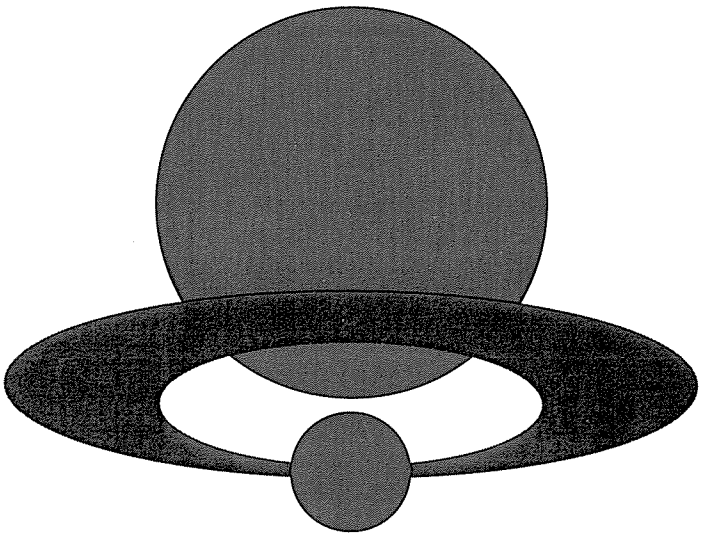
THE 29TH JAIF ANNUAL CONFERENCE

第29回原産年次大会



APRIL 17～19, 1996

JAPAN ATOMIC INDUSTRIAL FORUM

日本原子力産業会議

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第２９回原産年次大会プログラム

基調テーマ：エネルギー・環境・技術－原子力は期待に応えられるのか
平成８年４月１７日(水)～１９日(金)
於　名古屋国際会議場　センチュリーホール

	第１日 4月17日(水)	第２日 4月18日(木)	第３日 4月19日(金)
午前	開会セッション (10:00～12:00) ・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 [講　演]	セッション２ (9:00～12:00) 「拡大するアジアの原子力発電開発計画」 [パネル討論]	セッション４ (9:00～12:00) 「高ﾚﾍﾞﾙ廃棄物-研究開発と合意形成へのｽﾃｯﾌﾟ」 [講　演]
午後	(昼休み)	午　餐　会 (12:15～14:15) 於 名古屋国際会議場 ---------- 原子力映画上映 (13:00～14:00)	(昼休み)
	開会セッション (13:30～15:00) [講　演] ――Coffee Break――	セッション３ (14:30～17:30) 「高速炉の開発とﾘｻｲｸﾙ路線－もんじゅ事故を踏まえて」 [パネル討論] ――Coffee Break――	セッション５ (14:00～17:00) 「核不拡散体制の充実と課題」 [パネル討論] ――Coffee Break――
	セッション１ (15:20～17:30) 「ﾁｪﾙﾉﾌﾞｲﾘ事故から10年－検証と課題」 [講　演]		
	レセプション (18:00～19:30) 於 名古屋観光ホテル	市民との意見交換の会 (18:00～20:00) 於 名古屋国際会議場	

4月17日（水）

開会セッション（10：00～12：00）

議長：太　田　宏　次　　中部電力(株)社長

大会準備委員長挨拶

飯　田　経　夫　　年次大会準備委員長
国際日本文化研究センター教授

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

中　川　秀　直　　原子力委員会委員長　　(依頼中)
国務大臣・科学技術庁長官

＜講　演＞

「フランス原子力発電計画のマイルストーン：１９９６年」

Y．デスカタ　　フランス原子力庁（ＣＥＡ）長官

「核廃絶への努力とその具体策」

R．バットラー　　国連オーストラリア代表大使
核兵器廃絶キャンベラ委員会委員長

＜昼休み（12：00～13：30）＞

開会セッション（13：30～15：00）

議長：永　野　　健　　三菱マテリアル(株)取締役相談役

＜講　演＞

「原子力規制－変化への対応と改善への努力」

S．ジャクソン　　米国原子力規制委員会（ＮＲＣ）委員長

「科学技術と未来社会」

村　上　陽一郎　　国際基督教大学教授

「インドにおける原子力開発計画」

R．チダンバラム　　インド原子力委員会委員長

セッション1（１５：２０～１７：３０）
チェルノブイリ事故から１０年－検証と課題

１９８６年４月のチェルノブイリ原子力発電所４号機の事故は、原子炉から大量の放射性物質をウクライナとその国境を越えた多くの国に拡散させ、人々の環境と生活に影響を与えたが、同時に世界各国における原子力発電に対する信頼をも大きく損ねる結果を招いた。事故以来１０年を経過した現在、放射能の与えた影響を評価するとともに、事故の原因を改めて検証して今後の原子力発電の研究開発に活かすことが重要である。ここでは事故の原因と合わせて、９６年４月８日から欧州委員会（ＥＣ）、世界保健機関（ＷＨＯ）および国際原子力機関（ＩＡＥＡ）の主催でウィーンにて開催される国際会議「チェルノブイリ後の１０年」における討論の結果について報告を受けるとともに、放射能汚染地域における健康影響調査について、科学的な見地から、現時点で何がわかり、何が今後の課題として残っているかについて検証する。

議長：R. カール　　世界原子力発電事業者協会（WANO）議長
＜講　演＞
「チェルノブイリ後の１０年：その影響の総括」
M. ローゼン　　国際原子力機関（IAEA）事務局次長代行（原子力安全担当）
「チェルノブイリ事故の健康影響調査をどう理解するか」
重　松　逸　造　　(財)放射線影響研究所理事長
「チェルノブイリ事故の主原因とＲＢＭＫ炉の安全性」
A. シェーファー　　ドイツ原子炉安全協会科学顧問
＜議長コメント＞
＜参加者との意見交換＞

レセプション（１８：００～１９：３０）
於　名古屋観光ホテル　３階宴会場　「那古の間」

4月18日（木）

セッション2（9：00～12：00）
拡大するアジアの原子力発電開発計画

アジアはめざましい経済発展のさなかにあり、これにともなってエネルギー需要は急速に増大しつつある。同時にアジアにおける人口は今後ますます増加するものと予測され、この面からもエネルギーの安定供給は不可欠の要件となっている。こうした状況下にあって、アジア各国はそれぞれの国情に応じた多様なエネルギー開発をすすめているが、わけても環境負荷の少ない原子力発電に大きな期待と関心を寄せ、その開発計画の拡大あるいは新規導入計画を具体化しつつある。

２１世紀において世界の中心的役割を担うであろうこれらアジア諸国の原子力開発計画は年をおって進展しつつあり、この分野での国際的な協力活動も急速に活発化している。ここでは、アジア諸国における原子力発電開発の現状とその拡大あるいは導入に寄せる意欲と期待を確認するとともに、それらの計画を着実かつ健全に進展させるための相互協力のあり方を探る。

議長：植　松　邦　彦	前経済協力開発機構・原子力機関（OECD・NEA）事務局長
＜パネル討論＞	
パネリスト	
周　淵　泉	中国核工業総公司（ＣＮＮＣ）国際合作局長
アディワルドヨ	インドネシア原子力庁（ＢＡＴＡＮ）原子力エネルギー調査センター長
鷲　見　禎　彦	関西電力(株)副社長
洪　周　甫	韓国電力公社（KEPCO）原子力発電處處長
Ｉ．アーマド	パキスタン原子力委員会（PAEC）委員長

午餐会（12：15～14：15）
於　名古屋国際会議場　４号館　白鳥ホール

通商産業大臣所感

坪　井　一　宇	通商産業政務次官

＜特別講演＞
「登山とハイテク」

今　井　通　子	医師・登山家

原子力映画上映（13：00～14：00）　於　名古屋国際会議場

セッション３（１４：３０～１７：３０）
高速炉の開発とリサイクル路線－もんじゅ事故を踏まえて

わが国は資源を有効利用し、放射性廃棄物の処理処分を適切に行う観点から、使用済み燃料を再処理し、回収されるプルトニウムをリサイクルすることを開発の基本方針とし、その中核として高速炉技術の開発に早くから取り組んできた。原型炉もんじゅは実験炉常陽の成果を踏まえて実用技術を確立する役割を担って建設されたが、昨年１２月のナトリウム漏洩事故によって、原因の究明まで計画が中断される状況となっている。

ここでは、もんじゅの事故を契機として、来世紀初頭における高速炉の商用化への道程としての現在の開発段階を総合的に検証し、あわせてリサイクル路線の課題について意見交換を行う。また、高速炉のような長期にわたる大規模プロジェクトの遂行に当たって、どのように地元や一般社会の人々ならびに多様な分野の学識者の意見や見解を計画に反映させ、円滑な推進をはかるか、についても各国の経験に照らしながら討論を行う。

議長：村　田　　浩　　(社)日本原子力産業会議副会長

＜基調講演＞
「『もんじゅ』２次系ナトリウム漏洩事象と今後のＦＢＲ開発の課題」
近　藤　駿　介　　東京大学教授

＜パネル討論＞
パネリスト
G. スミス　　英国原子燃料会社(BNFL)英国ｸﾞﾙｰﾌﾟ統括本部長
N. エルマコフ　　ロシア原子力省(MINATOM)原子炉総局長
M. ミラー　　米国マサチューセッツ工科大学教授
近　藤　駿　介　　同　前
池　亀　　亮　　東京電力(株)副社長
小　林　圭　二　　京都大学原子炉実験所助手
コメンテーター
須　田　忠　義　　動力炉・核燃料開発事業団副理事長
B. バレ　　フランス原子力庁（ＣＥＡ）原子炉部長
田　村　新　次　　中日新聞社論説室顧問

＜参加者との意見交換＞

市民との意見交換の会－原子力開発利用をめぐって（１８：００～２０：００）
於　名古屋国際会議場　１号館４階　レセプションホール

座長：森　　一　久　　(社)日本原子力産業会議専務理事

○原産年次大会の参加者に加え、新聞等を通じて参加者を募集し、原子力に関する質問や意見を前もって提示してもらう。
○一般から寄せられた原子力に関する意見や質問について総轄的に紹介し、それらの中からいくつかに絞った質問・意見を中心に意見交換を行い、さらに会場からの自由な発言を受け、意見交換を行う。

4月19日（金）

セッション4（9：00～12：00）
高レベル廃棄物－研究開発と合意形成へのステップ

原子力発電は、世界の電力供給や環境保全において重要な役割を果たしつつある。しかし、原子力発電を進めていくにあたって、各国共通の重大な課題となっている高レベル放射性廃棄物あるいは使用済み燃料の処分を安全に実施できることを示すことによって、これに対する国民の理解を一層確実なものとすることができる。このため各国は、その管理や処分に関する研究開発成果や環境影響評価報告書（ＥＩＳ）の公表、その第３者機関による評価、立地選定にいたる意志決定方法の開示など、従来の原子力施設の立地にも増して特段の努力を行うこととしている。ここでは、フランス、スウェーデン、スイス、米国の経験をレビューし、わが国が研究開発の進展と併せてどのようにそれを評価し、国民に公表し、理解を得て、いかに合意を形成していくかについて議論する。

議長：熊　谷　信　昭　　大阪大学名誉教授

＜講　演＞
「フランスにおける高レベル廃棄物処分の地元合意形成」
M. アレーグル　　フランス放射性廃棄物管理機構理事長
「有効なパブリックコンセンサスの構築と維持：米国における高レベル廃棄物管理の進展のための必要条件」
S. ウィルトシャー　　米国JKリサーチ・アソシエーツ社副社長
「スイスの高レベル廃棄物貯蔵の実施に向けての戦略」
H. イスラー　　スイス放射性廃棄物管理共同組合（NAGRA）理事長
「スウェーデンの深地中処分実施のための計画」
C. テーゲルストローム　　スウェーデン核燃料廃棄物管理会社(SKB)
深地中処分場開発部長
「高レベル廃棄物処分への取り組み－諸外国の経験と日本の計画」
鈴　木　篤　之　　東京大学教授
＜コメント＞
土　田　　浩　　青森県六ヶ所村村長

＜参加者との意見交換＞

セッション5（１４：００～１７：００）
核不拡散体制の充実と課題

昨年５月に決定された核不拡散条約（ＮＰＴ）の無期限延長は、無条件に合意されたものではなく、むしろ、核兵器保有国と非保有国の立場の相違を鮮明にした。核保有国に核の独占的地位を許したＮＰＴは２５年を経た今日、冷戦終結後の流動的な国際社会において、新たな挑戦に直面している。条約の第６項に規定された核保有国による核廃絶にむけた努力は、今後一層、国際社会の監視下におかれるであろうし、核実験禁止条約の１９９６年中の締結、軍事用核物質生産禁止（カットオフ）条約にむけた早期交渉も、非保有国の合意を得るには不可欠である。南アフリカ共和国に見られるような核不拡散体制における前向きな動きがある一方、プルトニウム利用に関しては核拡散の潜在的可能性が議論される等、核不拡散体制をめぐる情勢は予断を許さない。このセッションでは、プルトニウム平和利用の正当性の探求と核不拡散体制を強化するための今後の課題を中心に議論する。

議長：Ｄ．ロッシン　　元米国原子力学会（ＡＮＳ）会長

＜基調講演＞
「プルトニウムと核拡散」
Ｒ．ガーウィン　　全米科学アカデミーメンバー
ＩＢＭ名誉研究員（米国）

＜パネル討論＞
パネリスト
Ｒ．バットラー　　国連オーストラリア代表大使
核兵器廃絶キャンベラ委員会委員長
Ｒ．ガーウィン　　同　前
今　井　隆　吉　　杏林大学教授
Ｊ．メルカド　　メキシコ外務省国連政策局長
朱　明　権　　復旦大学教授（中国）

大会関連ツアー（４月２０日(土)）
１．テクニカルツアーＡ：浜岡原子力発電所（中部電力）
２．テクニカルツアーＢ：東濃地科学センター（動力炉・核燃料開発事業団）
３．テクニカルツアーＣ：高速増殖原型炉「もんじゅ」（動力炉・核燃料開発事業団）

THE 29TH JAIF ANNUAL CONFERENCE

April 17 - 19, 1996
Century Hall, Nagoya Congress Center

Basic Theme:
"Energy•Environment•Technology—What Can Nuclear Energy Do?"

WEDNESDAY, APRIL 17
***REGISTRATION 9:00-**
at Century Hall, Nagoya Congress Center

***OPENING SESSION 10:00-12:00**

Chairman:
Hiroji Ota President
Chubu Electric Power Co., Inc.

Remarks by Chairman of Program Committee
Tsuneo Iida Chairman of Program Committee;
Professor of Economics
International Research Center for Japanese Studies

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

Remarks by Chairman of Atomic Energy Commission
Hidenao Nakagawa Minister of State for Science and Technology;
Chairman of Atomic Energy Commission

Lectures
"1996: A Milestone in the French Nuclear Program"
Yannick d'Escatha Administrator General
Commissariat à l'Energie Atomique
France

"The Process for Nuclear Elimination and Concrete Measures"
Richard Butler Ambassador to the United Nations
Australia

< Break >

13:30-15:00

Chairman:
Takeshi Nagano Director & Counselor
Mitsubishi Materials Corp.

Lectures
"Nuclear Regulation: The Challenges of Change"
Shirley Jackson Chairman
U.S. Nuclear Regulatory Commission
U.S.A.

"Science and Technology toward the Future"
Yoichiro Murakami Professor
International Christian University

"The Indian Nuclear Programme"
R. Chidambaram Chairman
Atomic Energy Commission
India

***SESSION 1 15:20-17:30**
"Ten Years after Chernobyl--Its Consequences and Tasks"

The accident at Chernobyl Nuclear Power Plant Unit 4 in April 1986 released a huge quantity of radioactive materials across Ukraine and neighboring countries. Not only did the accident affect the human environment, but it also detracted from the credibility of nuclear power around the world. Now, one decade since the accident, in this session it is important to assess the health effects of the consequences of Chernobyl, and study the causes of the accident to ensure that further encouragement is given to R&D on nuclear power and safety.

The session will also feature a report of the results of "One Decade After the Chernobyl: Summing Up the Consequence of the Accident," an international meeting scheduled from April 8, 1996, sponsored by the European Union, the World Health Organization and the International Atomic Energy Agency. Also, a radiological study on health effects in the contaminated areas will be discussed from a scientific point of view to verify what has so far become known and what remains to be solved in the future.

Chairman:
Rémy Carle Chairman of the Governing Board
World Association of Nuclear Operators

Lectures
"One Decade after Chernobyl: Summing Up the Consequences"
Morris Rosen Acting Deputy Director General
International Atomic Energy Agency

"How Chernobyl Accident Health Effect Research Should Be Understood"
Itsuzo Shigematsu Chairman
Radiation Effects Research Foundation of Hiroshima and Nagasaki

"The Chernobyl Accident--Main Causes and the Safety of RBMK Plants"
Anselm Schaefer Scientific Advisor to President
Gesellschaft für Anlagen und Reaktorsicherheit
Germany

Discussion with the audience

***JAIF Chairman's Reception 18:00-19:30**
at Banquet Hall "Nako," 3rd floor, Nagoya Kanko Hotel

THURSDAY, APRIL 18

***SESSION 2 9:00-12:00**
"Expanding Nuclear Power Programs in Asia"

Asia is undergoing remarkable economic development, causing a significant surge in its demand for energy. The population of Asia is expected to continue increasing, also underscoring the urgent need for securing a stable supply of energy. At present, each Asian nation is developing a diverse range of energy sources in coordination with its industrial conditions. In particular, nuclear power with a less burden on the environment, serves the interests of Asia. Countries already with nuclear power plants in operation are making vigorous programs for its further development, and those without plants considering to introduce it.

Asian nations are expected to play a leading role in socio-economic development in the next century. Particular in recent years, nuclear power development programs in Asia are expanding, with extensive international cooperation.

This session will confirm their aspirations and expectations for nuclear power in Asia, illustrating their programs for its further promotion and introduction. It will also explore possibilities for cooperation to help enable the programs of the Asian countries to make sound and steady progress.

Chairman:

Kunihiko Uematsu	Technical Advisor Power Reactor and Nuclear Fuel Development Corp.; Ex-Secretary General Nuclear Energy Agency, OECD

Panel discussion

Yuanquan Zhou	Director General Bureau of International Cooperation China National Nuclear Corp.
Adiwardojo	Director Nuclear Energy Research Center National Atomic Energy Agency Indonesia
Yoshihiko Sumi	Director & Executive Vice President Kansai Electric Power Co., Inc.
Joo-Bo Hong	General Manager Nuclear Power Generation Dept. Korea Electric Power Corp.

Ishfaq Ahmad — Chairman
Atomic Energy Commission
Pakistan

Discussion with the audience

***LUNCHEON 12:15-14:15**
at Shirotori Hall, 1st Floor, Bldg. 4, Nagoya Congress Center

Remarks by Parliamentary Vice-Minister of International Trade and Industry
Kazutaka Tsuboi — Vice Minister of International Trade and Industry

Special lecture
"Advanced Technology for Mountain Climbing"
Michiko Imai — Doctor; Mountain Climber

***FILMS 13:00-14:00**
at Century Hall, Nagoya Congress Center

Latest films on Japan's nuclear research & development activities will be presented to those who will not be attending the Luncheon.

***SESSION 3 14:30-17:30**
"FBR Development and Fuel Cycle Policy--Reflections on the Monju Accident"

Japan's basic policy of nuclear fuel recycling--reprocessing spent fuel and recycling recovered plutonium--has been formulated to ensure the efficient use of resources and the appropriate management and disposal of radioactive wastes. The policy is dependent on the further development of fast reactor technology. The prototype reactor Monju has been constructed based on the experiences at the experimental reactor "Joyo" for establishing a commercial technology.

However, a sodium leak in "Monju" last December has brought the project to a halt until the cause of the accident is identified. The lesson of the "Monju" accident will give this session an occasion to verify what has so far been achieved in the technology as a step toward the commercialization of FBR early in the 21st century, and discuss tasks for pursuing the recycling policy.

Also in this session, discussions will be held about how to pursue such a large-scaled project while reflecting the views and opinions of local people, the public and experts from various sectors of science, which is thought to be necessary to smooth the way for carrying out the plan over a long time-frame.

Chairman:

Hiroshi Murata	Vice Chairman Japan Atomic Industrial Forum

Keynote

"How to Continue the R&D of FBR Overcoming the Aftereffects of the Secondary Sodium Leakage Incident at Monju"

Shunsuke Kondo	Professor University of Tokyo

Panel discussion

Grahame Smith	Director of UK Group; Head of Sellafield Site British Nuclear Fuel plc
Nikolai Ermakov	Head Chief Administration for Development of Nuclear Reactors & Special Nuclear Plants Russian Ministry of Atomic Energy
Marvin Miller	Senior Research Scientist Dept. of Nuclear Engineering Massachusetts Institute of Technology U.S.A.
Shunsuke Kondo	As above
Ryo Ikegame	Executive Vice President Tokyo Electric Power Co., Inc.
Keiji Kobayashi	Instructor Research Reactor Institute Kyoto University

Commentators

Bertrand Barré	Director Nuclear Reactor Division Commissariat à l'Energie Atomique France
Tadayoshi Suda	Executive Vice President Power Reactor and Nuclear Fuel Development Corp.
Shinji Tamura	Senior Editorial Writer The Chunichi Shimbun

Discussion with the audience

***DIALOGUE WITH THE PUBLIC 18:00-20:00**
on Nuclear Energy Development and Utlization
at Reception Hall, 4th floor, Bldg. 1, Nagoya Congress Center

Moderator:
Kazuhisa Mori Executive Managing Director
Japan Atomic Industrial Forum

Besides the conference participants, the public will be invited through mass media to attend this session.

During the session, an overview will be given of all questions and opinions received from the public on energy and nuclear power. Competent nuclear experts will be on hand to give brief responses to some of the more important questions. Individual questions will also be invited from the floor, with an exchange of opinions to follow.

FRIDAY, APRIL 19

***SESSION 4 9:00-12:00**
"High-Level Waste Management--Promoting R&D and Consensus Building"

Nuclear power plays an important role in the supply of electricity and in environmental protection. However, management of high-level radioactive wastes (HLW) including its disposal is a critical task confronting all countries trying to promote nuclear power. Further assurances of public understanding will be secured if people learn about the safety of waste disposal. In that respect, such countries are prepared to make public the results of research on waste management and disposal, and to issue environmental impact statements (EISs). They also allow third parties to make and publicize their assessments, and to open the decision-making process of siting the facilities. Countries are now working much harder in this direction than they did when their existing nuclear installations were built.

In this session, experiences in France, Sweden, Switzerland, and the U.S. will be reviewed, with a discussion of how they should be evaluated and publicized. The achievements of Japanese R&D will also be explained. These efforts aim eventually to promote understanding and build a broader consensus among the public.

Chairman:
Nobuaki Kumagai Professor Emeritus
Osaka University

Lectures
"Nuclear Waste Management in France: The Dialogue Resumed"
Maurice Allègre Chairman
National Agency for Radioactive Wastes Management
France

"Building and Maintaining a Working Public Consensus: A Necessary Condition for Sustainable Progress in High-Level Waste Management in the United States"
Susan Wiltshire — Vice President, JK Research Associates, Inc., U.S.A.

