source of most of what we know about the effects of radiation on man. You know about the studies at the Radiation Effects Research Foundation. There have been a few other studies of long duration, but most of them have been concerned with particular issues such as thyroid cancer following childhood irradiation or lung cancer following exposure to radon in miners. The experience of the survivors in Hiroshima and Nagasaki has been unique because those exposed were ordinary people of all ages, not miners or children, and because the excellent Japanese system for recording vital events has made it possible to trace the results of the A-bomb exposures in more than 100,000 people, including both those exposed and those not in the cities and not exposed. The whole world owes a great debt of gratitude to those Japanese people who have made the studies possible.

Fifty years ago few people were exposed to ionizing radiation. X-rays were used in the diagnosis and treatment of tuberculosis and other diseases. But today radioactive materials are used routinely for diagnosis, radiation is used to sterilize medical supplies, to search for defects in welds and it has many other uses. All of these activities carry the possibility of radiation exposure to the operators. The generation of electricity by nuclear plants carries a risk of population exposures from accidents, such as at Chernobyl. Exposures occur also from manufacturing processes, as happened at Hanford and other nuclear facilities in the United States. We cannot, however, even if we want to, abolish entirely the use of radiation and thus avoid any exposures; the uses of radiation are too tightly bound into our technological civilization. What we can, and must, do is understand the risks as well as we can so as to minimize them and provide appropriate protection both to radiation workers and people generally. Our understanding of those risks principally depends on knowing what has happened, what is happening, and what will happen to the exposed survivors in Hiroshima and Nagasaki.

What have we learned? That unborn children, particularly those in the eighth to fifteenth weeks of pregnancy, may be greatly harmed by large radiation doses: mental development is impaired and growth and development is damaged. Genetic effects of radiation - the induction of mutations, occur in laboratory animals, and must occur in humans also. Fortunately, however, the rate at which genetic effects are induced by ionizing radiation is low enough that, despite diligent search, involving tens of thousands of observations, it has not been possible to detect any genetic effects in the children of the survivors in Hiroshima and Nagasaki. Cataracts of the eye can be induced by large doses, but only a few survivors have been so affected. But the most prominent harmful effect of radiation is the induction of cancer. Cancers may not occur until many years after the exposures that induced them, so the possibility is a worrisome one for the survivors. We will concentrate attention on the cancer-inducing effect of ionizing radiation.

Some kinds of cancer occur more frequently in persons who have been exposed to radiation. Although many kinds of cancer have been increased, the most prominent have been some forms of leukemia, breast cancer, lung cancer and cancers of the thyroid gland. The results of the follow-up of the A-bomb survivors have been summarized in a report from the National Research Council (1) that examines the occurrence of cancers at many sites and compares the results with those of other studies. We will have time for only two issues, the importance of age at exposure and time after exposure for two forms of cancer: leukemia and breast cancer.

Table 1 shows some data that have been adapted from the report by Shimizu and her colleagues concerning cancer mortality in 76,000 Hiroshima and Nagasaki survivors through the year 1985. There were nearly two thousand deaths from cancer, a third of them from stomach cancer. The excess risk of death from any kind of cancer, as a result of radiation, was calculated to be 39 percent, that is, survivors who received 1 Gray, or 100 rads, had nearly 40 percent more cancer deaths than would be expected among the same number of non-exposed persons. There were 202 deaths from leukemia, only a small fraction of the total, but the leukemia deaths after exposure to 1 Gray were increased by nearly 400 percent. Breast cancer mortality accounted for 155 deaths and the risk after 1 Gray was twice the risk among the non-exposed. Other kinds of cancer were responsible for varying numbers of deaths, but for all of the kinds shown in the table the excess mortality among the exposed survivors was significantly larger that would have occurred had the exposure to radiation not occurred.

Table 2 shows how the age at which the person was exposed affected the cancer risk. For the children exposed when less than ten years old the *extra* leukemia deaths were nearly twenty times the number among the non-exposed, while after age 40 the excess risk was a little more than three times the background rate for non-exposed persons. For breast cancer, the results were similar, but less extreme than for leukemia:

girls exposed below age ten had an *excess* of 190 percent of the baseline rate, but for those exposed after age 40, the excess was only 11 percent.