"A Phased Strategy towards Implementation of a Swiss High Level Waste Repository"
Hans Issler — President, National Cooperative for the Disposal of Radioactive Waste, Switzerland

"The Swedish Programme for Implementation of Deep Geological Disposal"
Claes Thegerström — Director, Deep Repository Division, Swedish Nuclear Fuel & Waste Management Company, Sweden

"Strategies for Geological Disposal of High-level Radioactive Wastes--Overseas Experiences and Japan's Programme"
Atsuyuki Suzuki — Professor, University of Tokyo

Comment
Hiroshi Tsuchida — Mayor of Rokkasho-mura, Aomori Prefecture

Discussion with the audience

< Break >

***SESSION 5 14:00-17:00**
"Nuclear Non-proliferation and Plutonium"

Last May's decision to extend the Nuclear Non-Proliferation Treaty (NPT) indefinitely was not reached unconditionally, highlighting the gap between those interests of nuclear and non-nuclear member states. After 25 years of the nuclear monopoly by five nuclear states, the NPT is now faced with challenges in the dynamic post-Cold War world. The requirements are heightened of the international society to limit nuclear weapons with efforts by nuclear parties with respect to the article 6 of the treaty.

The Comprehensive Nuclear Test Ban Treaty (CTBT) should meet a conclusion by the end of 1996 and negotiations for the cut-off production of fissile materials must start at an early date. While, in support of the NPT regime, some positive moves have been made as demonstrated by South Africa's renouncement of nuclear weapons program, there are arguments in some corners about the

potential of the plutonium use as this could generate the proliferation of nuclear weapons. It is of crucial importance to deal with those for the future NPT regime.

This session aims to provide a rationale for the peaceful uses of plutonium and discuss the measures to reinforce the nuclear non-proliferation regime.

Chairman:

David Rossin	Former President American Nuclear Society

Keynote

"Plutonium and Proliferation: A 1996 Personal View"

Richard Garwin	Member of National Academy of Science; IBM Fellow Emeritus U.S.A.

Panel discussion

Richard Butler	Ambassador to the United Nations Australia
Richard Garwin	As above
Ryukichi Imai	Senior Advisor Japan Atomic Industrial Forum, Inc.; Professor Kyorin Unisversity
Joaquin Mercado	Director General for the United Nations Affairs Ministry of Foreign Affairs Mexico
Mingquan Zhu	Professor Center for American Studies Fudan University China

Discussion with the audience

大会準備委員長挨拶

年次大会準備委員長
飯 田 経 夫

ご臨席の皆様、第２９回原産年次大会の開催にあたり、大会準備委員会を代表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。日本国内のみならず、国際機関および世界各国から多くの権威者の方々のご参加を得て、本年次大会をこの、わが国の産業・技術の中枢として発展しつつある名古屋の地で開催する運びとなりましたことを、この上なく光栄に存じます。

私たち人類が、生存し、文化的生活を享受していくためには、エネルギーが不可欠であることは申し上げるまでもありません。しかし現実には、エネルギー供給の約９割を占めている化石エネルギーは、その資源量に限りがあると同時に、二酸化炭素や、硫黄酸化物、窒素酸化物を発生する、すなわち、地球環境への影響という観点から、大きな課題を抱えています。また、太陽光や風力などの新エネルギーは、長期的な観点から研究開発を進めていくことは重要でありますが、経済的、技術的に多くの課題が残されており、近い将来に大規模なエネルギー源としての役割を期待することは困難な状況にあります。

このような中で、技術エネルギーである原子力については、エネルギーの安定供給や地球環境保全の見地から、将来のエネルギー供給において主要な役割を果たしていくことが期待されていますが、その一方で、昨年１２月に起きたもんじゅ事故を契機に、原子力発電の安全性に対する国民の不安は以前にも増して高まるとともに、放射性廃棄物の安全な管理など、これから解決されなければならない課題も残されています。

今大会は、このような状況を踏まえ、原子力がこれらの問題解決にどのように役立つのか、その道を探りたいという意味で、基調テーマを「エネルギー・環境・技術－原子力は期待に応えられるのか」としました。本大会では、この開会セッションに続き、３日間にわたる５つのセッションと「市民との意見交換の会」のもとに、発生以来１０年を経過したチェルノブイリ事故やもんじゅ事故の問題にも焦点をあて、議論を行うことにしています。

この開会セッションでは、フランス、オーストラリア、米国、インド、そして日本の代表から、各国の原子力開発計画、原子力規制の改善や核廃絶への努力、さらには未来における科学技術と社会との関係などについてのご見解を伺います。

本日午後のセッション１「チェルノブイリ事故から１０年－検証と課題」では、国際原子力機関、ドイツ、日本の各代表が参加して講演を行います。チェルノブイリ事故が起きてから、この４月で満１０年になります。当時のソ連政府が最初に行った事故の調査では、

その原因は運転員の規則違反など人的要因であるとされましたが、その後の調査で次第にソ連特有の原子炉の設計やメカニズムに安全上の欠陥があることが判ってきました。一方、事故による人々の健康影響は１０年を経て次第にデータが蓄積されてはきましたが、その科学的評価・分析はまだ十分ではないようです。このセッションでは、先週ウィーンで開催されたチェルノブイリ国際会議をはじめ、専門家による評価会議などの結果について報告を受け、健康影響についてこれまでに何が判り、何が今後の課題として残っているかについての講演を行い、また事故の原因についても最近の調査結果を明らかにします。

２日目のセッション２「拡大するアジアの原子力発電開発計画」では、中国、インドネシア、韓国、パキスタン、そして日本の各代表が参加してパネル討論を行います。アジアはめざましい経済発展のさなかにありますが、これにともなってエネルギー需要は急速に増大しています。このため、アジアの各国はそれぞれの国情によって、多様なエネルギー開発をすすめていますが、環境に与える影響の少ない原子力発電に対して大きな期待が寄せられています。このセッションでは、各国の原子力発電開発状況と課題について発表があり、アジア地域の協力の促進などについて意見交換が行われます。

同日の午後のセッション３「高速炉の開発とリサイクル路線－もんじゅ事故を踏まえて」では、英国、ロシア、米国、フランス、そして日本の各代表者が参加してパネル討論を行います。私たちがこの年次大会のプログラムの構成をほぼ固めようとしていた頃、もんじゅの事故が起き、次第に社会的な関心をよぶようになってきたので、急遽この問題を取り上げることにしました。原子力開発の関係者は、高速増殖炉の実用化技術を確立しようとする第一歩での失敗やそれに対する社会的反響を、適切に評価して今後の計画に生かして行くべきだと考えます。したがって、このセッションでは、もんじゅ事故をも踏まえながら、今後の高速炉開発とリサイクル路線について、批判的な意見をもまじえて討論を行います。

３日目のセッション４「高レベル廃棄物－研究開発と合意形成へのステップ」では、フランス、米国、スイス、スウェーデン、そして日本の各代表が参加して講演を行います。原子力開発を進めていく上で、使用済燃料や高レベル放射性廃棄物の管理、処分といった将来の課題が残されています。わが国では２０４０年代半ば頃に処分場の操業を開始することが目標とのことですが、この目標にむけてどの様な研究を推進し、どの様な体制をつくっていくのか、またこうした活動の状況を公表することなどを通じて、その安全性を国民に理解してもらうかが重要です。このセッションでは、各国における使用済燃料管理などの計画の進展状況、直面している問題、また、国民理解のあり方などについて講演が行われます。

３日目の午後の大会最後のセッション５「核不拡散体制の充実と課題」では米国、オーストラリア、メキシコ、中国、そして日本の各代表が参加してパネル討論を行います。

ご高承の通り原子力の平和利用は当初から軍事利用の影を背負ってきたわけですが、核兵器があること自体が、原子力の平和利用に対する一般の理解を妨げてきましたし、平和利用を通じて、多くの国が核兵器を持つことになるのではないかという誤解が、国際協力を著しく阻害してきたと思います。昨年５月に国際不拡散体制の中心となっているＮＰＴ条約が無期限延長になりましたが、いまなお解体される核兵器から回収される核物質の管理など多くの問題が残っています。このためこのセッションでは、プルトニウム平和利用の正当性の探求と核不拡散体制を強化するための今後の課題などについて討論が行われます。

なお、この大会を機会に、内外の原子力開発関係者と市民との意見交換の会を、４月１８日（木）の夕方６時からこの４階のレセプションホールで開くことにしています。

また、この大会をできるだけ開かれたものにするため、一般の方々にも参加をよびかけ、年次大会そのものにも参加していただいていますので、活発な有意義な討論が行われることを期待しています。

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、今大会が実り多い大会として終わりますように心から念願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 Chairman of the Program Committee of the 29th JAIF Annual Conference

Tsuneo Iida
Professor of International Research Center
for Japanese Studies

Ladies and gentlemen, it is my great pleasure to be given an opportunity to speak on behalf of the Program Committee, in opening the 29th JAIF Annual Conference. I consider it quite an honor that this Annual Conference is held in this city, Nagoya, which is growing as a center of Japanese industry and technology, and with many authorities participating in the Conference, not only from Japan, but also from abroad as well as international organizations.

It is obvious that energy is indispensable for mankind to live and enjoy a civilized life. In reality, however, fossil energy resources, which account for about 90% of our energy supply, have limited reserves, and these fossil resources pose a serious problem from the viewpoint of effects on the global environment, because they produce carbon dioxide (CO_2), sulphur oxides (SOx), and nitrogen oxides. As for renewable energy sources, such as solar power and wind power, it is important to pursue research and development of them from a long-range view. However, it is rather difficult to expect them to be a major energy source in the near future, because there are still many economic and technical problems left to be resolved.

Under such a situation, nuclear power, which is technology-oriented energy, is expected to play an important role in the future energy supply from the viewpoint of a stable energy supply and the conservation of the world environment. On the other hand, in the wake of the accident at Monju last December, there are growing anxieties among the people over the safety of nuclear power generation. Also, we are faced with other challenges to be solved, such as the safe management of radioactive waste.

After consideration of such circumstances, we have chosen the basic theme of the Conference, "Energy•Environment•Technology --What Can Nuclear Energy Do?" in the hope of finding out how nuclear power will help solve these problems. Following this opening session, the Conference will have five sessions lasting for three days and a "Dialogue with the Public," in which discussions will be held, focusing on the accident at Chernobyl which occurred ten years ago as well as the last year's accident at Monju.

During this opening session, the representatives of France, Australia, the United States, India, and Japan will speak about their countries' nuclear development programs, the efforts to improve nuclear regulations and eliminate nuclear weapons, and the relations between science/technology and society in the future.

Session 1 this afternoon, "Ten Years after Chernobyl--Its

Consequences and Tasks," will be attended by the representatives of the International Atomic Energy Agency (IAEA), Germany, and Japan, who will each make a presentation. Ten full years will have passed in this April since the accident at Chernobyl occurred. The initial study of the accident made by the then Soviet Government concluded that the accident had been caused by human factors, such as the operators' violation of rules. However, subsequent studies have gradually revealed the safety defects in the design and mechanism of Soviet reactors. Meanwhile, the data on human health effects of the accident has been collected for the past decade, but the data does not seem to have been fully assessed or scientifically analyzed. This session will also feature reports on the results of the assessment meetings attended by experts, including the international meeting on Chernobyl held in Vienna last week. The experts will speak on what is known about the health effects and what should be done in the future, and also present the recent findings on the accident's causes.

Session 2 of the second day, "Expanding Nuclear Power Programs in Asia," will have a panel discussion attended by the representatives of China, Indonesia, the Republic of Korea, Pakistan, and Japan. Asian nations are now in the midst of remarkable economic growth, with the demand for energy rapidly increasing. For this reason, each nation is developing diversified energy sources according to their own national requirements, and nuclear power generation is highly regarded as a promising energy source because it has fewer adverse effects on the environment. In this session, each nation will state the present status of their nuclear development and any problems they face. Opinions will also be exchanged in this session on how to promote cooperation in the Asian Region.

Session 3 to be held in the afternoon of the second day, "FBR Development and Fuel Cycle Policy--Reflections on the Monju Accident," will have a panel discussion, with the representatives of the United Kingdom, Russia, the United States, France and Japan taking part in the discussion. When we were about to finalize the program structure of this annual Conference, the accident occurred at Monju, which gradually drew social attention. Therefore, we immediately decided to deal with this issue. I think that the persons related to nuclear development should accurately assess the failure as the first step to establish FBR technology and its social reaction, so that such an assessment can be utilized in a future plan. For this reason, we will discuss in this session the future FBR development and fuel cycle policy, sometimes exchanging critical opinions, in consideration of the Monju accident.

Session 4 on the third day, "High-Level Waste Management--Promoting R&D and Consensus Building," will be attended by the representatives of France, the United States, Switzerland, Sweden, and Japan, who will each make a presentation. In pursuing nuclear development, there are problems yet to be resolved, including the management and disposal of spent fuel and high level radioactive waste. I understand that Japan aims at

starting the operation of a repository by the middle of the year 2040. In doing so, it is important to make the people understand what kind of research will be promoted to achieve this goal and what kind of system will be built. It is also essential to convince the people of the safety by communicating the present state of such activities. In this session, the participants will speak on how each country is developing plans to manage spent fuel, what problems they are facing, and how well the people understand the problem.

Session 5, "Nuclear Non-Proliferation and Plutonium," is the last session of this Conference, and will be held in the afternoon of the third day. This session will have a panel discussion featuring the participation of the representatives of the United States, Australia, Mexico, China, and Japan.

As you know, peaceful uses of nuclear energy have been haunted by the shadow of its military use from the very beginning. In my opinion, nuclear weapons' very existence has prevented the public from understanding the peaceful uses of nuclear energy, and the misunderstanding that peaceful uses may lead to proliferation of nuclear weapons has greatly obstructed international cooperation. In May last year, the Non-Proliferation Treaty of Nuclear Weapons (NPT), which is the center of international non-proliferation framework, was extended indefinitely, but many problems are still left to be resolved, including the management of nuclear material recovered from dismantled nuclear weapons. So, in this session, we will discuss the future tasks to ascertain the peaceful uses of plutonium and enhance the nuclear non-proliferation regime.

Taking the opportunity of this annual Conference, we are going to open a "Dialogue" between the citizens and the persons related to nuclear development both in Japan and abroad, in this Reception Hall on the 4th Floor at 6 P.M. April 18 (Thursday).

Furthermore, to make this annual Conference as open as possible, we are asking the general public to participate in the Dialogue, as well as in the Conference sessions. I hope we will have lively and meaningful discussions there.

Lastly, I would like to express my heartfelt thanks to the session chairmen and the participants who willingly accepted to be speakers at the Conference. I also would like to express my appreciate to everyone who will take part in this Conference from Japan and abroad. I sincerely hope that this Conference will be an especially meaningful and fruitful one.

Thank you very much for your attention.

第二十九回原産年次大会会長所信表明

平成八年四月十七日
(社)日本原子力産業会議
会長　向坊　隆

議長、ご臨席の皆様、日本原子力産業会議の向坊でございます。

第二十九回原産年次大会の開催にあたり、主催者を代表して、一言所信を述べさせていただきます。

まず、国の内外から多数の方々がこの大会にご参加くださいましたことに、厚く御礼もうしあげます。

さて、昨年のこの大会の冒頭におきまして、私はつぎのような趣旨のことを申し上げました。

「現在、人類は民族紛争、地球環境の汚染、食料の不足と人口の増加といった沢山の問題に直面しており、残念ながら私たちはこれらの問題を抱えたまま来世紀の門をくぐらなければならないわけであります。したがって、専門家やリーダーたちは将来や世界に対する深い洞察力をもって、情報を交換しあいながら、互いに協力し、問題の解決に努力しなくてはならない。とりわけ、エネルギーの供給は二十一世紀における人類の繁栄と安定の鍵となるものであるのに、エネルギー資源に乏しいわが国ではエネルギー源として原子力に頼るほかなく、私たち原子力関係者の責任は特に重い。」と言いました。

今日の人類の繁栄を支えてきたものの一つがエネルギーであったことは論をまたないところであります。今世紀に入ってからエネルギーの利用は飛躍的に増加し、この所有や分配をめぐって戦争や多くの紛争さえ起こりました。私たちはいま、石油、天然ガス、原子力と比較的豊富な資源に恵まれているといえます。しかし、エネルギー資源は無尽蔵ではありませんし、需要量は増加する一方であります。今や世界の経済成長のセンターとなったアジア諸国の今後の発展をみますと、豊富なエネルギーの供給が、この地域のみならず、世界全体の来世紀における安定にとっても、特に重要であることを痛感いたします。

一方、近年における在来の化石エネルギーの大きな利用量が、地球の持つ環境の自浄能力を越えてしまったことも事実であります。各国、とりわけ先進工業国はエネルギーの利用にともなう環境汚染の防止に積極的に取り組むとともに、環境に与える影響の少ないエネルギーへと、供給の構造を変えていく努力をしなくてはなりません。

原子力は多くの国においてすでに、主要電源としての役割を果たしておりますが、来世紀における世界的なエネルギー需要の増加を考えますと、炭酸ガスを放出しない原子力発電に対し、さらに重要な位置づけが行われるべきだと思われます。環境汚染

を理由として途上国の発展を押さえることはできませんが、私たちは、「原子力がクリーンで、しかも資源制約から説き放たれたエネルギーの供給を約束するものである。」という開発当初の目標をもう一度胸に刻む必要があります。私たち日本人にとって、隣人であるアジアの各国が、今原子力発電の利用に向けて大きく前進しようとしている現在、この目標を再び掲げ、これまで培ってきた技術を活用し、国際協力によってこれを成し遂げていくことが特に重要であります。

しかしながら、原子力がクリーンなエネルギーであるという事実が一般の方々になかなか受け入れられないということに対し、私たちは十分な反省をしなければなりません。十年前に起きたチェルノブイリ事故は各国、とりわけヨーロッパ諸国の原子力開発に大きなブレーキをかけることになりましたが、私たちはこの影響からまだ十分脱したわけではありません。事故が起きた当初ならびにその後もときどき、事故による被害がマスコミによってとりあげられてきましたが、この十年間の調査によって事故の原因に関するさまざまな事実が判明してきました。しかしそのことはまだ一般的に良く知られている、と言うことはできません。原子力開発関係者は事故原因に関する客観的な事実にもとづいて、このような事故が再び起こることはないということを訴えていくべきでありましょう。また、事故による住民の健康影響についてもだいぶ事実が明らかになってきましたが、こと人体にかかわる問題は解明まで沢山の調査の積み重ねが重要であります。今ここで大切なことは、明らかになった大部分の事実と今後さらに科学のメスがいれられるべき残りの核となる部分とを分けて、客観的に伝えていくことであります。

原子力と環境ということを考えますと、高レベル放射性廃棄物の処分の実施は残された課題であります。この問題に関する研究開発については過去長い間の実績があり、高レベル放射性廃棄物を安全に処分できるという知見も得られておりますが、地層処分の立地について一般の理解を得ることは、いずれの国においても困難な情勢にあります。わが国においては二〇四〇年頃に処分施設の操業を開始することを目標にして開発が進められておりますが、できるだけ早く研究開発の成果を得て、わが国において高レベル放射性廃棄物の処分を安全に実施できる見通しを国民の前に明らかにするべきであります。こうすることによって、真に原子力が環境に大きな負担をかけないエネルギーであることを示すことができるわけであります。

さて、皆様ご存知の通り昨年十二月にもんじゅの二次系でナトリウム漏洩が起きました。もんじゅは高速増殖炉の実用化の見通しを得るための、重要な開発ステップと位置づけられており、大きな期待がもたれておりました。それだけに性能試験中のつまずきは私たちにとりましても、衝撃でありました。この事故においては幸いにして放射能汚染は全く無く、人的被害もありませんでした。しかし、この事件によって私たちはまたもや、一般の方々と私たちの間に原子力に対する大きな認識のギャップがあることを思い知らされました。当事者の動燃事業団のみならず、私たちもまた、こ

の事故を真摯に受けとめ、教訓としなければなりません。とくに、情報の公開については特段の努力が必要でありますし、この事故を今後の高速炉開発に活かしていかなくてはなりません。

高速増殖炉の商用化こそ、冒頭で私が申し上げた「資源制約から説き放たれたエネルギーの供給」の目標を具現するものでありますが、このＦＢＲの開発を含めて原子力はまさに今その潜在的能力を発揮できるのかを問われているわけであります。今後官民が協力し、さらに研究開発にとりくんで信頼性の高い技術を完成させることが何よりも大切ですが、同時にこのような技術を活用するための制度を整えたり、さらには国民一般の方々から信頼を得られるようにすることが特に重要になってきております。

技術には多くの場合、商業機密とされている部分があります。しかし、一般の方々からの信頼を得られるためには、秘密とすべき部分を出来るだけ少なくし、安全を守るために、また、事故をなくするために周知を集めて努力することが大切であります。そのために、メーカーなり、政府なり、然るべき機関でその方策が示されることと思いますが、原子力という次代のエネルギーを担う重い責任に鑑みて、原子力関係者自ら、公開のガイドラインを作成し、その案について学識者等の意見を考慮した上で、決定し、自らを律すべき時期にきているのではないでしょうか。国民的組織である原産として、その母体となるもやぶさかではないと考えます。

このような認識にたって、本大会を、わが国の産業・技術の中枢として発展しつつある名古屋で開催することとし、準備委員長に日本経済を国際的視野からとらえ、現代社会の特性についても優れた分析をされている国際日本文化研究センターの教授で、当地ご出身の飯田経夫先生にお願いしました。また、委員には原子力開発関係者のみならず、他の分野の専門家やジャーナリストにも参加していただき、広い観点からご検討していただくことにしました。本大会のテーマなど熱心にご検討いただきました委員の方々に対し、この場をかりまして感謝の意を表したいとおもいます、また、最後にになりましたが、ご参集頂きました海外、国内の発表者の方々、会場の皆様に心からお礼申し上げ、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。

JAIF Chairman's Address
for the 29th JAIF Annual Conference

Takashi Mukaibo
Chairman
Japan Atomic Industrial Forum

Ladies and gentlemen, welcome to the 29th annual conference of the Japan Atomic Industrial Forum (JAIF). My name is Takashi Mukaibo, chairman of JAIF. We are heartily grateful for the participation of so many people from Japan and around the world. Speaking on behalf of my organization, I would like to make several comments before you today.

At my opening speech at last year's conference, I said that mankind faced a litany of problems -- including ethnic conflicts, environmental pollution, food shortages, and the population explosion -- and that we would unfortunately carry those problems over to the 21st century. I thus exhorted experts and leaders to apply their insight to the global problems of the future, exchanging information and cooperating with each other in those problems' solution. I especially emphasized the responsibility of nuclear power interests in ensuring an energy supply for the 21st century, as it could serve as the key to human prosperity and stability. I added that nuclear power was indispensable for a country like Japan that lacks natural energy resources.

It goes without saying that energy has been one of the main pillars supporting mankind's prosperity today. The utilization of energy has expanded exponentially since the beginning of this century, and many wars and conflicts have even been started fighting over the possession and allocation of energy resources. We are currently blessed by a relatively abundant range of resources, mainly petroleum, natural gas, and nuclear energy. However, not only those resources finite in nature, but energy demand is growing day in and day out. Considering the future development of Asia, now the world's center of economic growth, one painfully realizes the importance that an abundant energy supply will have for the stability of both this region and that of the whole world in the coming century.

Another fact that I would like to point out is the way that the extensive use of fossil energy to date has exceeded the earth's natural ability to cleanse the environment. Every nation on earth, and particularly the advanced industrialized countries, has the duty to carry out active measures to prevent environmental pollution stemming from energy usage, as well as to transform the supply structure to deliver forms of energy that are easier on the environment.

Nuclear energy is already playing a major role in many countries as a source of energy. In view of the increasing demand for energy well into the 21st century, the importance of nuclear-generated energy is expected to grow even further, given that it does not create CO_2 emissions. As we cannot use pollution as an argument to stifle the growth of countries still

in the process of economic development, we need to remind ourselves of the reasons for developing nuclear energy in the first place: "Nuclear energy promises to be a clean source of energy free from the restrictions of limited natural resources." At present, when our Asian neighbors are boldly marching toward the use of nuclear-generated electricity, it is especially important for us Japanese to proclaim that goal again, using the technological knowledge accumulated so far to ensure its fulfillment through international cooperation.

Nevertheless, the public consensus has failed to accept the fact that nuclear power is a clean form of energy, and we must fully take the blame for that misconception. The accident at Chernobyl a decade ago has brought the nuclear efforts of many countries to a halt, particularly in Europe, and we are far from being free from the accident's aftermath. The damage resulting from Chernobyl -- ever since the time of accident down to the present -- has been occasionally reported by the mass media, and many facts have come to light about the causes of the accident. We still cannot state, however, that the public knows about this. Nuclear power interests must continue to appeal their case that such an accident will never happen again, based on the objective assessment of the causes of Chernobyl. Moreover, while much light has been shed on the impact of the accident on the health of the local residents, there is still investigatory work that must be carried out before an understanding can be reached about the effects on the human body. It is essential for us now to objectively relate the facts, distinguishing between the bulk of facts that have already been ascertained and the core of the remaining questions that still require scientific investigation.

Upon considering the relations between nuclear power and environment, problems remain in carrying out the disposal of high-level radioactive wastes (HLW). Years of research have been devoted to this problem, leading to the conclusion that such disposal can be done safely. Nevertheless, it has been difficult for all the countries involved to gain a general understanding about the siting of geological disposal facilities. Japan is progressing with development aiming at the start of commercial operation of HLW disposal facilities by the year 2040. We must expedite a quick conclusion to R&D efforts in this regard, laying out a clear prospect before the Japanese public concerning the promise of carrying out HLW disposal safely. Only then will we be able to make good on our pledge to demonstrate that nuclear power is truly an environment-friendly form of energy.

Let me next make a few comments about the sodium leakage accident that occurred during performance testing at the secondary cooling system in the prototype fast breeder reactor (FBR) Monju last December, about which many of you are probably aware. Because of Monju's crucial role to play in our development of fast breeder reactors, we had pinned many hopes on its success. For that reason alone, the leakage accident was quite a shock to us. Fortunately the accident did not cause any radioactive contamination, nor did anyone suffer harmful radioactive dosages.

At any rate, the accident served again to underscore and highlight the perception gap about nuclear power between us and the public. The PNC officials directly responsible for Monju's operation and all nuclear interests in general must reflect earnestly on the implications of the accident and the lessons to be learned. There is especially room for improvement in the way that information is disclosed, and we must apply the lessons learned here to the course of future FBR development.

The realization of FBRs, indeed, is the embodiment of our goal of supplying "energy free from the restriction of limited natural resources" that I mentioned at the outset. Nuclear power, including FBR development, is now being tested on the question whether it can deliver on that latent promise. It is essential for public and private sectors to work together to pursue further R&D and devise highly reliable technologies to that end. Simultaneously, too, we must formulate a system that can apply that technology effectively, while making all efforts to gain the confidence of the people of the nation.

While technology is often kept under wraps for reasons of corporate confidentiality, we must minimize the number of confidential items to gain the public trust. Furthermore, we must continually strive to maintain safety and eliminate the possibility of accidents. While I am sure that manufacturers, governments and related organizations are developing measures toward that end, it is really our responsibility as nuclear interests to take the initiative in light of the heavy responsibility we bear to develop next-generation nuclear power. Namely, the time has now come for us to regulate ourselves, drawing up our own guidelines of information disclosure, and making decisions after obtaining the opinions of academic experts. JAIF, as an organization of the people, must be ready to assume the brunt of such a role.

With that perception in mind, we decided to hold this year's conference in Nagoya, one of Japan's main industrial and technological centers. We are lucky to have had Prof. Tsuneo Iida of the International Research Center for Japanese Studies serve as the chairman of the program committee for the conference. Hailing from the Nagoya area, Prof. Iida is well known for his studies of the Japanese economy from an international perspective, especially his brilliant analyses of the characteristics of modern society. Thanks to the participation in the committee of both nuclear interests and specialists from many fields, including journalism, we were able to discuss issues from quite a broad perspective. I would like to take this opportunity to thank these people for their contribution to the makeup of this year's conference, including the selection of the theme and discussion topics.

In closing, I would like once again to thank everyone present today in the conference hall for your participation in the conference, and your kind attention to my speech.

第二十九回原産年次大会　原子力委員会委員長代理所感（案）

（はじめに）

本日、第二十九回原産年次大会が、内外から多数の御出席を得て、かくも盛大に開催される運びとなりましたことは誠に喜ばしく存じます。

向坊会長、飯田大会準備委員長をはじめ、大会の開催にご尽力された皆様方に心からお祝いを申し上げますとともに、原子力分野で指導的な役割を果たされている皆様方とこの場に会することができ、大変嬉しく思っております。

（原子力の重要性）

今後の世界のエネルギー消費は、開発途上国を中心とした人口増加や生活水準の向上に伴い、大幅に増加するものと見込まれております。そうした中で、我が国のみならず世界の社会経済が、後世代にわたって、豊かで安定した発展を遂げていくためには、エネルギー供給の安定確保が不可欠であります。

このためには、省エネルギーや新エネルギー開発に努めることはもちろん、大量の電力を、安定して経済的に供給できるという特長を持つ原子力の役割は大変重要であります。特に、資源に乏しい我が国では、長期にわたるエネルギーの安定確保や放射性廃棄物による環境負荷の低減の観点から、使用済燃料の中から、利用価値の高いプルトニウムなどの有用な物質を取り出して再利用する核燃料リサイクルを確立することが重要と考えております。これは、リサイクル文明の創造に寄与するとともに、地球環境との調和を図りつつ、世界のエネルギー問題の解決にも貢献するものと期待しております。

また、人類の恒久的なエネルギー源として期待される核融合について積極的な研究開発が行われているほか、エネルギー利用以外の分野においても、がんの撲滅を目指した重粒子線によるがん治療をはじめ、医療、農業、工業など、広範な分野への放射線利用の展開を通じて国民生活や福祉の向上に大きく貢献するものであります。

（「もんじゅ」事故）

こうした中で、昨年十二月に、高速増殖原型炉「もんじゅ」において、二次系からのナトリウムの漏洩事故が発生しました。周辺環境や従事者への放射性物質による影響はありませんでしたが、地元はもとより、国民の方々にも大きな不安感、不信感を与える結果となったことは誠に残念であります。

徹底的な原因究明を進め、念には念を入れて万全の安全対策を講じるとともに、積極的かつ速やかに情報を公開していくなど、皆様の理解と信頼を得るために全力を尽くしてまいります。

特に、今回の事故を契機として、原子力施設の立地地域を中心に、原子力政策に関する国民的合意の形成に向けたより一層の努力を求める強い声が寄せられていることを真摯に受け止める必要があります。現在、このような観点から、原子力委員会において「原子力政策円卓会議」を開催するほか、関係省庁においてもシンポジウムや地域フォーラム等を開催するなど、地元の方々をはじめとする様々な御意見をお持ちの方々との対話を通じ、国民各界各層の幅広い意見を政策に的確に反映させるべく、関係者一丸となって精力的に取り組んでおります。

本大会においても、この「もんじゅ」事故に関するセッションが設けられており、積極的かつ有意義な意見交換が行われることを期待しております。

（高レベル放射性廃棄物）

さて、原子力開発利用を進めていく上で、放射性廃棄物、とりわけ高レベル放射性廃棄物の処分を確実に行うことは、避けて通ることのできない残された重要な課題であります。現に原子力による便益を享受している私達としては、将来の世代に過剰な負担を負わせることのないよう、この処分を安全に行うことのできる方策を確立するなど、責任のある対応をしていくことが必要であります。

とりわけ、処分に向けた取組を円滑に進めていくためには、これについての国民の理解を深めていくことが重要であり、原子力委員会の下に設置した「高レベル放射性廃棄物処分懇談会」において社会的・経済的側面を含めた幅広い検討を行うこととしています。また、地層処分を安全に実施するために必要な研究開発や、西暦二〇〇〇年を目安とする処分の実施主体の設立に向けた検討についても、関係機関が密接な連携の下に精力的に取り組んでいくよう期待します。

（原子力安全）

原子力開発利用を進めるに当たって、安全の確保が大前提であることは言うまでもありません。

本年は旧ソ連のチェルノブイル原子力発電所事故から丁度十年目に当たります。この事故を契機として、これまで世界の原子力発電所の安全性向上のために様々な取り組みがなされております。

例えば、「世界原子力発電事業者協会（ＷＡＮＯ）」の設立、国際原子力機関（ＩＡＥＡ）、二国間等における様々な支援・協力など、我が国としても人的、資金的な面で積極的に貢献しております。

また、「原子力の安全に関する条約」は、世界の原子力安全の水準を向上させていく上で大きな意義を持つものであり、我が国は既に批准しておりますが、今後、多くの国により締結され、速やかに発効することが期待されます。

さらに、この十九日、二十日には、「原子力安全に関するサミット」がモスクワで開催される予定であり、世界規模で原子力安全に対する認識を高める良い機会と位置付け、我が国としても積極的に貢献していくことが重要です。

また、アジア地域では、飛躍的な経済発展を背景としてエネルギーの確保が重要な課題となってきており、従来の放射線利用に加え、原子力発電の導入といった原子力開発利用に対する関心が高まっております。

このため、これまで以上にアジア諸国間の協力関係を強化し、原子力の安全確保の向上等、アジア地域共通の課題に取組んでいくことが重要であります。

（核不拡散）

核不拡散に関しては、昨年5月に核不拡散条約の無期限延長が決定され、これにより、核不拡散に対する国際的な枠組みの維持・強化が図られました。

また、この決定と同時に採択された「核不拡散及び核軍縮のための原則と目標」に沿って、現在、全面的な核実験禁止を目的とする「全面核実験禁止条約（ＣＴＢＴ）」交渉が、本年中の妥結を目指して精力的に進められております。

さらに、地域的には、北朝鮮への軽水炉供給に係る取極が、朝鮮半島エネルギー開発機構（ＫＥＤＯ）と北朝鮮との間で締結され、軽水炉プロジェクトが本格的に始動するなど、地域的にも核不拡散の維持・強化に向けた取組みが進展しております。

また、国際的に要請されているＩＡＥＡ保障措置の強化・効率化については、現在、ＩＡＥＡにおいて、未申告原子力活動の検知能力の向上等を主目的とした検討（「９３＋２計画」）がなされています。

我が国としては、このような世界の核不拡散体制の維持・強化に貢献すること、及び核不拡散条約の普遍性をより高めていくことが重要であると考えております。

（最後に）

このような原子力分野における重要な課題について、今後とも、安全確保と平和利用を大前提として、透明性の向上等により国内外の理解と協力を得つつ、取組みを強化してまいるとともに、より一層の国際協力を行っていくことが重要であると考えております。皆様方におかれましても、一層の御支援、御尽力をお願い申し上げます。

本日から三日間、「エネルギー・環境・技術　ー原子力は期待に応えられるのかー」という、基本に立ち返った基調テーマの下、内外の有識者、専門家の方々の間で忌憚のない活発な意見交換が行われ、また、貴重な提言がなされ、本大会が成功を収められんことを心から祈念して、私の所感とさせていただきます。

平成八年四月十七日

原子力委員会委員長代理　伊原　義徳

1996 :
A Milestone in the French Nuclear Programme

The start-up of MELOX

Mr President, Ladies and Gentlemen,

Let me first express my pleasure in participating to this 29th JAIF Conference, here, in Nagoya, a pleasure which is both personal and professional. This feeling arises on the one hand from the high standard of professionalism and insight of the presentations which have gained JAIF its flattering reputation. On the other hand, the main reason behind my pleasure is the opportunity I have to bring this distinguished audience up to date with the latest developments of the nuclear programme of my country, a program strongly similar to Japan's own, as we shall see.

In 1974/75, in the aftermath of the first oil shock, the french government and the french industry launched a very ambitious electronuclear programme, in order to significantly reduce the country's dependance upon imported energy sources. From the start, this program was unusually fast in pace and comprehensive in scope, with a strong long-term vision behind it.

In some 15 years were built, and put into operation :

- 34 standardized 900 MWe PWR plants,
- 20 standardized 1300 MWe PWR plants,
- the Eurodif enrichment plant, with a capacity in excess of 10 MSWU/y,
- the La Hague UP2 reprocessing plant, with a capacity of 400t/y,
- the AVM fission product vitrification prototype,
- the Superphénix 1200 MWe FBR,

and construction of the new 1600t/y reprocessing complex was in progress in La Hague.

In 1975, the USA generated 200 billion kWh of nuclear electricity, Japan, 36 billion, and France a mere 16. By 1990 the US production had been tripled, Japan had multiplied its nuclear output more than five times, and France, by a factor of 20, jumping from the 8th to the 2nd ranking nuclear power producer.

The vision behind this huge endeavour was that a *sustainable* development of nuclear power throughout the world implied extracting the full energy content of uranium, by plutonium recycle. Let us not forget that 1 gram of plutonium has the same energy content as 1 metric ton of oil. This vision, that France shares with Japan, remains perfectly valid today for the long term, to guarantee the satisfaction of future energy needs, while optimizing wastes management.

But during those 20 years, the world economic landscape has dramatically altered. The great nuclear expectations of 1975 have failed to materialize outside France, Japan, and a few other countries, a situation which triggered a collapse of world uranium prices. To adapt to this new environment France is now using its nuclear "tool" in a modified way : instead of deploying rapidly FBRs, the breeding capacity of which is no longer urgently needed, we recycle plutonium and its energy content in PWRs thus keeping our options open for the future while keeping the stockpile under control.

In that context, the startup of industrial operation of the Cogéma MOX fuel fabrication plant, MELOX, appears as a key milestone of the french electronuclear programme. It marks the actual capacity in France of plutonium recycle on a truly industrial scale.

Controlling the plutonium inventory

Today the french nuclear industry has given itself the means to valorize the energy potential of plutonium and to control its inventory. 28 of Electricité de France, EdF 900 MWe PWR plants can technically be loaded with 30% of MOX subassemblies, those subassemblies could be manufactured using the total maximum output of the french fabrication plants, and that would be enough to recycle, once, *all* the plutonium produced by the whole EdF nuclear park. This *monorecycle* strategy has a number of significant advantages :

- resources savings of 14% in natural uranium and 17% in SWUs (for an annual production of 400 TWh, those savings amount to 1260 tons of natural uranium and 1 MSWU),
- drastic reduction, by a factor close to 7, of the quantity of irradiated spent fuel to be kept in interim storage, underwater or dry (one must reprocess seven spent UO2 subassemblies to recover enough plutonium to manufacture one MOX subassembly),
- better management of ultimate wastes.

This monorecycle strategy, already competitive and adequate in a first phase, prepares longer term strategies of multirecycle of plutonium in LWRs or fast neutrons reactors and complete closure of the fuel cycle.

As for today, 16 french PWRs are authorized for 30% MOX recycle, and 7 reactors are actually loaded with MOX subassemblies. Furthermore, requests for authorization of recycle in 12 additional PWRs are being partly submitted by EDF to the safety authority. In the near future, the number of PWR plants loaded with MOX could reach 9 in 1996, and 16 in 1998. Being a much "younger" fuel than enriched UO2, MOX fuel is not yet authorized to reach as high a burnup : 37 instead of 42 MWd/kg.

The CEA research aims at allowing MOX fuel to reach burn-up values and performances as high as those of UO_2 fuel, which will increase even more the MOX profitability.

To complete the picture it is important to mention that two experimental campaigns, one in CEA's facility in Marcoule and the other in the La Hague Cogéma plant, both in 1992, have demonstrated that irradiated spent MOX fuel can be normally reprocessed, using the standard PUREX process.

Valorizing plutonium through MOX monorecycle appears to be an industrial solution both reliable and competitive, one which allows to balance the plutonium flowrates on the medium term. Further improvements, concerning both reactors and their fuel cycle, should be made possible by the results of the R&D activities now in progress along the following lines:

- Burnup increase. As already mentioned, we want to reach parity with UO2 fuel, which is improving its own performances. Increasing the fuel use will allow significant economic savings (all the more since there is no SWU penalty for high burnup MOX fuel) but it would also simplify core management by doing away with the "hybrid" management in which UO2 subassemblies remain four cycles in reactor while MOX subassembly stay only three cycles. Studies are based on "advanced" experimental subassemblies irradiated in PWRs and specific irradiations in CEA's experimental reactors.

- Improvement of the MOX fabrication process, in order not only to reach higher burnups but to reduce fabrication costs and make spent MOX reprocessing easier when the time is ripe for it. The main objective is to obtain the most homogeneous plutonium distribution in the MOX pellets.

- In-depth knowledge of MOX core physics, presently less well modeled than U02 core's. Those studies aim at increasing the MOX load fraction from today's 30% to 50% and up to 100% in the future EPR (European Pressurized Water Reactor). Experiments are carried out in zero-power experimental lattices, and credit is taken of the return of experience from MOX spent fuel.

Beyond MOX : CAPRA

Even monorecycle alone will buy time (one should realize that one full cycle takes from 12 to 15 years to complete) but on the longer run multirecycle and actual closure of the fuel cycle imply the use of fast neutron reactors (FRs). The number of plutonium recycles in a LWR is limited by the isotopic degradation of plutonium with the build-up of even numbered isotopes. Multirecycle also increases production of minor actinides which contribute to the radiotoxicity of ultimate radioactive wastes.
Conversely, FRs have the intrinsic capability to consume degraded plutonium and incinerate minor actinides. Both Phénix and Superphénix constitute for France invaluable tools to implement the "Knowledge Acquisition Program" whose results are needed to develop and qualify industrially solutions to multirecycle. The corresponding research is carried out in the framework of the CAPRA and SPIN programs.

Launched in mid-93, the CAPRA program (meaning Concept to Amplify Plutonium Reduction in Advanced FRs) has attracted a lot of interest from several countries, and very notably Japan. In a first stage, the feasibility has been demonstrated of a CAPRA-type 1500 MWe core using mixed oxide fuel assemblies with 40 to 45% plutonium and consuming around 60 kg Pu per electrical TWh. A CAPRA reactor of this kind could, if needed later, reverse to a breeding mode.

In order to illustrate the potential advantage of mixing PWRs and CAPRAs, let us consider a 60 GWe park with 88% PWRs, operating at 55 MWd/kg and monorecycling plutonium in 100% MOX cores, and 12% CAPRAs (only one reactor out of 8) in multirecycle mode. Such a park would consume *all* its plutonium and need only 5050 tons of natural uranium and 3,3 MSWUs to generate 400 TWh per year!

Reprocessing & Wastes Disposal

As far as reprocessing is concerned, the french industrial tool is now mature, as the La Hague reprocessing complex operates now at full capacity, and very satisfactorily so. Let us recall that one of the objectives of reprocessing is to make easier the management of ultimate radioactive wastes, both from a qualitative and from a quantitative point of view.

Quantitatively, the total volume of conditioned long-lived wastes issued from the reprocessing is already, with 1 m3/ton HM, somewhat smaller than the corresponding volume of spent fuel conditioned for direct disposal. In the next few years, this volume will be further reduced by a factor 2 owing to the following improvements :
- suppression of the bitumen conditioning of liquid effluents,
- high-pressure compaction of hulls and end-pieces,
- relaxation of the sodium content limit in glasses.

Qualitatively, reprocessing allows for the separation of each category of ultimate wastes in order to optimize their management : vitrification for the fission products, specific conditioning or transmutation for the minor actinides, subsurface disposal for low level wastes, etc.

R&D on high activity long-lived wastes management is carried out in the framework of a Law enacted by the french parliament in december 1991. According to this law, the parliament will decide upon the proper method of disposal at the end of a 15 year period during which R&D will be carried out along three lines :

- separation and transmutation of long-lived wastes,

- deep geological disposal (this line includes building and operating underground laboratories, the sites of which should be selected this year),

- waste conditioning and long term surface storage.

Studies now in progress have already shown that neptunium separation could be trivial, but to properly separate americium and curium new solvants would be needed. Experimental studies of transmutation are also carried out in thermal and fast neutrons reactors, Siloé, Osiris, Phénix and Superphénix.

Focussing on minor actinides should not hide the fact that the main source of radiotoxicity in irradiated spent fuel elements is, indeed, plutonium. The reprocessing-recycle strategy which aims at consuming plutonium while producing electricity offers therefore important benefits toward the protection of the environment.

Similarly, consumption and isotopic degradation of weapon-grade plutonium recovered from weapon dismantling, while producing electricity as MOX fuel, offers significant benefits in terms of non-proliferation.

Both these benefits - environmental protection and non-proliferation - add up to what is the main purpose of the reprocessing-recycle strategy, namely the possibility of using the whole uranium resources and not only 235 uranium. That is why the fast neutrons reactor technology has been developed, and notably by France and Japan, two countries which believe that nuclear energy is important for their long-term energy supply. As a matter of fact, if used in its totality, uranium can supply mankind with centuries of cheap, safe and abundant energy, without release of greenhouse gases. Nuclear has its part to play in a *sustainable* energy system, and a *sustainable* nuclear development implies plutonium recycle.