Table 3 shows how the radiation cancer effect changed as time passed: For leukemia, the risks were very large during the decade 1950 to 1960, but were ten times lower in 1976 to 1985; for breast cancer, however, the pattern was the opposite: there was no risk of radiation-induced cancer during 1950-1960, but the cancer rate was more than doubled in 1976 to 1985. What the future holds for the late-developing cancers only future follow-up can tell us.

These data form only a small part of the wealth of information for which we are indebted to the survivors. Nevertheless, those data cannot answer all of the questions that we have. What, for example, are the effects from very low radiation doses? The Hiroshima and Nagasaki data are strong because they come from survivors who were subjected to large doses, much larger than those received from natural background radiation, or from reprocessing plants or nuclear power plants. Some believe that such very low doses may actually be beneficial, but no strong evidence that this is true has yet appeared.

Although the data do not answer all of the questions we might have, most of our knowledge about radiation effects on health comes from the studies of the atomic bomb survivors, and we owe them an enormous debt of gratitude. We express that gratitude to the survivors for the knowledge they have given us out of the disaster that they have suffered. And we earnestly hope that no such disaster will ever be repeated.

Table 1

CANCERS SIGNIFICANTLY INCREASED AMONG A-BOMB SURVIVORS[1]
1950-1985

Site of Cancer	Number of Deaths All Survivors	Excess Risk at 1 Gray (percent)
All Sites	5936	39
Leukemia	202	392
Stomach	2007	23
Colon	232	56
Lung	638	46
Breast (female)	155	100
Cervix uteri	90	43
Ovary	82	81
Urinary bladder	90	113
Multiple myeloma	36	186
Central nervous system except brain	14	209

[1] Source: Shimizu et al. Ref. (2).

TABLE 2

CANCER RISK IN HIROSHIMA AND NAGASAKI SURVIVORS[1] 1950-1985
by Age at Exposure

Site of Cancer	Number of Deaths All Survivors	Excess Risk at 1 Gray (percent) All Ages	<10	40+
All Sites	5936	39	--	--
Leukemia	202	392	1910	340
Breast Cancer	155	100	190	11

TABLE 3

CANCER RISK IN HIROSHIMA AND NAGASAKI SURVIVORS[1] 1950-1985
by Years

Site of Cancer	Excess Risk at 1 Gray (percent) 1950-1960	1976-1985
Leukemia	1027	104
Breast Cancer	(-8)	174

1

[1] Source: Shimizu, et al. Ref.(2).

References

(1) National Research Council, Committee on the Biological Effects of Ionizing Radiation. *Health Effects of Exposure to Low Levels of Ionizing Radiation - BEIR V.* National Academy of Sciences-National Research Council, National Academy Press, Washington, D.C., 1990.

(2) Shimizu, Y., Kato, H., Schull, W.J. Studies of the mortality of A-bomb survivors 9. Mortality, 1950-1985: Part 2. Cancer mortality based on the recently revised doses (DS86). *Radiat. Res.* 121:120-141, 1990.

CHILDHOOD CANCER AND NUCLEAR INSTALLATIONS

Presentation at the 27th JAIF Annual Conference,
Hiroshima (Japan), 13-15 April 1994

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There has been considerable interest in recent years in reports of excesses of childhood cancer, specifically leukaemia, in the vicinity of nuclear installations in the United Kingdom. A Government inquiry[1] confirmed an excess of childhood leukaemia in the village of Seascale, close to the Sellafield reprocessing plant in West Cumbria. In particular, 4 cases of lymphoid malignancy were diagnosed during 1963-83 at ages under 15 years, compared with 0.25 expected[2]. However, it was concluded that this excess could not be explained in terms of radioactive releases into the environment from Sellafield[1,3]. Studies around the Dounreay reprocessing plant in northern Scotland[4], the Aldermaston and Burghfield weapons plants in southern England[5], and around nuclear installations in England and Wales generally[6] have indicated excesses of leukaemia in young persons. Again, however, these findings could not be explained on the basis of environmental discharges. Indeed a leukaemia excess was observed in areas where nuclear plants had been planned or were later built[7]. Studies around nuclear installations in countries other than the UK, such as France[8] and the United States[9], have generally not shown raised levels of either childhood leukaemia or childhood cancers overall.

Among the hypotheses put forward to explain the above findings are that conditions in isolated areas, such as where the Sellafield and Dounreay plants were built, may be conducive to exposure to some specific infectious agent[10] or to general infections[11] which increase the risk of childhood leukaemia. Kinlen's hypothesis for an effect of 'population mixing' receives support from, for example, studies in new towns[10], although no specific infectious agent has been identified. A large amount of attention has been devoted to the results of Gardner et al's case-control study of leukaemia among young persons in West Cumbria[12]. This found a statistically significant association with recorded pre-conception external dose for fathers employed at Sellafield, although based on only 4 cases. Further investigation of leukaemia in the offspring of Sellafield workers[13] showed that the association with external dose was confined to children born in Seascale, and that there was little evidence for associations with potential exposure to internal emitters or to chemicals.

Studies of the offspring of the Japanese atomic bomb survivors[14] and of radiation workers in Scotland[15] and Ontario (Canada)[16] have not shown associations between childhood leukaemia and paternal pre-conception irradiation, although these worker studies did not have large statistical power. A much larger study which involves linking the UK National Registry for Radiation Workers with national databases of childhood cancer is currently in progress[17], and will have high statistical power to address Gardner et al's hypothesis. More generally, large case-control investigations are currently being conducted in England and Wales and in Scotland to test hypotheses relating to infections, chemicals, electromagnetic fields and natural radiation. These studies may be able to provide deeper insights into the causes of childhood cancer.

References

1 Black, D. Investigation of the possible increased incidence of cancer in West Cumbria. Report of the Independent Advisory Group (Chairman: Sir Douglas Black). London, HMSO (1984).

2 Craft, A W, Openshaw, S, and Birch, J. Apparent clusters of childhood lymphoid malignancy in Northern England. Lancet ii, 96-97 (1984).

3 Stather, J W, Dionian, J, Brown, J, Fell, T P and Muirhead, C R. The risks of leukaemia and other cancers in Seascale from radiation exposure. Chilton, NRPB-R171 Addendum (London, HMSO) (1986).

4 Committee on Medical Aspects of Radiation in the Environment (COMARE). Second Report: Investigation of the possible increased incidence of leukaemia in young people near the Dounreay nuclear establishment, Caithness, Scotland (Chairman: Professor M Bobrow). London, HMSO (1988).

5 Committee on Medical Aspects of Radiation in the Environment (COMARE). Third report: Report on the incidence of childhood cancer in the West Berkshire and North Hampshire area, in which are situated the Atomic Weapons Research Establishment, Aldermaston and the Royal Ordnance Factory, Burghfield. (Chairman: Professor M Bobrow). London, HMSO (1989).

6 Cook-Mozaffari, P J, Darby, S C, Doll, R, Forman, D, Hermon, C, Pike, M C, and Vincent, T. Geographical variation in mortality from leukaemia and other cancers in England and Wales in relation to proximity to nuclear installations, 1969-78. Br.J.Cancer, 59, 476-485 (1989).

7 Cook-Mozaffari, P J, Darby, S C, and Doll, R. Cancer near potential sites of nuclear installations. Lancet, ii, 1145-7 (1989).

8 Hill, C, and Laplanche, A. Overall mortality and cancer mortality around French nuclear sites. Nature, 347, 755-757 (1990).

9 Jablon, S, Hrubec, Z, Boice, J D, and Stone, B J. Cancer in populations living near nuclear facilities. NIH Publication No. 90-874. Washington DC, National Institutes of Health (1990).

10 Kinlen, L J, Clarke, K, and Hudson, C. Evidence from population mixing in British new towns 1946-85 of an infective basis for childhood leukaemia. Lancet, 336, 577-82 (1990).

11 Greaves, M F. Speculations on the cause of childhood acute lymphoblastic leukaemia. Leukaemia, 2, 120-5 (1988).

12 Gardner, M J, Snee, M P, Hall, A J, Powell, C A, Downes, S, and Terrell, J D. Results of case-control study of leukaemia and lymphoma among young people near Sellafield nuclear plant in West Cumbria. Br. Med. J., 300, 423-429 (1990).

13 HSE. HSE investigation of leukaemia and other cancers in the children of male workers at Sellafield. Health and Safety Executive (1993).