ILLUSTRATIONS

I - USINE EURODIF

2 - SUPERPHENIX

3 - USINE DE LA HAGUE

4 - EVOLUTION PRODUCTION ELECTRONUCLEAIRE : USA/JAPON/FRANCE

5 - USINE MELOX

6 - TABLEAU ECONOMIE nat. U, WSU : cycle ouvert -> monorecyclage

7 - GAIN SUR ENTREPOSAGE INTERIMAIRE (schéma EDF)

8 - CARTE DES REACTEURS MOXES ET MOXABLES EN FRANCE

9 - SCHEMA PLANNING DE REALISATION DU PAC

10 - SCHEMA COEUR CAPRA OXYDE

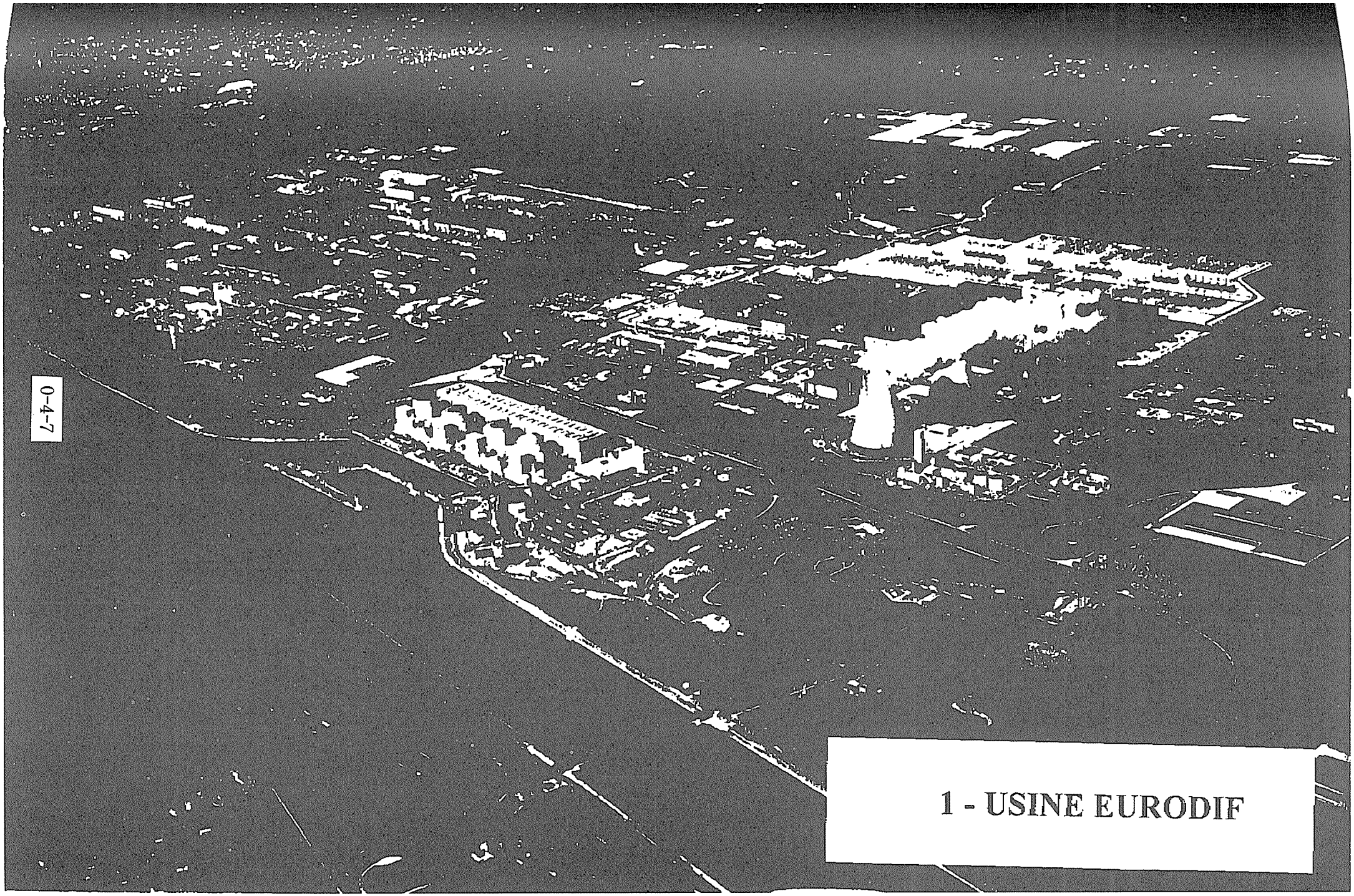
11 - TABLEAU ECONOMIE nat. U., WSU : cycle ouvert/ monorecyclage -> multirecyclage mixte

12 - REDUCTION DANS LE TEMPS DU VOLUME DES DECHETS (schéma COGEMA)

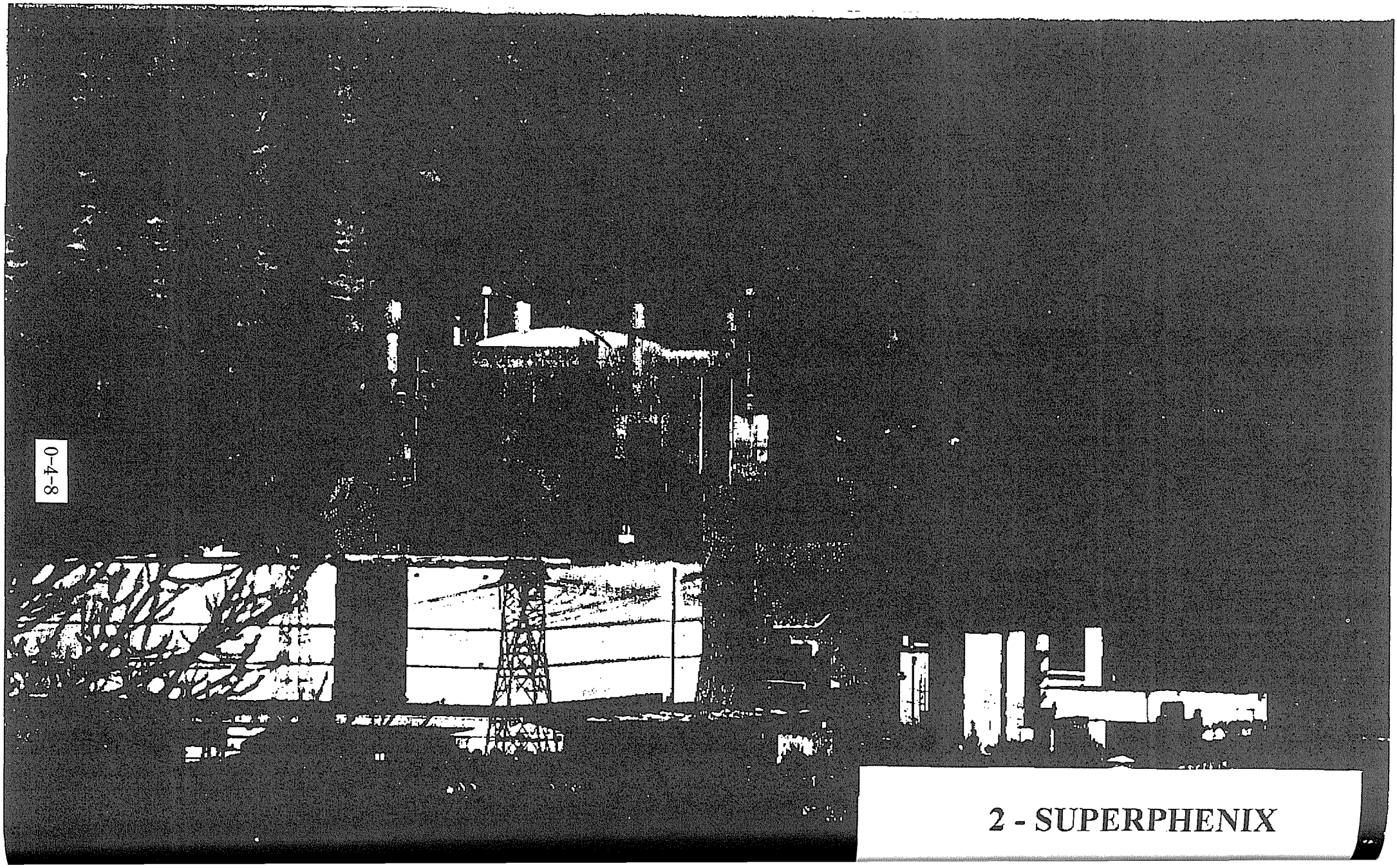
13 - ATELIER VITRIFICATION

14 - ARTICLES DE LA LOI DE DECEMBRE 1991

15 - RADIOTOXICITE POTENTIELLE (évolution temporelle)

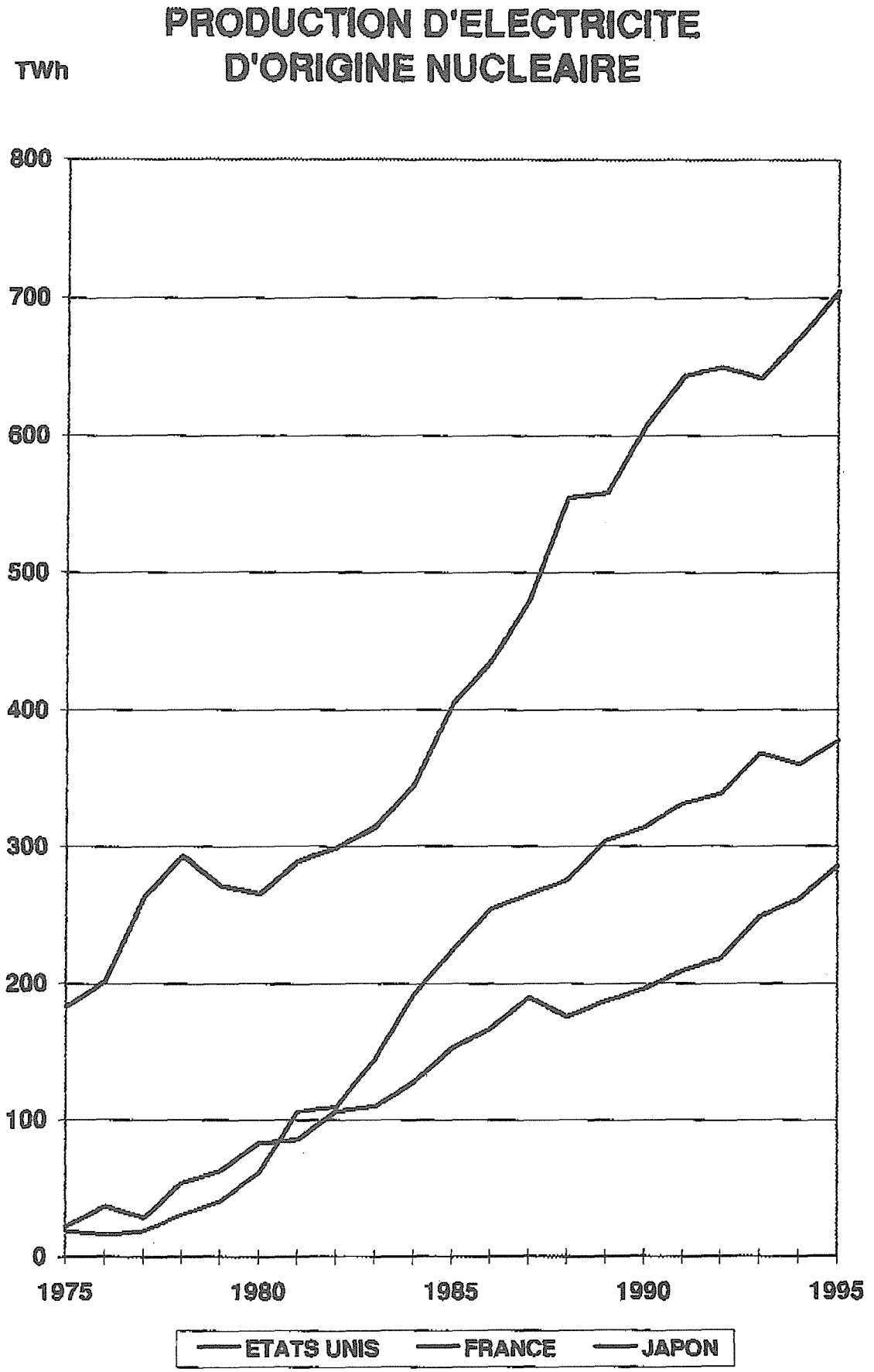


1 - USINE EURODIF

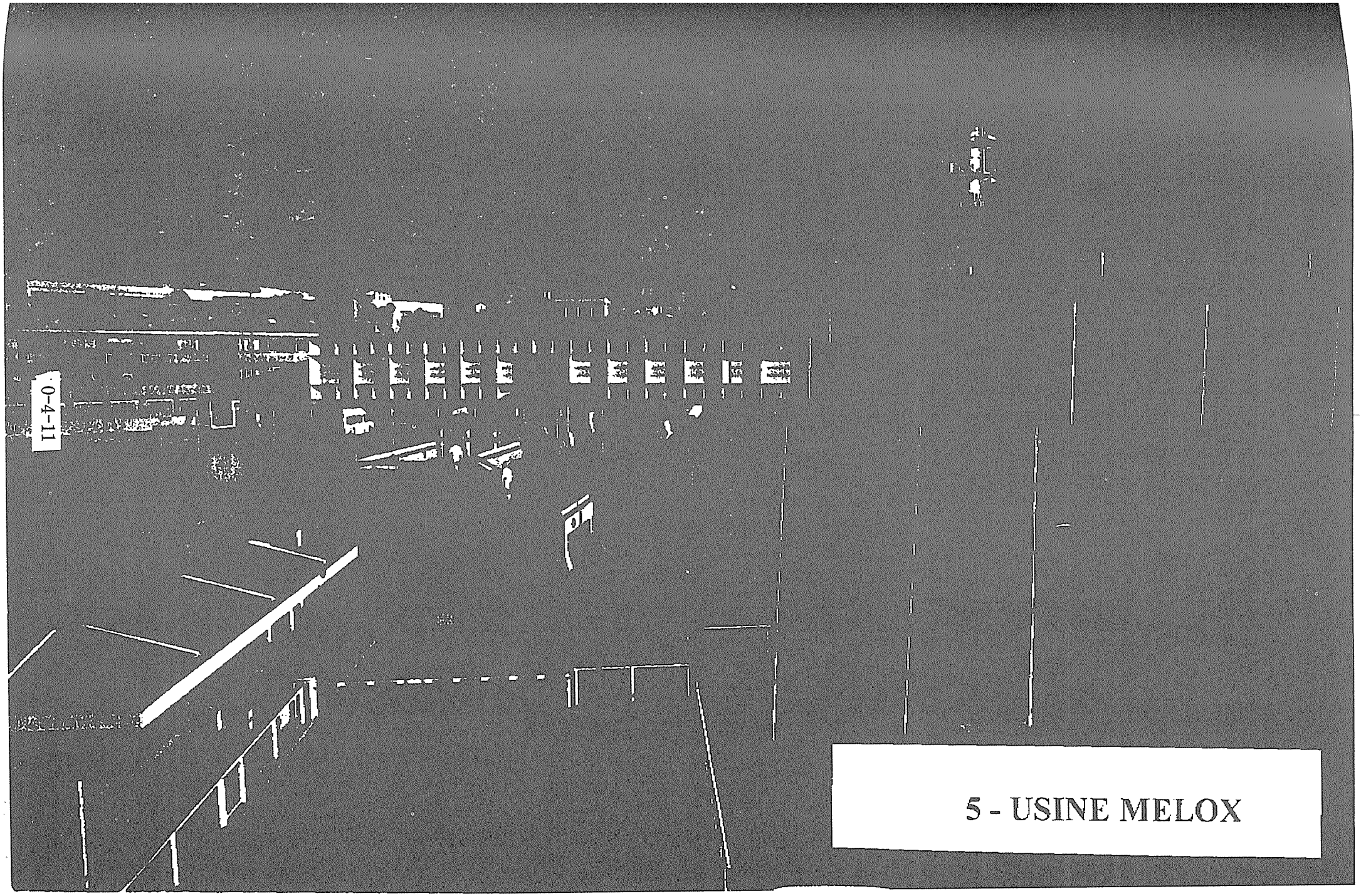


2 - SUPERPHENIX

3 - USINE DE LA HAGUE



4 - EVOLUTION ELECTRONUCLEAIRE USA / JAPON / FRANCE



5 - USINE MELOX

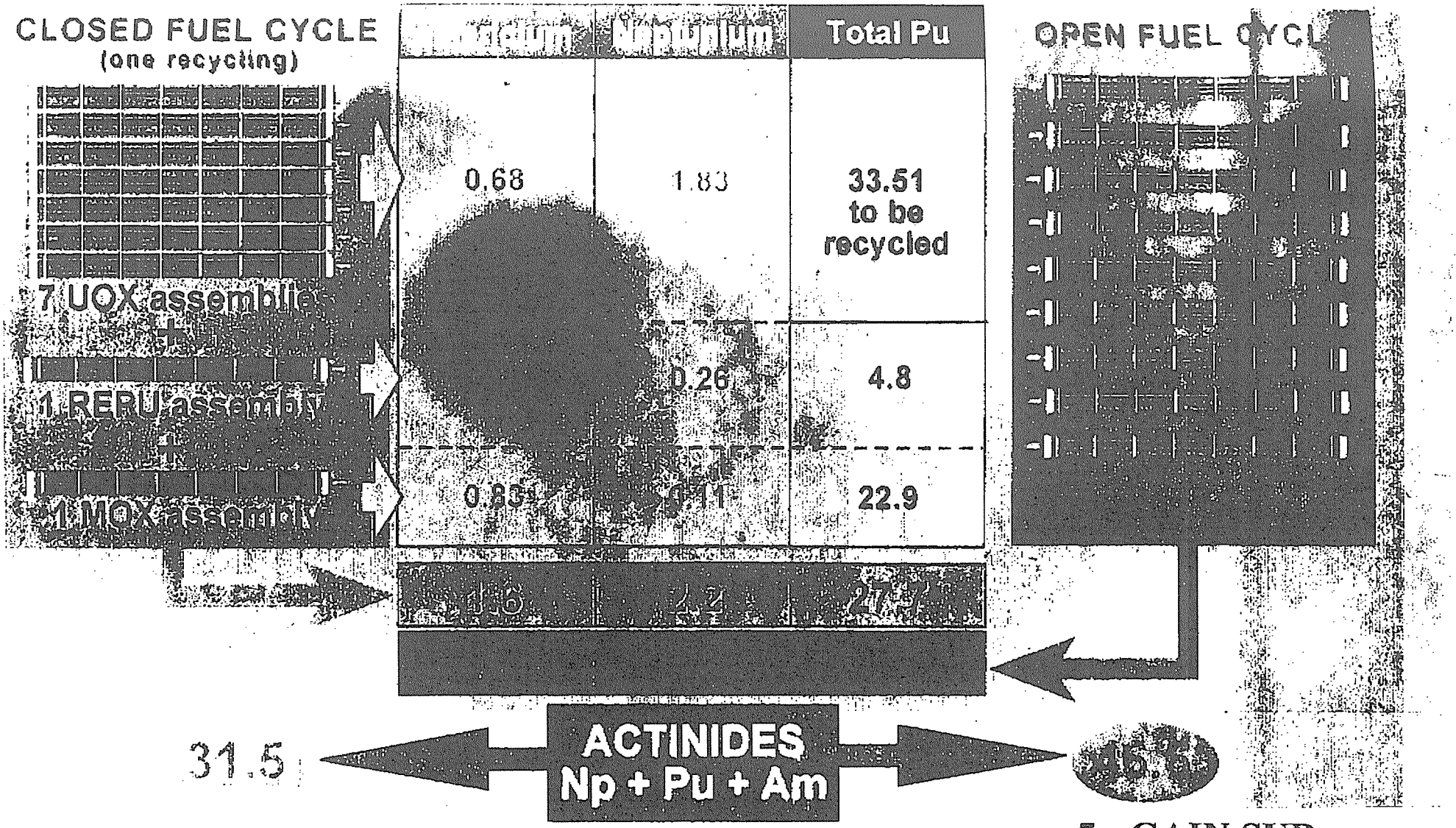
fuel cycle scenarios comparison
60 GWe installed for 400 TWe/year

6 - TABLEAU ECONOMIE

nat. U, WSU :
cycle ouvert ->
monorecyclage

	nat. U (T)	*enrichment (10^6 WSU)*	*Pu in waste (T)*
open cycle	***8900***	***6***	***13***
mono-recycling	***7640***	***5***	***8***

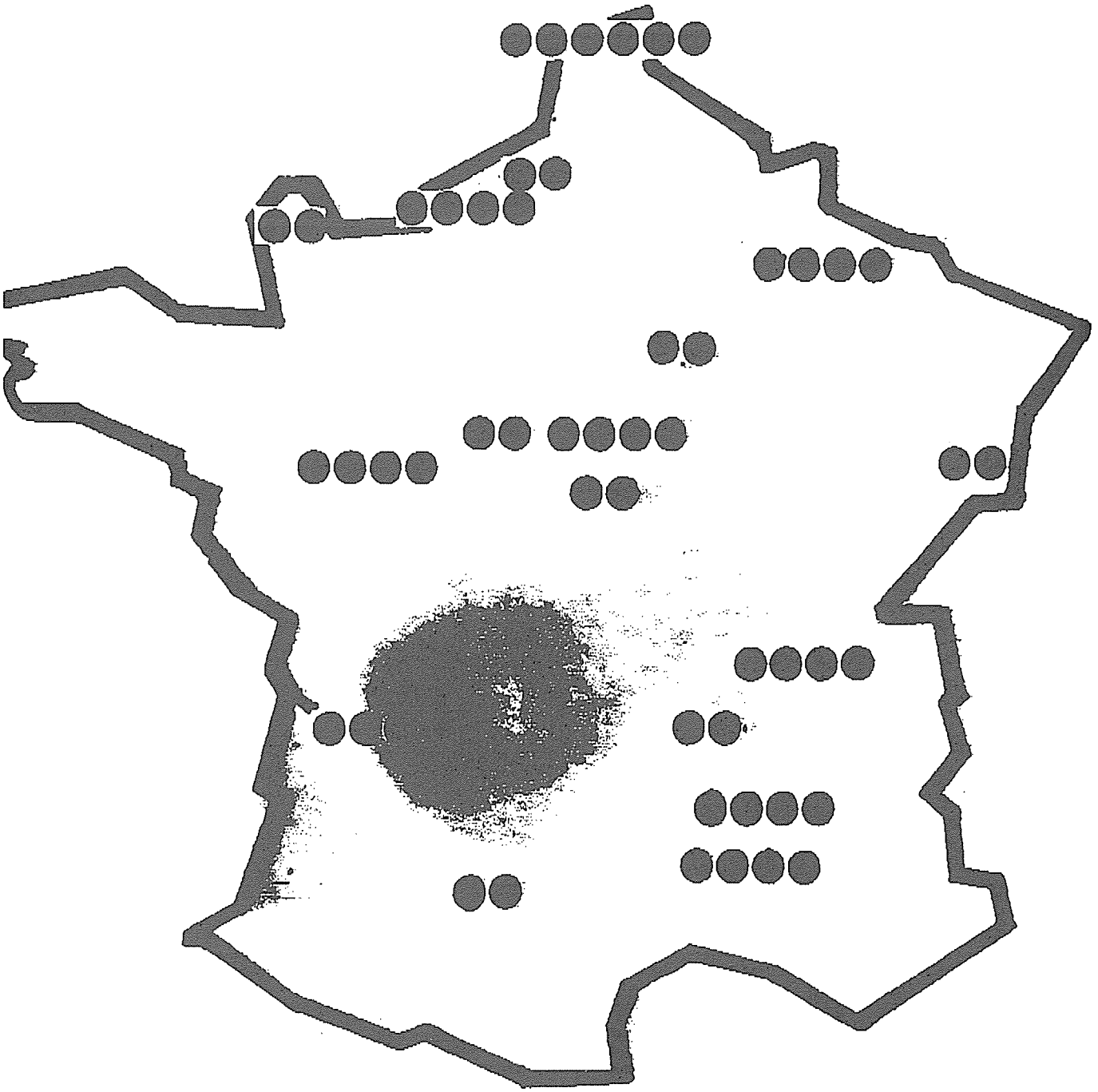
6 - TABLEAU ECONOMIE
nat. U, WSU :



7 - GAIN SUR ENTREPOSAGE INTERIMAIRE (Schéma EDF)

MOX RECYCLING REACTORS IN 2000

8 - CARTE DES REACTEURS MOXES ET MOXABLES EN FRANCE



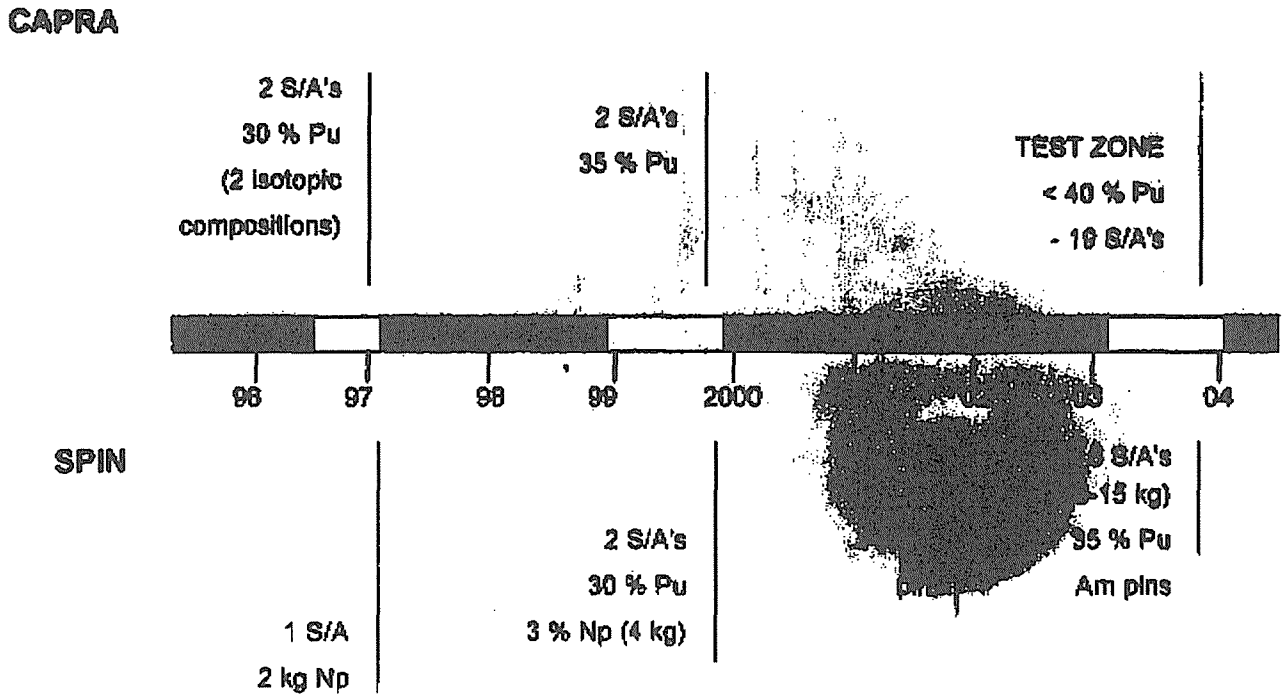
) « MOXABLE » REACTORS BY THE YEAR 2000

) MOX-LOADED REACTORS AS OF JULY 1995

) NON MOXABLE REACTORS

SUPERPHENIX

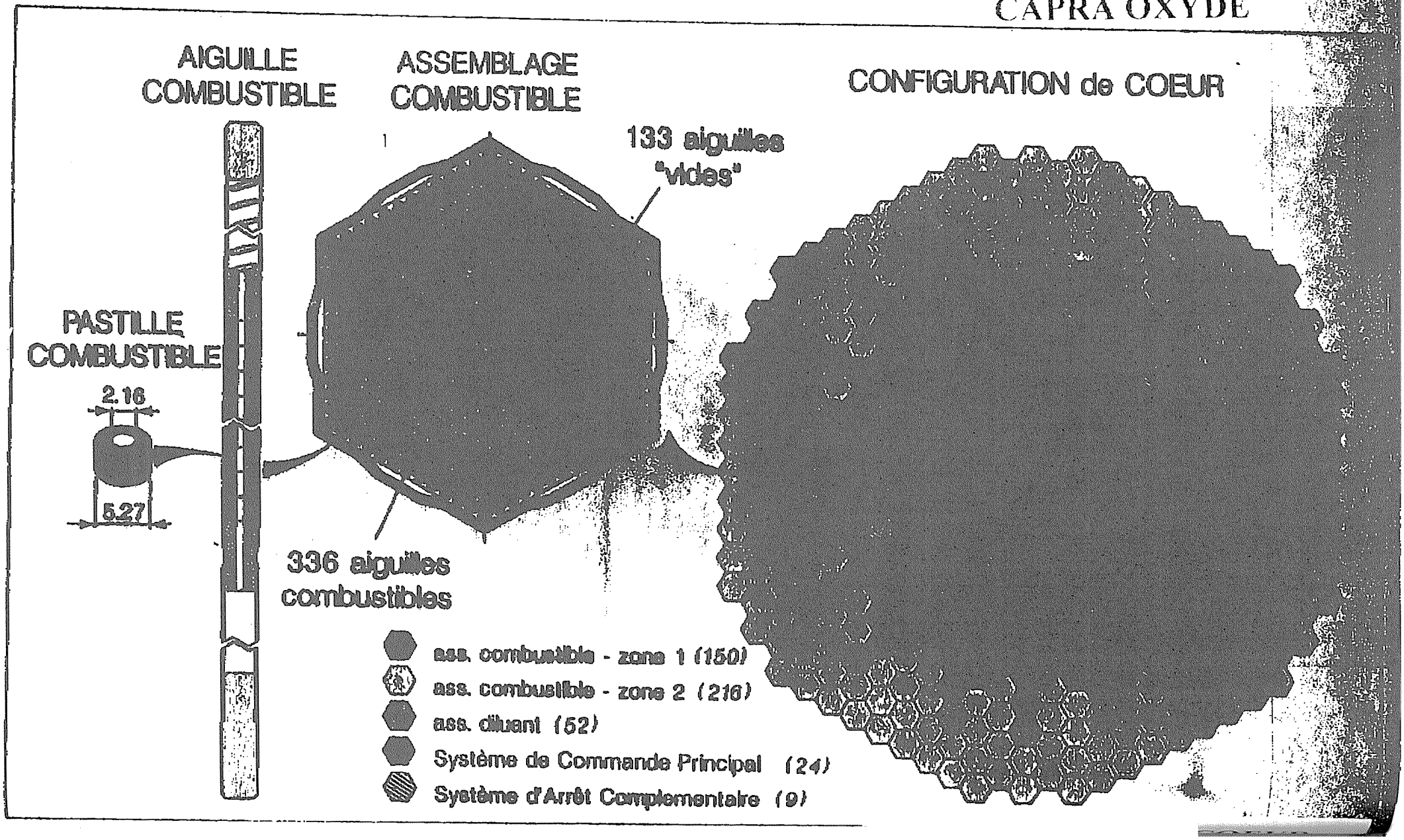
CAPRA AND SPIN SUBASSEMBLIES TESTS



9 - SCHEMA PLANNING DE REALISATION DU PAC

CAPRA

10 - SCHEMA COEUR CAPRA OXYDE



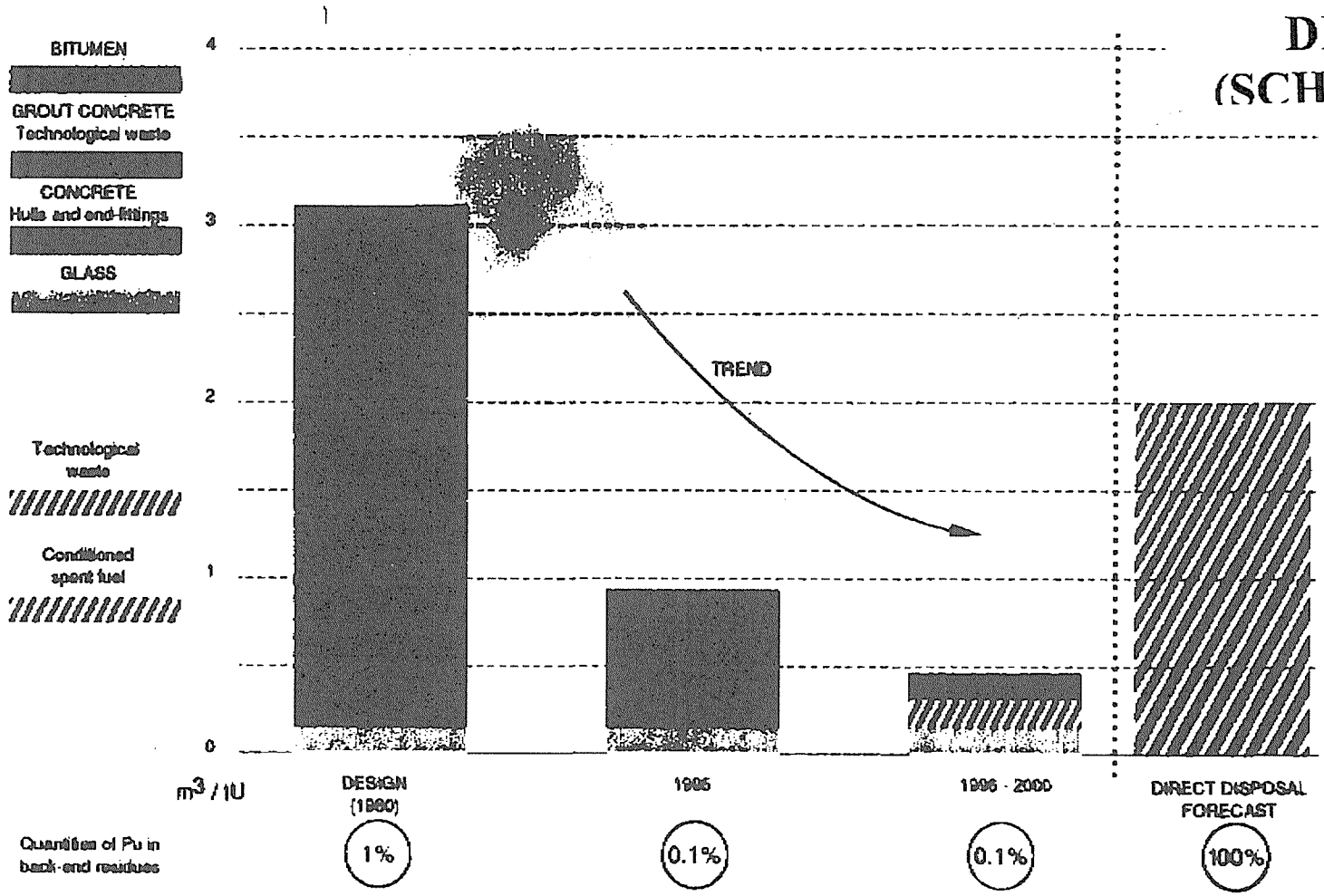
fuel cycle scenarios comparison
60 GWe installed for 400 TWe/year

	nat. U (T)	enrichment (10^6 WSU)	Pu in waste (T)
open cycle	**8900**	**6**	**13**
mono-recycling PWR UOx : 32 GWe PWR Mox : 28 GWe	**7640**	**5**	**8**
multirecycling PWR UOx : 44 Gwe PWR MOX : 8,8 Gwe CAPRA : 7,2 GWe	**5050**	**3,3**	**0**

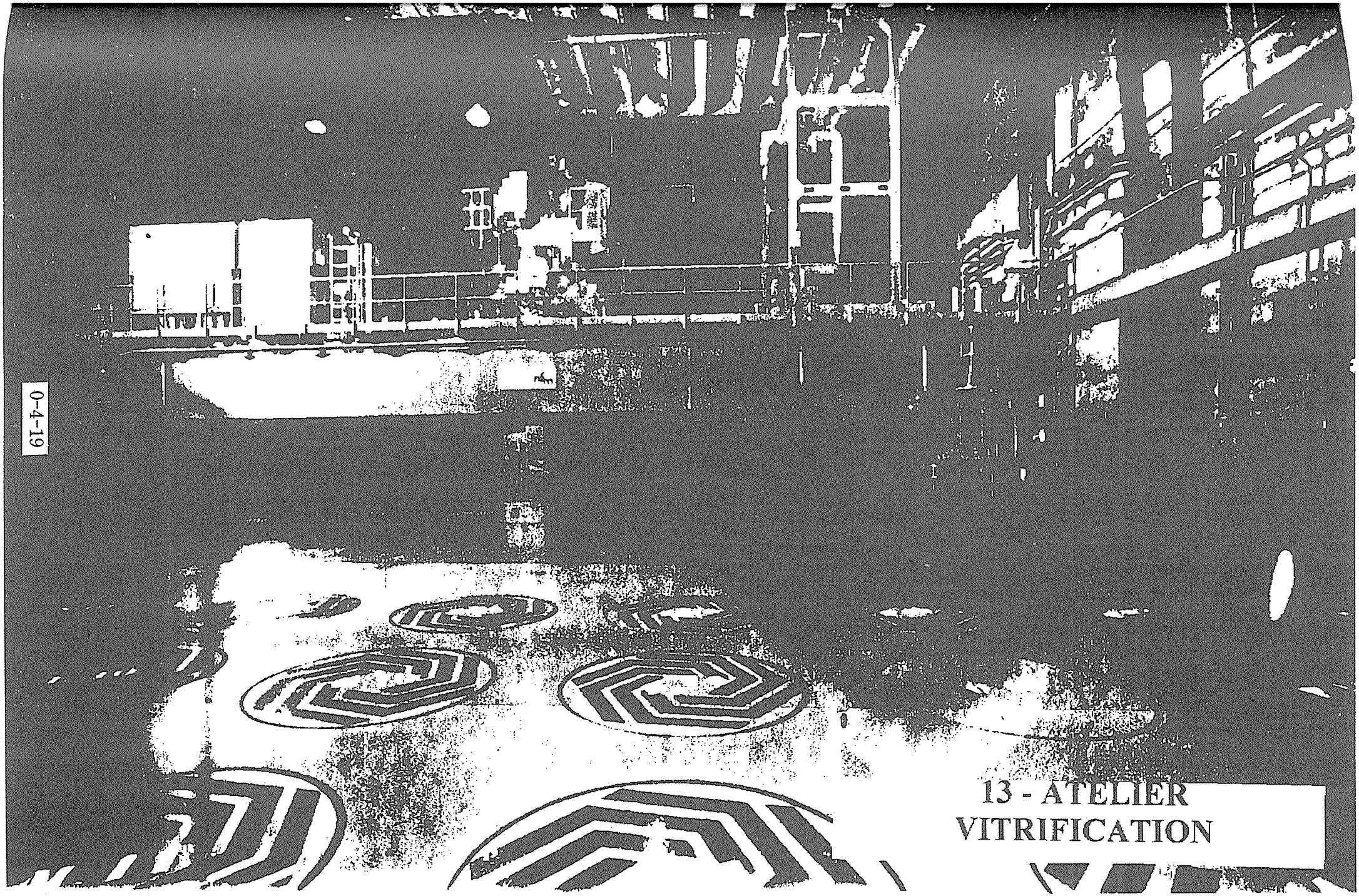
11 - TABLEAU
ECONOMIE nat. U, UTS :
cycle ouvert/monorecyclage>
multirecyclage mixte

VOLUMES OF FINAL RESIDUES GENERATED IN UP3 (LONG-LIVED WASTE AFTER CONDITIONING)

12 - REDUCTION DANS LE TEMPS DU VOLUME DES DECHETS (SCHEMA COGEMA)



12 - REDUCTION DANS LE TEMPS DU VOLUME

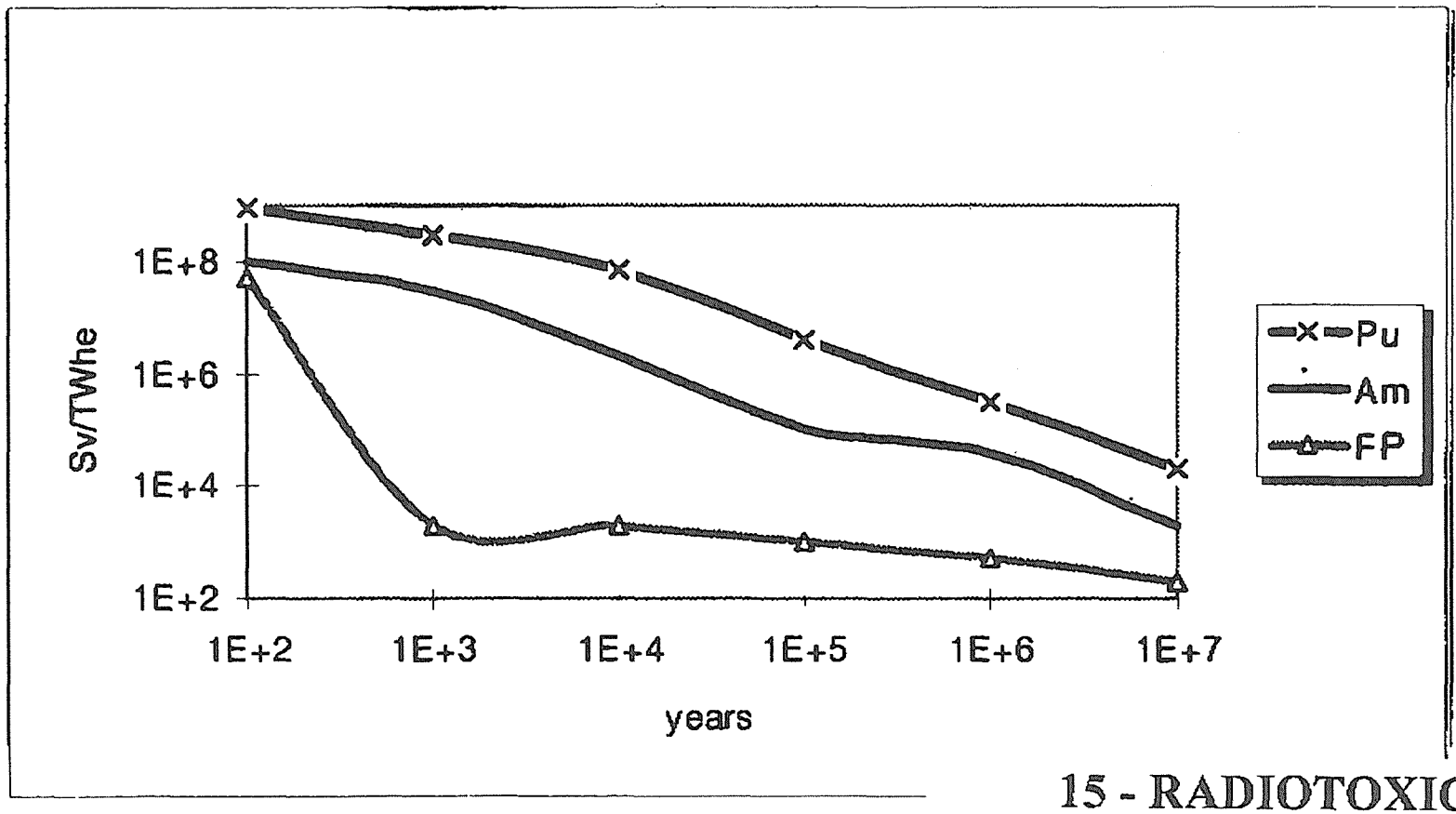

13 - ATELIER
VITRIFICATION

high level waste : 3 directions for R and D (law of december 30th 1991)

- separation and transmutation (SPIN)
- deep underground storage (reversible or irreversible)
- packaging and surface disposal

14 - ARTICLES DE LA LOI DE DECEMBRE 1991

radiotoxicity of Pu, Am and FP



15 - RADIOTOXICITE POTENTIELLE (Evolution temporelle)

ABSTRACT

"The Elimination of Nuclear Weapons"

Ambassador Richard Butler AM
Permanent Representative of Australia to the United Nations
Convenor, Canberra Commission on the Elimination of Nuclear Weapons

The two great challenges faced by the community of nations during the fifty years since the end of the Second World War have been those of the atom and development.

Each have their own separate characteristics and political imperatives but the solutions to the problems they pose are related. They also share the feature that they each directly affect the prospects of global peace and security.

The need to address "the awful arithmetic of the atomic bomb"[1] was recognised immediately following the end of the Second World War but first attempts at international control of atomic energy failed as the Cold War and the nuclear arms race started. It took almost half of the era of nuclear weapons, 20-23 years, before the International Atomic Energy Agency was established and the Nuclear Non-Proliferation Treaty was formulated.

The statute of the IAEA addressed a central connection between the atom and development, insisting that it must not be the case that wherever nuclear energy is used for peaceful purposes it would be inevitable that the military uses of that energy and technology would spread. It also gave expression to the notion of the right of all states to enjoy the benefits of the peaceful uses of nuclear energy and science.

The NPT, very specifically, sought to prevent the possession of nuclear weapons from spreading beyond those states which, by January 1967, had concluded a nuclear treaty and it enshrined the major political and legal commitment by those states to nuclear disarmament. The NPT established the norm that no, state should possess nuclear weapons. Echoing the statute of IAEA, NPT also pledged the benefits of nuclear energy and science to all states, particularly developing countries.

These two events, of 1957 and 1968, constitute the major responses of the international community in the post Second World War/post colonial period to the problems of the atom and to major issues of development, including the specific relationship which was perceived to exist both practically and politically between the atom and development.

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[1] President Eisenhower: United Nations General Assembly, 8 December 1953.

In very many respects, these agreements and bargains of the first half of the era of the atom have served the international community well. But, it is now clear that their deficiencies, particularly with respect to nuclear disarmament and in the face of a developing world very different from that of only fifteen years ago, point to the need for a new nuclear compact. The development of such a compact has been made possible by the end of the Cold War. It has been made necessary by the globalisation of technology and the fact that the need for development has increased not diminished.

It was in response to both this opportunity and need that the Australian Government, late last year, formed the Canberra Commission on the Elimination of Nuclear Weapons.

The Commission will complete its report in August 1996. It will cover two main questions: why we must now move to eliminate nuclear weapons and how can this be done safely.

On the question of why, the Commission will seek to demonstrate that: nuclear weapons offer no credible solution to any security problem other than deterring their use, any use of them would cause problems larger than they could conceivably solve, it has been by good fortune rather than solely by good management that we have not experienced a nuclear weapons-based catastrophe, like any weapons of mass destruction they are morally insupportable, their manufacture causes significant environmental damage and is fantastically expensive, perhaps above all, their existence ultimately dooms attempts to restrain nuclear weapons proliferation because of the inner truth that so long as any state possesses them others, state and/or non-state actors, will seek to acquire them.