14 Yoshimoto, Y, Neel, J V, Schull, W J, Kato, H, Soda, M, Eto, R, and Mabuchi, K. Frequency of malignant tumours during the first two decades of life in the offspring (F_1) of atomic bomb survivors. RERF TR 4-90. Hiroshima, Radiation Effects Research Foundation (1990).

15 Kinlen, L J, Clarke, K, and Balkwill, A. Paternal preconceptional radiation exposure in the nuclear industry and leukaemia and non-Hodgkin's lymphoma in young people in Scotland. Br. Med. J., 306, 1153-58 (1993).

16 McLaughlin, J R, King, W, Anderson, T W, Clarke, E A, and Ashmore, J P. Paternal radiation exposure and leukaemia in offspring: the Ontario case-control study. Br. Med. J., 307, 959-966 (1993).

17 Draper, G J, Kendall, G M, Muirhead, C R, Sorahan, T, Fox, A J, and Kinlen, L J. Cancer in the children of radiation workers. Radiol. Prot. Bull., 129, 10-14 (1992).

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私は、「被爆の社会的影響」について簡単に述べることにする。

被爆直前の広島は、西日本最大の軍都（軍事都市）であり、多数の軍事施設と軍人を擁していた。被爆時に広島にいた軍人の数は4万とも6万ともいわれている。しかし、同時にここでは、３０万人前後の市民（非戦闘員）が生活をしていた。原爆の爆心地は、広島市のほぼ中央にあたり、爆心地から３キロメートル圏内には、全市の建物の約８５％、居住人口（市民）の約８４％が存在していた。原爆被爆により、市内の建物の９２％にあたる約７万戸が半焼・半壊以上の被害を受け、１０万人前後の市民が死亡した。軍事施設は、爆心地に近い広島城を中心とする地域に集中しており、１万人以上の軍人が死亡した。

原爆は、広範な家族の崩壊をもたらした。原爆被害復元委員会の調査によれば、被爆時の爆心地域の１世帯当りの平均人員は４．９人であり、その内の死亡人員は、２．３人という結果が出ている。原爆により父母を失った子供は、４－５千人に及ぶと推定されている。また、家族崩壊は、のちに、原爆孤老という問題を生んだ。１９７５年の政府の調査によれば、広島市の被爆者世帯に占める老人単独世帯の割合は8％、老夫婦の世帯の割合は7％であった。これらの割合は、非被爆者世帯と比較してそれぞれ2倍・3倍という高率である。

原爆被害の特異性は、その瞬時性、大量無差別性とともに放射能の持続性にある。放射能の人体への影響は、直接被爆した人々のみならず、被爆後早期に入市した人々や、被爆地域外で救援活動に従事した人々をも、今日までなお苦しめ続けている。

１９８５年の日本政府の調査により、回答者の７４％にあたる約２３万人の被爆者が、自分の健康に不安を感じていることが明らかになった。また、１９９０年に韓国政府がおこなった在韓被爆者２３０７人の調査結果では、８９％の被爆者が何らかの後遺症に悩んでいることが明らかになっている。

このほかにも、原爆被爆者問題は、深刻な問題を抱えている。政府は、被爆２０周年に

あたる１９６５年に全国の被爆者約２７万人を対象に実態調査をおこなったが、その結果、約６千人が、就職について差別を受けたことがあると答え、約７千人が結婚について差別を受けたことがあると答えている。また、１９９０年、ＮＨＫが広島市内の被爆者を対象におこなった意識調査では、３４％の人々が、被爆したことにより、その後の生活が不利になったと回答している。

１９５７年、つまり被爆から１２年後に、やっと原爆被爆者医療法が制定され、国費による原爆被爆者の健康管理と原爆症患者の医療がおこなわれるようになった。この法律に基づく被爆者健康手帳の所持者は、初年度には約２０万人であったが、年々増え続け１９８０年度には、約３７万人を数えた。しかし、その後、減少が始まり今日では、約３４万人となっている。減少の理由は、被爆者の死亡数が、新たな手帳所持者数を上回るようになったからで、被爆者の死亡数は急速に増加している。広島市の原爆慰霊碑に納められている名簿によれば、広島の原爆被爆者の１年間の死亡数は、１９７０年前後には約１０００人であったが、８０年前後には約２０００人となり、最近では約３５００人となっている。