On the question of how, the Commission will outline the steps which can be taken towards the elimination of nuclear weapons and the prevention of their proliferation. The Commission is determined to recommend realistic steps which take full account of the need: to maintain stability while nuclear disarmament proceeds, to address the particular concerns of states and regions in which the political pressures towards proliferation are strong, to prevent break-out and nuclear terrorism, and to develop political and other co-operative structures for the management of security in a nuclear weapon free world (NWFW). It will also be central to the success of such a world that it responds positively to development and economic needs, including through the peaceful use of nuclear science and technology.

A central determinant of whether states will agree to act towards the elimination of nuclear weapons, in addition to the necessary condition of their accepting the why arguments, is that they are able to envisage a common, co-operative political commitment to that end. This means that, in addition to the necessary steps such as; CTBT, cut-off, START III, nuclear disarmament negotiations involving all relevant states, global measures against break-out, and a strengthened IAEA, it will be necessary that there be a major political agreement, a new nuclear compact that: enshrines the commitment to a NWFW, and designates the steps, including those just mentioned and whatever others prove necessary, which when taken will constitute the architecture of that world.

The indefinite extension of NPT can be seen as a vital foundation for a new compact, provided the political conditions under which that extension was agreed are correctly understood.

That post Second World War/post colonial response to the challenges of the atom and development must now be expanded into the post-Cold War/globalised world response - to ensure that the 21st century becomes a world without nuclear weapons and in which economic and development issues are seriously addressed.

"The Elimination of Nuclear Weapons"
Ambassador Richard Butler AM
Permanent Representative of Australia to the United Nations
Convenor, Canberra Commission on the Elimination of Nuclear Weapons

Two events, both of which occurred in August 1945, uniquely shaped the world in which we have lived for the past fifty years. Atomic bombs were used at Hiroshima and Nagasaki and Mahatma Gandhi was released from jail and, shortly thereafter, was received at the Viceroy's mansion in Delhi.

These events signalled the end of the Second World War and the end of the age of colonialism.

Neither of these events had a direct relationship. They had their separate characteristics and were driven by their own political imperatives. But, together they defined the central challenges of the second half of the 20th Century - the atom and development. They also share the reality that the solutions we have sought and must continue to seek to the problems posed by the atom and development directly affect the prospects of global peace and security.

As the Second World War was drawing to its end, the community of nations meeting at San Francisco, designed the rules and structure of the new world. The Charter of the United Nations has proven, in many ways, to have been a gifted and astonishingly far-sighted, indeed prophetic, document. It enshrines the right of all peoples to self-determination, thus recognising the justice and inevitability of decolonisation, but it was, of necessity, a pre-atomic age document. Nowhere does it mention atomic weapons, yet within a breathtakingly short time the problem of the atom and then the onset of the Cold War and the nuclear arms race, was to confront its operation and vision massively.

The first resolution of the General Assembly addressed nuclear disarmament. In 1946 the United States proposed, in the Baruch plan, international control of nuclear weapons. This was rejected. Seven years later, almost twenty years into the nuclear age, President Eisenhower delivered his "Atoms for Peace" speech at the General Assembly in which he proposed that what he called "the awful arithmetic of the atomic bomb"[1] should be addressed through international co-operation on the regulation of atomic energy. His proposal succeeded because he added to control the crucial element of development.

The result was the opening, in 1954, of the Conference on the Statute of the International Atomic Energy Agency. That Statute entered into force in 1957 and IAEA was born.

Where all previous attempts by the international community to forge co-operation in addressing the problem of the atom had failed, this enterprise was successful, for two main reasons: the United States monopoly on the

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[1] President Eisenhower: United Nations General Assembly, 8 December 1953.

possession of nuclear weapons had been broken and, the IAEA idea recognised the central connection between the atom and development.

The first of those reasons set up a problem which would need to be addressed and remains with us today - the proliferation of nuclear weapons.

The second saw the development, in the Statute of IAEA and elsewhere, of elemental recognition that denial of technology is a doomed policy, especially in the decolonised world which had emerged. What was clearly asserted however was the conviction that it must not be the case that wherever nuclear energy is used peaceful purposes it would be inevitable that the military uses of that energy and technology would spread. It was of crucial importance that the Statute gave expression to the notion of the right of all states to enjoy the benefits of the peaceful uses of nuclear energy and science. So again, the atom and development were joined.

In certain measure this evolution in international thinking and codification began to fill the empty space in the Charter of the United Nations. But, the silence of the Charter on the subject of nuclear weapons was growing louder as the possession of those weapons spread and the prospect of the emergence of some 20 nuclear weapons states became real.

Taking up an Irish proposal, the international community began and then concluded in 1968, the negotiation of the Treaty on the Non-Proliferation of Nuclear Weapons.

With its provisions on non-acquisition of nuclear weapons and its pledge of good faith negotiations on nuclear disarmament, NPT established the political and legal norm that no state should possess nuclear weapons. Thus, NPT finally filled the space that had been left in the Charter of the United Nations. It is the multilateral treaty with the largest number of adherents and last year, having completed its first 25 years, it was extended indefinitely.

The statute of the IAEA and the NPT constitute the major responses of the international community in the post-Second World War/post-colonial period to the problems of the atom and to major issues of development, including the specific relationship which was perceived to exist both practically and politically between the atom and development.

In very many respects, these agreements and bargains of the first half of the era of the atom have served the international community well. But, it is now clear that their deficiencies, particularly with respect to nuclear disarmament and in the face of a developing world very different from that of only fifteen years ago, let alone that of 1945, point to the need for a new nuclear compact.

The development of such a compact has been made possible by the end of the Cold War. It has been made necessary by the globalisation of technology and the fact that the need for development, including energy development, has increased not diminished.

It was in response to both this opportunity, a window which is clearly open but may not remain so indefinitely and this need, the size of which is unprecedented, that the Australian Government, late last year, formed the Canberra Commission on the Elimination of Nuclear Weapons.
The Commission is made up of seventeen members drawn from around the world and each with a particular expertise in nuclear weapons, ranging from the management of those weapons to decades of striving towards their elimination. While the Commission was established by the Australian Government it is independent. It will be open to all, including the Australian Government, to decide upon their attitude towards the report of the Commission, which will be completed by August 1996. The report will be made available publicly.

The Commission held its first meeting, in Canberra, in January this year. At that meeting it agreed to the basic approach it would take and to an outline and structure of its report. Since that time work has proceeded on developing the report. The Commission will meet for the second time in New York towards the end of this month.

At its first meeting a number of basic agreements were reached amongst Commissioners. I will mention one of them straight away.

Following extensive discussion and taking into account those points of view which argue that while the number of nuclear weapons in existence should be drastically reduced, it would neither be possible nor safe to reduce that number to zero, the Commission formed the view that the goal must be zero and that it would conduct its work in pursuit of that goal. I will return to this point again shortly.

While it would be wrong to simplify what we may expect from the report of the Canberra Commission, not least because the issues it will cover are complex, it does not run the risk of simplification to state that the report of the Commission will cover two main questions: why we must now proceed to eliminate nuclear weapons, and how this can be done safely. At its first meeting the Commission unanimously and strongly held the view that the why arguments were crucial. This was more than a question of mere logic. What was very much in the mind of Commissioners was their recognition, based on long experience, that all of the central actors - those who manage national security and weapons systems, those who form policies and opinions, and members of the concerned public - deserve respect. They could not be expected to contemplate zero nuclear weapons, let alone take any action towards that end within their own sphere of influence, unless they were convinced that such action was right and would improve the situation for which they are responsible and in which they have a fundamental interest.

It would be premature to state now, in any detailed way, how the Commission will tackle this crucial, determining task, that is, of proving the case for why. But, in general terms, I believe that amongst the realities the Commission will seek to demonstrate are that: nuclear weapons offer no credible solution to any security problem, other than deterring their use by others; any use of them would cause problems larger than those they could conceivably solve; it has been by fortune rather than solely as the result of

good management that we have not experienced a nuclear weapons-based catastrophe; like any weapons of mass destruction they are morally insupportable; their manufacture causes significant environmental damage and is fantastically expensive; perhaps above all, their existence ultimately dooms attempts to restrain nuclear weapons proliferation because of the inner truth that so long as any state possesses nuclear weapons others, state and/or non-state actors, will seek to acquire them.

I said earlier I would return to the Commission's reasons for commitment to zero. These are those reasons.

A few moments ago I made brief reference to the history of the international community's attempts to manage the atom both as such and in its relationship to development. In parallel with that history has been the history of the development of nuclear weapons, from the evidently crude devices used at Hiroshima and Nagasaki down to the amazing array of nuclear weapons and their associated delivery systems which were the offspring of the nuclear arms race.

There are some aspects of the history of nuclear weapons development which, with hindsight, we are now able to reflect upon. Among these are the following:

. the development of nuclear weapons, from the beginning, has been a series of unintended consequences. For example, the development of the atomic bomb was begun in response to Nazi Germany's bomb program but never used against Germany. It was used instead in Japan and, among many other miscalculations, against a background of what we now know that those regarding the predictions of the harm that would or would not be done by radiation were seriously inadequate;

. the progress of the nuclear arms race had no linear, rational pattern. It was marked by action and reaction which meant that qualitatively, in terms of the weapons and made and, quantitatively in terms of the huge numbers produced, the outcomes were not what an overall rational plan would have described;

. it surely is true that if the question had been asked in, say, 1955 or 1965 or 1975, "do we have enough nuclear weapons?", the sensible answer would have been in the affirmative. Yet the race went on and the numbers and types increased;

. as already mentioned, and perhaps above all, we came to understand the inner mechanism of proliferation - that it is simply impossible to draw, forever, a line on one side of which is those who have nuclear weapons and on the other side of which is those who do not.

I want it to be clear, I do not expect the Commission to be disparaging of those who have sought to manage the age of nuclear weapons or needlessly scornful of the rationales on the basis of which they have done their work. The rationales were not, at their given time, empty of meaning. But when the significance of nuclear weapons and the way in which they evolved is considered in depth, it surely is true that the point at which we

found ourselves a few years ago, at the height of the Cold War, where several new warheads were being made each week and the overall number, if we were ever to really know it, was clearly in excess of 60,000; this 50 years of unintended consequences can be seen to be history's greatest accident.

The Commission will also recognise the very considerable steps that have been taken over the years and particularly since the end of the Cold War, directed specifically at reducing the danger of nuclear weapons. The fact is the list of treaties is not short whether with respect to nuclear testing, prevention of accidents and communications between the nuclear weapons states and nuclear disarmament. On the latter, the number of some 60,000 is now able to be revised to some 40,000 and if all extant agreements are implemented in full, in particular START II, then the number of nuclear weapons left will be a fifth of what existed in the past. This growth of resolve on the part of the major nuclear weapons states must be recognised.

On the second major question, the question of how, the Commission will be deeply challenged. The world is fairly awash with plans and proposals for the elimination of nuclear weapons. Their quality varies greatly ranging from the modest to the utopian. I think it is fair to predict that the Commission will act, at all times, on the assumption that the possibility of states moving towards the elimination of nuclear weapons will be determined by their judgement of whether the task is practicable but, above all, whether it can be carried out securely.

For these reasons, the Commission is certain to recommend realistic steps which take account of the need to: maintain stability while nuclear disarmament proceeds; address the particular concerns of states and regions in which the political pressures towards proliferation are strong; prevent break-out and nuclear terrorism; and, develop political and other co-operative structures for the management of security in a nuclear weapons-free world (NWFW.).

In addition, I think we can expect the Commission to take full account of another reality, namely that it will be central to the success of such a world that it includes agreements and structures which will facilitate development and economic needs, including through the peaceful use of nuclear science and technology.

Perhaps the major display of the realism and determination of the Commission will be their recognition that even if states can broadly see the point of the why arguments and can feel relative security in the answers advanced to the questions of how, they will still need something more - the additional fundamental political will, the impetus, to do it - to move towards the elimination of nuclear weapons, as indeed they have all promised to do. This additional political ingredient is, to use an appropriate word in a nuclear context, critical.

In my personal view, it may be possible to achieve this through the formulation of the new nuclear compact I have already referred to. This would be a stated political understanding, at a high level, that the meaning

and purpose of certain specific activities undertaken in a common, co-operative effort, is to create a NWFW.

The components of such a compact are largely already known but they need to be characterised as the components of a larger, agreed, political goal. They include: CTBT, a cut-off convention, START III under which the START II limits would then be extended down to zero: three nuclear stockpile reduction processes by; the United States and the Russian Federation, all nuclear weapon states and, the threshold and undeclared states; the development of global measures against break-out and nuclear terrorism; and a strengthened IAEA.

Measures such as these may not be the only measures required. Others may be able to be designed and others may prove to be necessary as the work towards a NWFW proceeds. But the measures that are able to be described and those that are then added as the work proceeds should be seen as constituting, as a whole, the means through which we build the architecture and the fact of a NWFW.

A new nuclear compact would also add the critical political dimension. If all states were to commit themselves anew to the common goal of a world without nuclear weapons and give their support to a given list of actions, they will not only greatly increase the chances of success within the individual negotiations on the component parts of a NWFW but would ensure that the underlying momentum is maintained and the indispensable sense of security protected.

In one sense, the international community has already taken a step towards the development of a new nuclear compact, that is, in its decision to extend NPT indefinitely. That action put beyond doubt the determination of the world community to maintain the norm that no state should possess nuclear weapons and to try to keep its promise of the elimination of nuclear weapons. This is the widely supported interpretation of the political conditions under which the indefinite extension of NPT was agreed to.

The continuation of Chinese nuclear testing and the resumption for some seven months of French nuclear testing, justifiably, caused widespread scepticism about what happened at the NPT Review and Extension Conference. The depth of those feelings was expressed by the General Assembly of the United Nations, five months ago, when it adopted by an overwhelming majority, a simple resolution sponsored by Australia and Japan, among 40 others, calling for an immediate end to all nuclear testing.

But, there can be no doubt, the fact that the NPT is now permanent can become the first foundation stone of a new nuclear compact.

The second such foundation stone should be a CTBT this year. The negotiations in Geneva are at a crucial stage. But, with effort and political persuasion, not least by persons attending this forum, we should be able to see a text of the Treaty submitted to the General Assembly in September.

The same applies to the IAEA's current effort to create a strengthened safeguards system in order to provide an effective verification regime into the 21st century.

At the end of the Second World War, the end of the colonial period, the international community designed responses to the challenges of the atom and development which were the best that could be achieved under the increasingly threatening circumstances of the Cold War and the nuclear arms race.

What is now required is the response demanded by the end of the Cold War and the emergence of a truly globalised world.

That response must include the deepest possible recognition that nuclear weapons are unacceptably dangerous to all and the only safe course is to eliminate them. The task of carrying out such elimination is difficult but not impossible. It is in fact smaller in scale and complexity than what the international community has agreed to in the field of the chemical industry and chemical weapons.

If this is to be achieved we will need, in addition to conviction about its importance and confidence in its feasibility, a new level of political commitment to carrying it out. That commitment or compact and the measures that would be taken in fulfilment of it should ensure that in the 21st century the world will become free of nuclear weapons and a world in which the most truly compelling of human concerns - those of economic and social development - are seriously addressed.

We would also have reversed history's greatest accident.

It is my hope that the Canberra Commission will be able to contribute to these objectives.

NUCLEAR REGULATION: THE CHALLENGES OF CHANGE

BY

DR. SHIRLEY ANN JACKSON, CHAIRMAN

U.S. NUCLEAR REGULATORY COMMISSION

BEFORE THE

JAPAN ATOMIC INDUSTRIAL FORUM

NAGOYA, JAPAN

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INTRODUCTION

Oh-Ha-Yo Go-Zei-Mas

Good morning. It is a privilege to have this opportunity to address the annual meeting of the Japan Atomic Industrial Forum (JAIF). I would like to use this occasion to discuss the challenges which nuclear regulators face as a result of a variety of changes. The future of nuclear regulation, and indeed of nuclear power as an energy source, will depend on our ability to meet these challenges effectively.

In the United States, change is being driven by sometimes conflicting pressures in four areas: (1) economic constraints and the restructuring of the electricity industry; (2) the changing role of government, in response to evolving public concerns; (3) the maturing of the nuclear

industry; and (4) technological innovations. All four factors have major implications for nuclear regulation.

The United States is not unique in this respect. To varying degrees, other countries are facing similar challenges. These efforts are often hampered by resource constraints, complicated by changing perceptions of the appropriate limits of regulatory authority, both inside and outside of government; and challenged by the need to stay abreast of technological advances. Although the precise character of the response to these challenges may differ between countries, the objectives are largely the same everywhere: (1) improvement in the already high levels of safety in the peaceful uses of nuclear energy; (2) improved nuclear power plant operating performance (which has the incidental effect of improving economic performance); and (3) better public understanding of the basis for the regulators' confidence that, with proper regulation, nuclear energy can play a part in the economic and social development of nations.

The common thread running through these issues is change. Governments, like individuals, sometimes feel most comfortable clinging to the status quo, even as circumstances shift around them. In the nuclear area, this is a luxury we cannot afford. Ignoring change can compromise public health and safety. If a nuclear plant is badly designed, or poorly operated, or inadequately regulated, remedial action must be taken. Safety upgrades, power reductions, or even shutdown and decommissioning

must be considered -- even in the face of power shortages, human and financial resource constraints, and political obstacles.

At the same time, change for the sake of change is by no means desirable. Allowing change to drive our decision-making in a haphazard and premature manner could be as dangerous as an overly rigid refusal to contemplate doing things differently. Unnecessary alterations in designs, or modifications or backfits ordered in haste, without a proper understanding of their long-range impact, can erode safety rather than increasing it.

In the end, the only acceptable approach is "managing change," by means accepting that change is inevitable and focusing our efforts on best defining and implementing long-term, well thought-out approaches to doing so. This will tax our human and infrastructural resources. It will require both vision and political will. However, I am convinced that "managed change" will have the best chance of maintaining nuclear power as a viable energy alternative, supported by a public which believes that its essential health and safety concerns are taken into account.

Just before leaving the United States to come to Japan, I addressed the eighth annual Nuclear Regulatory Commission (NRC) Regulatory Information Conference -- a major event on our nuclear safety calendar. The overall theme this year focused on enhancing and promoting a better

understanding of future trends for improving nuclear safety. The topics were, in microcosm, a mirror of the four challenges I outlined above. Economic constraints were addressed in the session on competition, utility restructuring, mergers, and NRC licensing activities. The changing role of government was reflected in the four sessions on NRC-licensee interface and communications. The broad issue of regulating a maturing industry was addressed in multiple sessions on updates to the rules on decommissioning, maintenance, license renewal and shutdown. Finally, technological change was the subject of sessions on such areas as the increased use of probabilistic risk assessments, advanced studies of reactor vessel aging, and even electronic information exchange.

As in all previous NRC Regulatory Information Conferences, the discussions were enhanced by various perspectives from the audience, which included representatives not only from the U.S. nuclear industry and utilities, but from almost all countries with nuclear power programs. This is ample confirmation that the development and regulation of nuclear power, while a national choice and sovereign responsibility, has significant international dimensions. Decisions on nuclear power issues in one country can affect nuclear programs of other countries as well, for good or ill. We need to learn from one another, and benefit from one another's technological and governmental expertise and experience.

I would like now to discuss in greater detail how we might approach each of the four areas of change I have outlined.

DIMENSION OF CHANGE

Economic Change

First, let me address some economic dimensions of change.

The U.S. electric utility industry is currently facing challenges that will inevitably change its business practices in fundamental ways. At present, the industry is restructuring in an effort to become more competitive, to lower electric rates to consumers, and to respond to Federal and state regulatory initiatives. The implications of these challenges to U.S. utilities and to the NRC are not yet clear. It is important to place these developments into proper context. Safety performance, reliability, and availability of U.S. power reactors during the 1990's have been good and generally continue to improve slowly. This is demonstrated by the key operational safety indicators monitored by the NRC. Improved management of operational safety has been accompanied by decreases in average plant operation and maintenance costs, and increased plant availability.

Paradoxically, this excellent record of nuclear power may also contain a degree of risk: that complacency might subtly erode the vigilance that a true safety culture requires. Further, there is the danger that increased competitiveness in the electricity industry, driven in part by pressures from state public utility commissions to contain costs, may create pressures to minimize expenditures to the point that safety is compromised.

In all countries I have visited during my first year as Chairman, I have seen that securing reliable sources of energy dominates national agendas. Those states which have significant national nuclear energy programs face increased competition from alternate sources of energy, often compounded by new policies directing the privatization of the nuclear sector. In countries just beginning nuclear programs, or contemplating a nuclear power option, high start-up costs and extensive infrastructural demands are weighed against the costs of imported fossil fuels, or their associated environmental effects. In states with aging nuclear power facilities, the decision to continue operating is sometimes a function of social need, which may outweigh strict cost accounting.

In this complex situation, the regulator must keep abreast of how rate deregulation, competition, and economic constraints affect reactor licensees, because all three can impact safety. In the U.S. I have to ensure that nuclear electric generators continue to maintain high safety

standards, with sufficient resources devoted to nuclear operations, and with decommissioning funding assured. I have asked the NRC staff to analyze this changing business environment carefully to determine the adequacy of our current regulatory requirements. To this end, the NRC staff has proposed that the Commission initiate a rulemaking to provide adequate assurance of decommissioning funds for those power reactor licensees which are no longer economically regulated.

Changing Role of Governments

Many Americans have come to believe that Government is too large, with too pervasive an impact on industry and the public. Each country's experience is different, but the United States is not alone in facing questions about the proper role of government regulation. Part of our task is to assure that, regardless of where the lines are drawn, adequate protection of public health and safety is not compromised.

Budget Cuts and Deficit Reduction

Continuing budget constraints affect all U.S. government agencies which must be managed to avoid impact on the NRC's -- ability to carry out its mandate to protect public health and safety. The NRC itself has taken a ten percent budget cut for fiscal year 1996. All indications from the U.S. Congress are that, in subsequent years, we can expect a continuing

decrease in available funding. Within this tighter fiscal environment, it is essential to prioritize our activities.

Moreover, smaller budgets do not necessarily mean decreased responsibilities. For example, in the newly independent states of the former Soviet Union, governments with slender and uncertain budgets have had to take on the demanding responsibilities of regulating, as well as operating, existing nuclear power plants. They often lack trained personnel, adequate facilities, and even design information, and they have limited funds to devote to this complex process.

In the U.S., despite budget cutbacks, the NRC may have to assume new missions. An advisory committee was formed in 1994 by the Department of Energy to examine and make recommendations on external regulation of DOE facilities. DOE is currently studying the advisory committee's recommendations, and this month expects to issue its findings. If full responsibility for DOE oversight is assigned to the NRC, it would add significantly to the NRC's current regulatory responsibilities, would require agency restructuring, and significant additional resources. Such a step also would require Congressional approval.

Changes in a Maturing Industry

In those countries which began their civilian nuclear programs in the 1950's and 1960's, the industry has operated long enough to have

accumulated challenges such as aging facilities and disposal of substantial quantities of nuclear wastes. On the face of it, for countries just now beginning nuclear programs, planning at the outset for aging, plant life extension, and even disposal of waste may seem remote and possible to defer. In reality, however, addressing these issues at the outset of a program is fundamentally important. Without advance planning, preferably in the design stages, modifications needed to operate and eventually extend the operating life of a plant may be very difficult and very costly.

In the U.S., we have learned that planning for decommissioning a plant is as important as planning to construct and operate it safely. In the U.S., as elsewhere, the short- and long-term disposition of wastes has become a national problem. Without early, detailed attention to the safe management of these wastes, it is unlikely that nuclear power will garner the public support needed to invest in developing the industry.

Aging Reactors

Aging, as you know, affects all plant structures, systems, and components to varying degrees and can affect operations and safety, if not properly managed. The regulatory authority of each country must examine the standards and operating procedures imposed on critical components to assure itself and the public that an adequate safety margin will be maintained. Two specific aging problems of great

importance worldwide are reactor pressure vessel embrittlement and steam generator tube degradation. Some U.S. reactor pressure vessels may approach pressurized thermal shock screening criteria before the end of their license terms. If so, licensees will have to perform detailed analyses to demonstrate that the plants can be operated safely. If the analyses do not support continued safe operation, the embrittlement of the reactor pressure vessel must be mitigated in some way, such as by thermal annealing, or these reactors will have to be shutdown.

Steam generator tube degradation represents potential failure of one of the principal fission product barriers in a pressurized water reactor. The NRC is considering a generic approach for dealing with steam generator tube degradation that will reduce plant-specific regulatory decisions, while ensuring defense-in-depth through a balance of protection, inspection, and mitigative measures. In the end, however, many plants may have to replace the steam generators; and, indeed, a number have done so.

The NRC believes that, as operating plants age, an important step in ensuring that licensees continue to focus on safety-important plant equipment is our risk-informed and performance-based Maintenance Rule, which will become effective in July. Under this rule, licensees will establish maintenance programs determining the risk-significant structures, systems, and components for the specific plants. Additionally, they must: (1) establish equipment performance and

condition goals, and the requisite equipment monitoring regimes; (2) modify established goals on the basis of plant or equipment performance; and (3) determine whether to rely on preventive maintenance in lieu of establishing goals and performance or condition tracking. Through inspection, the NRC will monitor performance against the licensee's program.

Life Extension

The NRC recognizes that, if age-related issues are properly addressed, there is no reason that electric utilities, and our nation, should be deprived of the electricity that these older plants can generate. Therefore, we have worked to create an effective regulatory environment in which plants still capable of additional years of safe operation may continue to operate beyond forty years. In the U.S. regulatory scheme, this means extending or renewing a nuclear plant operating license. The NRC has recently developed a regulatory process to handle license renewal in 10 CFR Part 54, and stands ready to review an application when one is received. Reports from industry groups to discuss generic license renewal programs have been received, but no license renewal application has yet been filed. I would like to see this process tested during my tenure as Chairman of the NRC.

Waste Storage and Disposal

One of the most important and highly publicized issues facing the nuclear industry worldwide is nuclear waste storage and disposal. Without satisfactory resolution of this issue, the future role of nuclear energy in the overall U.S. energy mix will be severely constrained. This is both a technical and a public policy issue. The continuing delays in achieving a demonstrated and workable facility for permanent disposal of nuclear wastes has had a major influence on public attitudes toward the nuclear power option in the United States.

Based on what we know today, the NRC believes that a deep geologic repository is a technically feasible solution to the problem of permanently disposing of spent fuel and other high-level radioactive waste in the U.S. Once an application is submitted from the Department of Energy (DOE), the NRC will have to determine whether spent fuel and other high-level nuclear waste can be disposed of safely in a geologic repository constructed and operated by the DOE. To make that determination, the NRC will have to maintain, in the face of budget constraints, the technical capability and resources for developing the necessary analyses and determinations. In addition, the NRC could be called upon to license an interim centralized storage facility. The NRC is initiating an examination of its existing licensing capabilities and staff resources in case of that eventuality.

Finally, in the U.S., the responsibility for identifying sites and developing disposal facilities for low-level radioactive waste was given to the states. They may enter into compacts for the establishment and operation of regional disposal facilities for low-level wastes. The NRC or, as appropriate, those 29 states which have signed agreements with the NRC allowing them to regulate the use of radioactive material within their borders (the so-called Agreement States) are responsible for licensing these facilities. It currently appears that most, if not all, low-level waste disposal facilities will be licensed by Agreement States. Nevertheless, the NRC must also maintain some level of licensing capability in case we are called upon to license directly a low-level radioactive waste disposal facility.

Technological Change

I believe the term "technological change" should be interpreted in the broadest possible manner -- to include, for example, new reactor designs as well as improvements in the methodologies used to calculate the probable risks of operating existing plants. These technical innovations provide important tools for industry and regulator alike.

New Reactor Designs

Although new nuclear generating capacity does not appear to be on the U.S. electric power industry's horizon at the moment, the possibility

remains that utilities and other electric power generators will consider a standard nuclear power plant as a source for new generating capacity. The NRC has issued final design approvals for two standard reactor designs and is in the process of certifying these designs by rulemaking. We expect that the certification of the two standard reactor designs -- the General Electric Advanced Boiling Water Reactor and the ABB/Combustion Engineering System 80+ -- for which we are currently assessing public comments, will be completed in 1996. The NRC is also reviewing the Westinghouse AP-600 standard design application for a novel light water reactor design employing passive safety features and greater use of modular construction. While General Electric announced that it was ending its Simplified Boiling Water Reactor program, Westinghouse has confirmed its continued participation in the DOE's first-of-a-kind-engineering Advanced Light Water Reactor effort.

New Methodologies

In regulating the mature nuclear industry in the U.S., I favor the use of risk insights, such as Probabilistic Risk Assessments (PRAs), although I myself prefer the phraseology "risk-informed, performance-based regulation." This approach, if properly applied, tends to relieve regulatory burden by focusing on those aspects of nuclear operations that have the greatest safety significance, while maintaining the principle of defense-in-depth. It may also reveal vulnerabilities which, in principle, could result in new requirements. On balance, a

risk-informed, performance-based approach allows a sharpening of focus and a targeting of attention and resources in the most efficient, cost-effective ways.

The NRC has some regulatory initiatives embodying this approach -- including amendments to the containment leakage testing rule, the maintenance rule, and a proposed reliability data rule. But the significant limitations of PRAs must also be acknowledged, especially if industry seeks to use them for lightening regulatory requirements within the existing framework of regulations. Further improvement of PRA methodology includes narrowing the gap on assumptions, consistency, level of detail, reliability of data, organizational factors, management oversight, and the cumulative effect of equipment degradation. In part to foster consistency in the use of PRA in NRC decision-making, the NRC last year issued a PRA policy statement and related implementation plan. The NRC staff has been tasked to develop a basic structure for a risk-informed, performance-based regulatory framework, including standards development and, on an expedited basis, a standard review plan.

Nondestructive evaluation (NDE) is also a technique with considerable promise for regulatory authorities -- in particular, for dealing with the issue of neutron radiation embrittlement of reactor pressure vessels. Over the past 30 years, researchers have made significant progress in understanding the variables that affect such embrittlement. However, we have not yet made sufficient progress in measuring

embrittlement changes in operating reactor vessels and relating those changes to microscopic models which give a stronger predictive capability, and which allow an assessment of post-annealing properties. To improve this situation, we should pursue the use of advanced NDE techniques to measure embrittlement of irradiated reactor vessels, with direct monitoring, not restricted by a limited number of test specimens. Advanced techniques will become increasingly important during the later stages of reactor operation when toughness properties are approaching safety limits. Although the development of new NDE methods for measuring radiation embrittlement is a formidable task, such methods would be clearly beneficial as a supplement to current practices.

APPROACHES FOR MANAGING CHANGE

As I noted at the beginning, the development of nuclear power is and always has been an international undertaking, with extensive technology transfer between nations. However, countries have differed in the way they have developed and applied the operational and regulatory safety culture by which the risks and consequences of radiological accidents are kept within acceptable bounds. I have tried today to point out the similarity of the challenges that currently face many nations with nuclear power programs. Given those common challenges, it is time that we share not just technology, but also our collective wisdom in coping with today's change-driven environment. We need to explore how better

to communicate our experiences and coordinate the use of resources to manage the changes and challenges which we all confront. I now would like to focus on two approaches to achieve this end: transparency and coordination of resources.

Transparency and Public Trust

How best can we assure safety and public confidence during periods of economic constraints and industry restructuring? What role should downsized and budget-restricted government have in ensuring domestic and international safety? What is the most appropriate and effective way of regulating a maturing industry? And finally, what technological changes can be harnessed for maximum effect in ensuring public health and safety? I believe transparency is the beginning of an answer for each of these questions, because it generates public trust, demonstrates how decisions to allocate scarce resources are made and implemented, ensures effective cross-fertilization of experience and information, and promotes the use of new ideas and technology.

Public trust in nuclear energy, and by extension in those who regulate it, is inherently fragile. It is nurtured and strengthened only when government officials and the industry they regulate are utterly candid and honest -- painful as that sometimes may be. There is a kind of pact that exists between the public and those who operate and regulate technologies such as nuclear power; and the rock-bottom foundation of

that pact is candor. The temptation to mask the unpleasant truth, or gloss over the embarrassing failure, is one that must be resisted to the utmost. Otherwise, public confidence may be lost irretrievably. Moreover, if we are not candid with the public when we discuss our shortcomings, we cannot expect to be believed when we describe our successes. Overall, the story of commercial nuclear power and its regulation has been admirable, in the United States and abroad, but public acceptance has lagged behind, and to some extent that is attributable to the fact that transparency has not always been the guiding principle.

I believe that the only answer is to transact our business in the most public way possible. I have been reminded of that recently in the publication of articles in the U.S. on the Northeast Utilities' Millstone plant and its noncompliance with its Final Safety Analysis Report (FSAR). Millstone operators allegedly were routinely performing full core off-loads, were ignoring the mandated 250-hour cool-down period for these offloads, and allegedly were placing the primary cooling system at risk. Further, evidence suggests that this activity had been taking place for over twenty years, without NRC intervention. In response to the situation, and in an effort at honest self-appraisal, I have requested an in-depth lessons learned assessment -- incorporating suggested improvements of oversight processes including:
(1) clarification of relative responsibility and accountability of those with direct plant oversight; (2) development of appropriate guidance for

performance-based regulatory approaches; (3) strengthened training of inspectors; and (4) improvement of our responsiveness to the public, including whistleblowers. These assessments will help us to improve our performance as regulators/safety officials. Has it been painful? Of course. But I do not doubt that out of these pains will come gains for the NRC, the nuclear industry and the American public.

Coordinating Resources

The nuclear industry has long seen the benefit of sharing information and cooperating in reactor research, and in the design, development, and construction of nuclear power plants. The major vendors have invested in increased efficiencies, such as building reactor pressure vessels in one country, constructing instrumentation and control systems in another, and bringing them together in a single project in a third country. Likewise, they have banded together in domestic and international operators' groups to share information and experiences to build a common basis for safe operation of their facilities.

I believe the world's nuclear regulators should follow suit, and consider establishing a better mechanism for coordinating their own efforts. This could be done through a more regular forum for the exchange of information and views on topics of mutual interest. I know that significant exchanges already take place on an ad hoc basis and sometimes in the context of meetings at the IAEA in Vienna or the NEA in

Paris. However, these efforts do not always reflect the needs or priorities of regulators. We do not need a multilateral nuclear regulatory organization with a secretariat and headquarters. Nuclear safety must remain the responsibility of the nations in which the technology is utilized. However, a more formal organization of nuclear regulators on the international level might identify common themes and approaches and provide greater support for safety.

Another means of combining enhanced safety with a recognition of fiscal constraints is to build on the internationally applied concepts of collaboration and peer review, comparing perspectives on problems and the means of resolving them. A striking example of the success of this policy has occurred in the area of research, where many countries already share the results of their reactor research. In some specific technical areas, a number have joined together to address issues of common concern and interest by building upon the unique areas of expertise each nation possesses.

Specifically, I suggest that we consider an international reactor safety research program, focused on aging and risk assessment methodologies, in which we integrate our safety research activities. In certain areas of mutual interest, coordinated international safety research has already occurred, with excellent results. My proposal is meant to be a more structured and focused safety research program than generally exists internationally at this time. For this effort, existing multilateral

structures may be able to provide appropriate planning, focus, and coordination; if not, other mechanisms should be considered. The task may be difficult to achieve, but at least deserves careful consideration.

Another effective mechanism for sharing information is through the international Convention on Nuclear Safety (CNS), negotiated over three years by representatives from over 65 states. Among its significant obligations, the Convention requires each contracting party to "maintain a legislative and regulatory framework to govern the safety of its nuclear installations." Each party is required to establish or designate an independent regulatory body, independent of the promoters or producers of nuclear energy, and is obligated to keep the public informed. This instrument will help assure a safer global environment, not solely because of guiding principles that participants are obliged to follow, but because of the reporting and peer review processes implemented by the Convention. The Convention on Nuclear Safety is currently before the U.S. Congress for ratification.

CONCLUSION

I hope my remarks have given you some insight into why I believe our mutual goal should be the effective management of change in four major areas. These changes and the challenges they present, viewed as an

interrelated series of opportunities which both the international and the U.S. nuclear industries and regulators are facing, require from us greater efforts to coordinate and pool our information and our resources, and to maintain a climate of candor at all times.

There is today, in nations around the world with civilian nuclear programs, a wealth of experience of all kinds -- technical knowledge, operating experience, and understanding of what government regulation can and should accomplish. Much of that experience is in this room today. By ensuring that this experience is shared widely, we have the ability to benefit the people of our own nations and the world community as well. Great as this challenge is, it is an even greater opportunity.

Domo Arigato.

科学技術と未来社会

村上　陽一郎

近代科学の歴史は三層に分けられるというのが、私の考え方である。第一層は「前科学期」（pre-scientific）とでも名付けられるべきもので、１７世紀から１８世紀の西欧に生まれた自然についての知識活動である。代表はニュートン、ガリレオ、デカルトなどを挙げればよいだろう。第二層は１９世紀に誕生したもので「原科学期」（science in prototype）と名付けよう。われわれの常識的な理解のなかでの科学は、これに属する。第三層は２０世紀後半から顕著になってきた新しいタイプの科学研究活動であって、これは「新科学期」という言葉で呼びたい。

前科学期の知識

第一層の「科学」を科学と呼ぶことに、私は賛成ではない。というのも、ニュートンにせよ、誰にせよ、この時期の自然探求者は、その世界観の根底にキリスト教があって、自然とは神の被造物であり、神の計画の具現体であって、それを探求することは即神の計画の探求であるという確信の上に追求されるべきものとして、知識を理解していたからである。確かに彼らの提案した自然についての様々な知見のなかには、今日の科学者共同体（scientific community）の共有財産になっているものも多々ある。例えばコペルニクスの地動説（heliocentric model）、ケプラーの惑星の楕円軌道説（Keplerian model on plametary orbits）、デカルトの慣性（inertia）概念、ニュートンの万有引力（gravity）などは、その部分だけを取り上げれば、われわれの現在の科学のなかでそれなりに「正しい」と認めている考え方であり、概念である。しかしながら、われわれが現在の科学のなかで、そうした考え方や概念を「正しい」と認める理由と、彼らがそうした考え方や概念を「正しい」と認める理由との間には、相当の距離を見なければならない。

例えばコペルニクスの地動説と言われるものを例にとろう。たしかにコペルニクスは、それまでのプトレマイオスの「地球中心説」に替えて、「太陽中心説」を提案した。しかし、それが「正しい」と考えた理由は、神がこの世界を創造した際に、『創世記』の第一章に言われるように、最初に「光」を造ったと言われる考え方に忠実であるとすれば、どうしても太陽を宇宙の中心に置かなければならない、と考えたところにある。言い換えれば、コペルニクスは、キリスト教的な神学上の理由から、太陽を宇宙の中心に据えたのであって、そうした考え方はわれわれの「科学」とはおよそ掛け離れたものであった。

同じように、ニュートンは確かに、二つの物体の間には、距離の二乗に反比例する引力があることを主張した。だが、彼はそれがどのように働き合うのか、という問に対して、ニュートンは、空間は神の身体であり、神は身体である空間を通じて、引力を働かせると考えていた。彼の引力もまた、キリスト教的な神学の枠組みを強化するための一つの概念として、万有引力を提案していたのである。もし彼がこのような考え方の下で、万有引力の存在を主張した論文を、今の物理学会雑誌に投稿したとしたら、レフェリーは問題なく拒否の答えを出すはずである。

簡単に言えば、彼らは「哲学者」であり、キリスト教的な知の愛好者であった。もちろん、現在の科学者の間にも、キリスト教信仰を持つ人はいるだろう。しかし、現代われわれの科学のなかでは、研究の成果は、そうした個人的な信仰の様態とは全く関のないものでなければならず、そうした要素は邪魔な「夾雑物」として、厳しく排除されているのである。しかし１７世紀までは、そうした要素は「夾雑物」どころか、まさしく知識の根幹であり、それこそが知識追求の根源と考えられていた。したがって、１７世紀の哲学者たちのなかに、われわれの科学が容認する要素を見いだせたからと言って、かれらを、われわれの概念での「科学者」と考えてしまうことは、「時間錯誤」があると言わなければならない。そもそも「科学者」という言葉は、Wiliam Whewellが８４０年ころに造り出すまでは、英語のなかに存在しなかった。言い換えれば英語における《science》という語は１８世紀までは「知識一般」を指し、そこには、現在の「科学」に相当するような意味は含まれていなかったのである。

１８世紀に啓蒙主義の洗礼を受けて事情は一変する。啓蒙主義的姿勢にとって、キリスト教は啓発を受けるべき、より正確に言えば、廃棄さるべき迷妄に過ぎなかった。フランス革命に最も象徴的なように、宗教は最大の「旧制度」として、あらゆる場面から一旦剥奪されることになった。知識の世界も例外ではない。かくて、キリスト教を礎に構築されていた自然哲学は解体され、その解体作業のなかから立ち上がってきたのが科学であった。

プロトタイプの科学

１９世紀に初めて出現した「科学者」は、もはや神の計画の追求者ではなかった。彼らは自らのなかにある好奇心（真理探究心）に駆動されて、ひたすら自然についての知識を目指した。１９世紀前半では、その数は極端に少なかった。科学者を養成する機関もどこにも存在しなかったと言ってよい。大学は、伝統的な哲学部と、医学校、法学校、神学校という組織構造を守っており、理学部に相当するもの、つまり新興の科学を専門的に教育・研究する場所は、まだ大学にはなかった。そこで、第一世代の科学者たちは先ず仲間造りから始めた。ドイツ語圏に生まれた《Gesellschaft Deutscher Naturforscher und Aerzte》（通常ＧＤＮＡと略称される）や、イギリスの《British Association for the Advancement of Science》（同じくＢＡＡＳと言われる）などは、１９世紀前半、専門の違いなどは顧慮せず、とにかく数少ない科学者が集まって、同志を増やし、世間の理解を得ることに力を尽くした団体である。

次に彼らが行ったことは、同じ専門的好奇心を共有する人々だけで仲間を造ることであった。そしてそうした仲間だけが関心を持つような「専門的」知識を少しでも増やすことに全力を挙げ始めた。こうして専門学会が誕生し、専門ジャーナルが刊行され、専門論文が掲載されるようになり、「仲間うち評価」（peer review）が確立した。ダーウィンは１８５９年に『種の起源』を書物の形で、一般の読者を対象にして出版した。彼は生物学上の自らの学説を、一般の読者に宛てて発表したことになる。しかし１９０５年にアインシュタインが特殊相対性理論を発表したときには、それは完全な論文の形で、物理学の仲間だけが読む《Annalen der Physik》という論文誌を媒体としていた

さらには、そうした研究業績の褒賞制度も着々と整備された。ノーベル賞が制度化されるのは１９０１年のことである。

この科学活動では、科学者は個人に内発する好奇心をよりどころに、仲間にのみ評価される論文を書く（業績を挙げる）ことがその唯一の義務であり責任であることになった。その研究成果から、仲間の外の世界がどのような応用を造り出そうと、それは自分の責任ではないと考えることができた。核兵器の開発に際して、原子核研究に従事した物理学者の相当数は、そのような態度をとった。

他方社会の方も、これを支援する絶対的必然性はなかった。もちろん新興の科学を支援しようとする社会の側の反応がなかったわけではない。１８７５年にはドイツの大学に理学部が生まれた。科学を支援する財団も徐々に増えていった。しかしこうした支援の根拠は、《philanthropic》な動機からであり、それはバレーやオペラのような芸術活動を支援する論理と同じだった。こうした個人の好奇心に基づく知的活動も、人間活動として認めるべき一つの可能性である。これが支援を理由だったと言ってよい。

付言しておこう。この１９世紀から２０世紀前半に至る過程のなかで誕生し、育ったプロトタイプの科学は、当時進行中であった産業革命による技術の革新と、近代工業の成立という現象にはほとんど関わらなかった。化学を例外とすれば、産業技術の開発は、大学などで行われる学問や知識とはおよそ無縁の《entrepreneur》たちによって担われており、科学と技術の間の距離は、非常に大きかったと言える。

新科学の状況

「新科学」では、ここでも様相は一変している。プロトタイプの科学の使命が「真理の探求」という科学者個人もしくは科学者共同体の内部に存在する目標に向けられていたのに反して、「新科学」においては、使命は科学者共同体の外から来る。例えば軍事、産業、医療、教育、経済、安全保障、、、など様々な外部のセクターから、科学者共同体に対して提示される使命を、科学者が「請け負う」という形式を取る。したがって、そこでの研究活動の基盤は、もはや個人ではない。多くの、専門分野を異にする研究者の有機的構成（configuration）が個人にとって替わっている。。ここでは科学的知識は「搾取可能」（exploitable）なものとして捉えられる。「搾取」するのは外部世界である。科学者たちは、そうした「使命」を「請け負う」ことによって、言い換えれば「搾取される」ことによって、その反対給付として、肥大化した研究を遂行するのに必要な研究費を受け取る。

ここでは、科学と技術との距離は極めて近くなっているか、もしくは、もはやその距離は存在しない。ここでの科学者の研究は、その成果を「仲間うち」だけに発表するだけで満足すべきものではなくなっている。

そこでの科学者としての責任と義務とは、先ず、使命の発注主に対して、請け負いを十分誠実かつ効率的に果たしたか、というところで問われる。しかしことはそれだけではない。それは科学者共同体にとって、外の世界での使命達成であるから、それが外の世界全体に対して十分倫理的に妥当性をもっているかどうか、というところにまで、責

反社会的な使命達成のために「研究」に従事した。彼らは、使命の達成という発注主対する義務・責任は果たしたが、その使命達成そのものが、社会全体としては、倫理責任を厳しく追及さるべきものであった。

将来の科学技術と社会

２０世紀の後半から目立つようになってきた、こうした「新科学」はときに「モー２の科学」（science in Mode 2）ときに呼ばれたりもするが、いずれにせよ、２１世紀の社会において、この種の科学（それは「科学と技術」ではなく、純粋に「科学技であると考えられる）は益々、社会の重要な要素としての位置を獲得していくに違いい。もちろん今後もプロトタイプの科学がなくなってしまうと言いたいわけではない恐らくはプロトタイプ科学と新科学とは割合を変えることはあっても、共存しつつ推するであろう。

しかし、そうした場合に科学技術と社会との間の関係は「原科学」の時代とはかな違ったものになるだろう。プロトタイプ科学では、「科学者共同体」は「仲間うち」閉ざされており、評価も「仲間うち」であった。その意味ではそれは「閉鎖的」な組と言えた。外部からの介入は本質的な意味をもたなかった。新科学では、科学者共同は否応なく、外部に開かれている。使命と資金とは、組織的に外部から来る。その評もまた外部の介入が本質的である。こうした状況のなかでは、科学者たちは、自分たの研究内容を外部に対して十分納得できるように説明する義務・責任（accountabili が要求される。

他方外部社会の方でも、そうした説明を理解することを要求される。科学者の側にめられる《accountablity》という責任は、むしろ双務的なものである。外部社会、言い換えれば非専門家も、専門家の研究がどのような結果をもたらし、何が可能であっ何が不可能であるのか、将来にどのような問題が起こり得るのか、といったことについて、明確な判断ができる程度に、専門家の研究内容を理解することが求められる。

その意味では、今後の科学技術は、専門家の集団である「科学者共同体」が生産す知識を外部世界が「搾取」するという図式、あるいは科学者共同体は外部社会からでるだけの研究費をせしめるという図式から、両者の十分な相互理解のなかで、相互の力によって、社会的な問題を一つ一つ解決するという関係へと変わっていく必要があ

そのためには、科学者は、自分の研究をつねに社会的文脈のなかにおきながら、開れた目で、その研究を位置付ける能力を求められるし、非専門家の側も、つねに専門の研究に目を配り、理解し、建設的な批判を行う能力が求められる。科学教育も、こした面から、基本的に考え直さなければならない。そうしてこそ、われわれは、２１紀に楽観的になることができるのではないか。

JAIF ANNUAL CONFERENCE
April 18 1996, Nagoya

One Decade After Chernobyl: Summing up the Consequences

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[The presentation is based on Background Papers and Conclusions of the *International Conference One Decade After Chernobyl* held in Vienna, 8-12 April 1996.]