被爆者に対する国の援護施策は、原爆被爆者医療法の制定以後、徐々に改善された。特に、１９６８年には原爆被爆者特別措置法が新たに制定され、被爆者の福祉を目的として、諸種の手当が支給されるようになった。こうした改善にともない、政府の原爆被爆者対策予算は、年々増加している。１９５２年に約1億７０００万円から出発した予算が、今年度には約１４００億円となっている。

しかし、被爆者の多くは、これら二つの法律に基づく施策を充分なものと考えているわけではなく、国家補償の理念に立った原爆被爆者援護法の制定を国に強く要望している。１９８５年の朝日新聞社の世論調査の結果によれば、７９％が被爆者援護法を制定し補償すべきだと回答している。また、現在、全自治体の３分の２以上が同法制定促進決議をおこなった。これらは、被爆者援護法制定の要望が、広範な世論の支持を得ていることを示している。

マスメディアの社会的影響について

私は、この問題に触れる前に、戦後の日本社会が原爆被害をどのように扱ってきたかということを簡単に述べる。

日本は、広島の被爆から８日後に降伏を決定し、以後、ほぼ７年間占領状態にあった。この間、原爆被害に関する問題は、タブー視され、原爆被害者が社会の関心を受けることは極めてまれであった。

しかし、独立後、日本のマスコミは、原爆被害について大々的にとりあげた。また、１９５４年３月のアメリカの南太平洋ビキニ環礁での水爆実験を契機に、原爆被害についての問題は、日本の重要な社会問題として存在し続けるようになった。

広島では、毎年８月の原爆記念日を中心に、さまざまな行事が催されている。その一つである広島市の平和記念式典は、被爆から２年後にはじまり、今年には、４６回目の式典が開催された。この式典は、はじめは一地方都市の行事に過ぎなかったが、被爆１０周年ごろからは、全国からの参加者がみられるようになり、２０周年前後から政府の閣僚の参列がみられるようになった。さらに、１９７９年からは、この式典に国費から補助金が支出されている。このような式典の歴史は、原爆被害にたいする社会の関心が、次第に広がり、定着していく様子を如実に示す一例である。

このほか、原爆による犠牲者を出した企業や学校・団体単位の慰霊行事が多数おこなわれているが、こうした行事は、年々少なくなるどころか、逆に年を経るにしたがい、活発になっている。その理由には、被爆当時に存在した学校・職場・団体とは別に、平和団体や労働組合などによる新たな慰霊行事が生まれたことや、遺族会や同窓会によってひっそりと営まれていた学校単位の慰霊行事に、生徒会の参加がみられるようになり、慰霊行事が、平和教育の場になっていることなどをあげることができる。

被爆１０年目から開催されるようになった原水爆禁止世界大会は、当初すべての政党や多様な階層をまきこんだ国民的な大会であった。これは次第に政党や団体ごとの大会に変

化してきたが、それでも毎年、広島・長崎を中心に開催されつづけている。これらの大会は、いづれも核兵器禁止の課題とともに、原爆被害に関する諸問題を中心的な課題として開催されている。

１９６０年代後半、原爆被災白書作成運動・原爆ドーム保存運動など被爆の実相を明らかにし、この体験を継承しようという運動が、それまでの原水爆禁止運動とは別に、全国的に展開された。また、７０年代には、原爆展・被爆の記録を贈る運動や１０フィート運動あるいは平和教育などが、国内のみならず国際的なひろがりをもって展開されるようになった。

また、１９８２年以降、国内の自治体総数の半数に相当する自治体が、非核自治体宣言をおこなったが、ほとんどの宣言の動機に、広島・長崎の被爆体験が盛り込まれており、原爆展の開催、広島・長崎の平和式典への市民の派遣といった各自治体独自の被爆体験継承事業が、次第に広がっている。

被爆者の中には、自分が被爆者であることを隠そうとする傾向が少なからずみられた。しかし、１９８０年代に入ると、被爆者の中に大きな変化が起こった。被爆者団体は、原爆展の開催や国連軍縮特別総会への代表派遣など、原爆被害の実相の普及に積極的に取り組んだ。また、原爆手記が被爆者団体により多数出版された。原爆手記の出版点数は、被爆後２０年ほど経過して活発になったが、それでも年間の手記出版点数は数百点であった。ところが、１９８２年以降、千点を数えるようになっている。

このような原爆被害をめぐる戦後の動きの中で、マスコミはどのような対応を示したか。

広島・長崎両被爆地のローカル紙・ローカル局は、１９５０年代後半から毎年７・８月に原爆問題を継続的に取り上げるようになっている。

８月６日の社説を調べてみると、朝日・読売・毎日・日経の各紙が、占領期にすでに原爆問題を取り上げている。１９５５年以降は、この４紙がほぼ毎年、８月６日前後に、広島・長崎に関連した社説を掲げ続けている。こうした傾向は、今日ではローカル紙にも見

ることができる。

１９６０年代後半には、マスコミ全体が原爆キャンペーンをおこなうようになり、その後、毎年８月に向けて各新聞社・放送局が原爆企画をめぐりしのぎを削るという状況が続いている。日本においてこのような形でマスコミに取り上げられる社会問題は、他に存在しない。また、これらは、一般に「原爆報道」と呼ばれているが、このような報道の分野がみられるのは、おそらく日本のみであろう。

日本における「原爆報道」は、日本における原水爆禁止運動が分裂した１９６０年代半ばに成立し、原爆被害実態の解明や被爆体験の継承の機能を積極的に担ってきた。今日では、「原爆報道」は、さまざまな原水爆禁止団体・反核団体の運動、広島・長崎両市を初めとする自治体による平和行政、原爆被害者自身による運動と並んで被爆国日本の内実を構成する４つの要素の１つであると私は考えている。

原爆報道の歴史を振り返ると、一時期、活発に取り上げられながら、急速に姿を消したテーマが存在する。

マスコミは、１９５０年代初めから原爆の後障害に関する問題を取り上げるようになった。取り上げられたのは、当初は、ケロイドなど外科的障害が中心であった。しかし、５０年代半ばには内科的障害に移り、原爆被爆者の個々の死亡が逐一報道されるようになった。私が確認した限りでは、こうした報道は、１９５２年から５４年にかけて１０件であったのが、５５年１年だけで１４件に増え、５６年３５件、５７年４９件、５８年４１件、５９年３５件となっている。

被爆者の死亡報道は、被爆者救援の世論を高める役割を果たす一方で被爆者に大きな不安を与えた。原爆被爆者の死亡記事の出所は、広島では主に日赤広島病院、１９５６年９月に広島原爆病院が開院してからは同院であった。しかし、１９５９年３月、広島原爆病院の運営委員会は、つぎのような理由から入院患者の死亡発表を取りやめることを決定している。

１．被爆者や入院患者への精神的なショックが大きい。

２．原爆医療法による患者の秘密保護の建前から、病院が一方的に発表することは差し控える。

３．入院患者の疾患が医学上、果たして原爆によるものかどうか、決定的なキメ手がない。

この措置の後も、しばらく原爆被爆者の死亡報道が続いたが、次第に姿を消していった。

被爆二世問題も同じような経緯をたどっている。この問題は、１９６０年代後半に取り上げられ初め、１９７２年から７３年にかけて大々的に取り上げられた後、極端な形でマスコミに登場することは無くなっている。

被爆者の多くは、自らや子孫に対する健康の不安を抱えながら戦後を過ごしてきた。被爆者であることを隠すだけでなく、原爆報道に触れることすら避けようとする人々が少なからず存在する。原爆被爆者の死亡と被爆二世に関する報道に共通していることは、原爆被爆者の一部から強い反発を招いたことである。

参考文献

「ふたつのジレンマー原水爆とマスコミ」（『仲間とともにー中野清一教授広島大学御退官記念論集』、１９６５年）

Y.Scott Matsumoto「原爆の被爆者の及ぼした社会的影響」（『原爆傷害調査委員会業績報告書』１２－６９）

Ｒ・Ｊ・リフトン『死の内の生命』（朝日新聞社、１９７１年）

宇吹暁「原爆報道の軌跡」（『広島市公文書館紀要第８号』、１９８５年）

宇吹暁「軍縮と市民運動」（『国際政治第８０号』、１９８５年）

宇吹暁「過去１５年間の原爆報道（新聞）の検討」（『長崎医学会雑誌６５巻原爆特集号』、１９９０年）