Ten years after the tragic accident at Chernobyl Unit 4, reports about its consequences continue to differ widely. To assess the situation as it is known today and to clarify the many issues involved - the health, environmental, social, economic and political along with the technical nuclear safety issues - the International Atomic Energy Agency a major international conference to take stock of the situation as it is now known. The Conference was co-sponsored with the European Commission and the World Health Organization and was chaired by Germany's Environment Minister, Dr. Angela Merkel. More than 800 participants took part with significant representation from the three most heavily affected former Soviet republics including the President of Belarus and the Prime Minister of the Ukraine.

Few accidents have been so thoroughly investigated as Chernobyl. In 1990 the IAEA carried out the International Chernobyl Project, the first major international scientific study on the accident's consequences. More than 200 experts from 23 countries were involved over a one year period. Today, five years later, the major conclusions of the Project still stand. The project reported at that time that no health effects could be directly attributed to radiation exposures. It predicted that with one exception any future increase over the natural incidence of cancers or hereditary effects would be difficult to discern even with large and well-designed long term epidemiological studies. The one exception was the forecasted detectable increase in thyroid tumors in children due to the high estimated dose from radioactive iodine - and this has been dramatically confirmed. The project also reported on the psychological effects, particularly brought about by stress and anxiety. The 1990 report indicated that the accidents social and economic aspects could be far more significant than any radiation related effects.

Following the IAEA's International Chernobyl Project, other intergovernmental organizations, notably the World Health Organization and the European Commission, took the lead in the international efforts to clarify the accident's consequences. Japan and other countries have also generously contributed to these and other more modest efforts. The Vienna conference last week was an opportunity to seek a common understanding and a consensus on the current and possible future impact of the accident. It would be unrealistic to expect full consensus among scientists on all issues, however broadly supported answers to many of the principle questions which have been publicly discussed over the past years were reached.

A wealth of information was presented. Eight background papers were prepared for discussion, each one during a full Conference session. The papers covered distinct key topics:

clinically observed effects,
thyroid effects,
longer term health effects,
other health related effects,
environmental consequences.
social, economic, and political impact,
nuclear safety remedial measures, and
the consequences in perspective.

To meet the needs of the diverse audience here today, I will during the remainder of this presentation summarize the major conclusions drawn by the Conference for each of the eight session topics. We begin with the clinically observed health effects.

Clinically observed effects

Of those involved in the initial response to the Chernobyl emergency, principally the Chernobyl plant staff and fireman, 237 were hospitalized. Of these 237, a group that clearly received the highest radiation exposures, 134 - more than half - were diagnosed as suffering from acute radiation sickness. Acute radiation sickness or ARS arises from impaired body organ functions due to the death of a large number of body cells. Of those with ARS, 28 died shortly afterwards - two others were killed by the initial explosion and fire, and another is thought to have died of a coronary attack. Subsequently, fourteen deaths from all causes among the ARS survivors have been reported, however the causes appear not directly related to radiation exposure.

In summary, early deaths occurred only among the initial responders to the Chernobyl accident and the total number that died stands at 31.

Thyroid cancers

Another clinically observed health effect has emerged during the past years involving young people up to the age of 14 at the time of the accident. It is due to the large quantity of short lived radioactive iodine that was released in the early phase of the accident. Iodine inhaled or ingested concentrates in the thyroid gland, resulting in large thyroid doses that are much higher than doses to other parts of the body. Young children with small and developing thyroids are especially vulnerable.

An increase in the incidence of childhood thyroid cancer has been documented in Belarus, the Ukraine and to a lesser extent in the Russian Federation - the variation brought about by the geographic distribution of radioactive iodine contamination during the early days of the accident. If the increase continues, the current 800 cases would increase substantially in the coming decade as the age group affected grows older - some estimates of the total cases being as high as several thousand. Three children have died. Fortunately, the number of fatalities should be limited as treatment is well over 90% successful if the thyroid cancer is diagnosed early. Surely, the affected group, estimated at about 1 million coming from the areas that were heavily affected by the early radioactive contamination, must continue to be closely monitored.

As would be expected, the incidence of thyroid cancer in young children today who were born more than 6 months after the accident is at levels of unexposed populations. An increase in thyroid cancer of those who were adults at the time of the accident has not been observed.

In summary, there will likely be an increase in the incidence of thyroid cancer during the next years. The estimated number of total cases in those who were children in 1986 is in the range of a few thousands - the number of fatalities limited with diagnosis and treatment.

Longer term health effects

Turning now to the longer term radiation induced health affects which would primarily show up as cancers late in life, reducing life expectancy by several years. For a variety of reasons they will be difficult to assess, particularly because radiation induced cancers cannot be distinguished from other cancers which normally results in the death of up to 25% of most populations.

Radiation doses received from the accident can only be estimated and the relationship between dose received and cancer induction is still debated and not well understood. Required epidemiological investigations are complex and extremely difficult to conduct as appropriate control groups for comparative purposes are difficult to find. The situation is more difficult as there has been a documented general deterioration in public health in the countries of the former Soviet Union since 1987. This general trend towards poorer health can be misinterpreted as due to radiation exposure.

The lack of an observable increase in leukemia in children - a prime indicator of radiation effects - implies that it is unlikely that increases in illnesses currently observed are radiation related. Also, Increases in leukemia among the most highly exposed liquidators and early evacuees have not been demonstrated.

To date there has been no statistically detectable increase in the incidence of cancer as a whole or in general mortality attributable to radiation exposure. The overall mortality rate for Russian males from 1990 to 1993 has increased by about 50%, much of it due to accidents and circulatory diseases - the cancer rate however has remained unchanged. During a similar period, the total death rate among the liquidators did not exceed that for the corresponding age group in the Russian Federation as a whole.

Nevertheless, because of the long delay between radiation exposure and the appearance of solid cancers, it is necessary to continue monitoring the exposed populations, concentrating on those who have received the highest doses - that is the liquidators, the evacuees from the 30 km zone and those living in contaminated areas. Based on an estimated dose, the possible number of cancers for each of these groups has been calculated.

Approximately 200,000 of the 800,000 registered liquidators were involved during the 1986 through 1987 time period. They received an average dose of approximately 100 mSv - equivalent to several years of allowable occupational radiation exposure. The predicted lifetime excess of solid cancer deaths over the normal number of 42,000 cancer deaths for this group is 2000 or a 5% increase. The excess predicted number of leukemia cases would be 200 compared to a normal 800 or a 20% increase. The 135,000 evacuated in the first weeks after the accident from the 30 km received an estimated dose of less than 20 mSv - equivalent to about one year of allowable occupational exposure. Among these evacuees, fewer than 200 of the normal 22,000 cancers would be expected to be radiation induced - a very small increase of 0.1%.

Of the 270,000 residents of the strict control zone 1,500 excess deaths over the normal 44,000 would be expected. For the 3.7 million residents of other contaminated areas the predicted lifetime excess is 2500 over the normal 430,000. Thus, the projected total excess cancers for all of the residents in all the contaminated areas would be about 4000 and would be indiscernible from the fluctuations in the statistical incidence of normal cancers. Large scientific and epidemiological research programmes, some of them sponsored by international organizations such as the WHO and EC, are being conducted to provide de further insight into possible future health effects.

In summary, on the basis of the current estimated doses for the liquidators, evacuees and those living in contaminated areas, the projected excess total cancer incidence would be indiscernible. Increases in leukemia may be discernible.

Other Health Related Effects

Turning now to one of the most important legacies of the accident, that is the extensive psychological effects in the affected regions, Psychological factors, such as stress and anxiety,

are known to lead to widespread health effects. The World Health Organization has concluded that psycho-social effects, unrelated to radiation exposure, resulted from a wide variety of reasons. They were most notably the lack of information immediately after the accident, the stress and trauma of compulsory relocation, the breaking of social ties, and the fear that radiation exposure was damaging their and their children's health. The effects are being prolonged by the protracted debate over radiation risks, necessary countermeasures and general social policy compounded by the appearance of thyroid cancers in children. The psycho-social effects among the population are extensive, serious and long-lasting.

In summary, overall the only health effects to date that are attributable to radiation exposure are those among the initial responders to the Chernobyl emergency and an increase in the incidence of thyroid cancer in children. Psychological effects are unrelated to radiation but are attributable to the accident and the countermeasures taken.

Environmental consequences

Turning now to the environmental consequences of the accident. During the first weeks after the accident, lethal radiation exposures were reached for some radiosensitive local ecosystems in the vicinity of the Chernobyl site, notably for coniferous trees and for some small animals within 10 km of the reactor site. By 1989 the natural environment in these localities had begun to recover. Today, no significant long term impacts on the ecosystems have been observed. However, possible long term genetic impacts remain to be studied.

The initial ground contamination principally from Cs-137 with a minor contribution from Sr-90 resulted in external radiation and also internal radiation from contaminated food in the normal diet. Milk and green vegetables had contamination levels in excess of what is today considered acceptable by the WHO/FAO Codex Alimentarius Commission.

Currently, ten years after the accident, 70 to 90% of the originally deposited Cs-137 is still to be found in the topsoil. However, effective countermeasures have been taken to achieve significant reduction in the uptake of cesium into food. In general, at this time, no food produced by the collective farm system exceeds established international levels, although some foods produced by private farmers do. It has been estimated that residents of the contaminated areas to date have received up to 70% of their expected lifetime excess exposure due to the Chernobyl accident and thus future exposure to radiation in these areas would pose a minimal risk.

However, complete rehabitation of the 30 km zone is currently not possible owing to specific hot spots of contamination near residential areas which would impose restrictions on lifestyle and possible future local radioactive contamination of ground water. Problems also exist because of the significant amount of buried radioactive materials where local dose rates can be considerable. Without orderly management of the provisional waste depositories, some long term risk for local groundwater contamination exists.

In summary, there are no obvious long-term impacts on the ecosystem that have been observed. Effective countermeasures can be taken to limit the uptake of caesium into the food supply. Thus, there is a low risk associated with the present radiation levels in the contaminated areas.

Social, economic and political impact

The real tragedy of the Chernobyl accident lies in its social, economic and political impact. The accident occurred at a time of major change in the former Soviet Union. Economic restructuring in the 'post perestroika period' since 1987 has resulted in a sharp fall in economic indices. The gross national product of Russia fell by more than 50%, industrial production by

even more, and investment by as much as 70%. The life expectancy of Russian men has fallen by about 6 years.

Owing to societal pressures and the political situation, there was between 1990 and 1995 a resettlement of 53,000 people in the Ukraine, 117,000 in Belarus and 50,000 in Russia. This was in addition to the original 116,000 evacuated in 1986 that includes the 40,000 residents of Prypyat, The evacuation and resettling of more than 300,000 people has created serious social problems linked to the hardships of adjusting to new living conditions.

In the contaminated regions, the birth rate has decreased, the work force is migrating from 'contaminated' to 'clean' areas, creating labor and professional shortages. The social and economic status of people living and working in the contaminated territories is heavily dependent on state subsidies. Some of the controls imposed to limit radiation exposure impede normal industry and agriculture. The situation has been compounded by incomplete and distorted information on the accident's consequences and the measures to alleviate them - especially during the first years after the accident. The majority of the population considers that the information concerning the radiological situation is insufficient.

In summary, the Chernobyl accident's consequences, aggravated by the political, economic and social changes of the past years, have led to a worsening in people's quality of life and health and to negative impacts on social activity.

Chernobyl in perspective

The question today for all those involved with the aftermath of Chernobyl is "what policies can be developed to yield the greatest benefits in human terms, taking into account both the real radiological risk and the current economic, social and psychological situation? Putting the accident into perspective may offer some insights.

For much of the remaining contaminated areas, the current dose rates are within the range of doses due to the natural background found in areas of Europe uncontaminated by the accident. For those who have continued living in the high contaminated areas, their lifetime radiation dose will actually be less than those of people living in Finland, France and Spain because of the high radon levels in these countries. Additionally, the largest part of the excess lifetime radiation dose has already been received. With these considerations, any proposed remedial measure intended to reduce the future dose further should be carefully weighed against their probable economic and psychological impact.

An examination of non-radiological accidents and their consequences may also be useful. Although none have come close to the economic, social and political damage of Chernobyl, some have had considerable environmental and health effects - the Bhopal accident in India killed 3000 and affected almost 200,000 people.

Concluding remark

A final brief word in concluding. Last week's conference on Chernobyl has clarified many of the outstanding issues, but it is only one step in providing help to those affected by the accident. Although much help has already been rendered, there remains a continuing need for further humanitarian and economic assistance to the peoples and countries to whom the Chernobyl consequences will remain a formidable burden for years to come.

Nuclear and radiation safety remedial measures

To complete a review of the Conference sessions, a few conclusions about the nuclear

safety aspects of the accident will be briefly itemized. The main causes of the Chernobyl accident were severe deficiencies in the reactor design and shut-down systems, in combination with violations of procedures. The lack of a 'safety culture' led to the inability to remedy such design weaknesses, even though they had been known long before the accident. A significant number of nuclear safety remedial measures have been taken during the past decade and a repetition of the explosion-like accident is no longer possible. Plans exist to further upgrade all Chernobyl type RBMK plants, but their implementation has been hindered by a lack of resources due to economic problems. The planned RBMK safety improvements have been identified as a top priority for national programmes as well as for international cooperation.

The condition of the sarcophagus around the destroyed reactor at Chernobyl remains a major concern. It was designed for a 25 year life, but built under difficult conditions. About 200 tones of irradiated and fresh nuclear fuel are in the enclosure, mixed with building materials mainly in the form of dust. The Conference reached conclusions on four items of concern.

High radiation dose rates as a result of a potential collapse of the sarcophagus would be confined to the plant's immediate vicinity with effects beyond 20 km not expected. However, a collapse of the sarcophagus could have implications for nuclear safety at the operating Unit 3. If fuel mass configurations exist that would become critical in contact with water, it could lead to significant radiation levels inside the sarcophagus, but large off-site releases are ruled out. Finally, the sarcophagus and more importantly material buried in the site vicinity are a source of significant radioactive material and pose a contamination hazard for the local groundwater.

チェルノブイリ事故後の健康影響調査をどう理解するか

（財）放射線影響研究所 理事長　重 松 逸 造

私は、チェルノブイリ事故後の健康影響調査について、スライドを使いながらお話しいたしますが、一部のスライドが日本語だけ Japanese version only のため、議長はじめ外国からの参加者の皆様には御迷惑をおかけすることを予めお詫びしておきたいと思います。

（S 1）　はじめに、一般論として、放射線の健康影響を集団 population について把握するための必須条件を申し上げます。それは、分母となるべき放射線被ばく者集団を、できれば被ばく線量別に明らかにして、この分母から発生する健康異常者を分子として把握することであります。つまり、この分母と分子の両者が揃って、はじめて放射線の健康影響情報として役立つわけでありますが、このような観点から、原爆も含めた放射線事故で有意義な情報を提供しているのは、広島・長崎とマーシャル群島の原爆をはじめ、南ウラルの核事故、医療被ばく、職業被ばくなどがあります。チェルノブイリは分母の把握が不十分で、健康影響情報としてはまだ有用とはいえません。

（S 2）　現在までに得られている放射線の健康影響に関する知識の最も重要な情報源が広島・長崎の原爆被ばく者データであることは周知の通りでありますが、過去約 50 年間の原爆放射線による過剰死亡の発生状況を模型的に図に示しました。急性死亡は 4 か月以内に終わり、2 ～ 3 年後より白血病が増加をはじめ、6 ～ 7 年目にピークに達してから漸減しましたが、一方数年後より固形がん solid cancers が増え出して、この傾向は現在も続いています。最近になってがん以外の心臓病なども被ばく者間で増えている点が注目されています。

（S 3）　このスライドは、ただ今の超過死亡の発生時期を数字で示したもので、白血病は 3 年目より増加が疑われ、5 年後には増加が確実となりました。甲状腺がんの場合は、それぞれ 7 年目と 10 年後ということで、これに比べるとチェルノブイリの甲状腺がん発生はかなり早いということになります。

（S 4）　このスライドは、広島・長崎の原爆生存者とチェルノブイリの被災者各グループについて、1 人平均の放射線被ばく線量推定値を比較したものでありますが、チェルノブイリで最も被ばく線量の高い応急作業者でも、広島・長崎の半分以下であり、原発周辺 30km 以外の汚染地に住む住民の場合は、今後 70 年間の推定被ばく線量が 0.08 ないし 0.16Gy ということであります。

（S 5）　チェルノブイリ事故が発生した際に、現場の作業員 400 名以上のうち、134 名が急性放射線症 acute radiation disease に罹患し、28 名が 3 か月以内に死亡しました

が、その後10年間にさらに9名が死亡しています。ただし、この9名は被ばく線量とも相関せず、死亡原因も放射線とは無関係なようであります。いわゆる汚染除去作業者 liquidators に多数の死亡者が出たという話は、放射線被ばくとの関係では信頼できるものとはいえません。

（S 6） 1991 年5月に IAEA より発表された“国際チェルノブイリ計画” International Chernobyl Project の“放射線影響のアセスメントと防護対策の評価” Assessment of Radiological Consequences and Evaluation of Protective Measures は、1年間にわたり世界約 200 名の専門家が参加して実施した計画で、この時点での最も信頼すべき科学的報告ということができます。この点は、先週のウイーン会議でも確認されたと考えています。

（S 7） 国際チェルノブイリ計画の報告書の一部には次のように述べられています。すなわち、「IAEA 調査班の推定線量と現在用いられている放射線リスク推定値によると大規模・長期の疫学調査でも将来のがん発生・増加を識別することは困難であろう。ただし、子供の甲状腺被ばく線量は、将来甲状腺がんの有意な増加をもたらす程度の線量といってよい。」こういう但し書きがこの報告書にあることを皆さんお忘れのようであります。

（S 8） 1990年 12月に WHO ヨーロッパ地域事務局がウクライナ共和国の Chernikov で開いたチェルノブイリ甲状腺シンポジウムの結論はスライドの通りで、この時点では結論を下すにはデータ不足ということになっています。

（S 9） 1995年 11月には WHO が中心になってチェルノブイリとその他の放射線事故に関する会議がジュネーブで開催され、多数の研究者や行政担当者が参加しました。

（S 10） この会議の目的のひとつが、1992年以来 WHO が主として日本政府の財政支援によって進めてきた“チェルノブイリ事故健康影響国際プログラム” International Programme on the Health Effects of the Chernobyl Accident、いわゆる IPHECA の現状報告と、このプログラムに対する今後の支援を求めることにあったようでありますが、この目的が遂成されたかどうかは、今の時点では必ずしも明らかではありません。

（S 11） この写真は、この時の WHO 会議の総括パネル風景ですが、会議の President を向かって右端の広島県藤田知事が務められたことは、広島・長崎の被爆 50 周年にふさわしい出来事かと考えています。

（S 12） これは、WHO 会議場の風景です。

(S 13) WHO 会議の結論を紹介します。（スライドの文章を読む）

(S 14) 同上の続き。　　（同　　上）

(S 15) WHO 会議が開かれた同じ 1995 年 11 月には OECD の核エネルギー局 NEA がチェルノブイリ事故の健康影響に関する見解を発表しています。

(S 16) その結論はこのスライドの通りで、要するに、WHO 会議での結論とほぼ一致しています。（スライドの文章を読む）

(S 17) 先月、3 月の 18～22 日には Beralus の Minsk で EC などの主催による同様の国際会議が開催されました。

(S 18) これは、その時の配布資料の一部で、EC が今日までに実施してきたチェルノブイリ関係の調査データを集めてあります。

(S 19) 1991 年より 50 億円 US$50Million の予算で開始されたチェルノブイリ笹川計画は、ベラルーシ、ウクライナ、ロシアの 3 共和国に協力して 5 か所の検診センターを設置し、10 歳以下の子供を対象に全身線量測定 whole body dosimetry counting、甲状腺診断 thyroid diagnosis、血液検査 hematological examination の検診を 15 万人以上に実施して、本年 4 月に当初の 5 か年計画を終了しようとしています。3 共和国の各センターとも全く同じ装置と手技で検診が行われたのが特徴で、各センター間で相互比較性 comparability のあるデータを提供しています。

(S 20) 検診自動車 mobile unit 内での甲状腺検査風景を示しています。

(S 21) センターでの採血風景です。

(S 22) 毎年出版されているチェルノブイリ笹川計画の検診報告書です。

(S 23) 1991 年より 1994 年に至る間における甲状腺検査成績を示していますが、Gomel 地区では甲状腺結節 nodule と甲状腺がん cancer が突出して多いことが示されています。

(S 24) 甲状腺機能異常と抗甲状腺抗体 anti-thyroid antibody に関しては 5 センターともそれほどの差はみられません。

(S 25) 3 共和国の 0 ～14 歳小児甲状腺がんの 1981 年より 1995 年に至る発生数。（口頭で説明を追加）

（S 26）　ウィーン会議で発表された最近の数字（同上）

（S 27）　ベラルーシにおける事故前後の地区別急性白血病数（同上）

（S 28）　甲状腺がんの期待数と実測数・地区別（同上）

（S 29）　チェルノブイリ事故後の固形がん・白血病発生予測数（同上）

（S 30）　同上続き

（S 31）　チェルノブイリの遺伝的影響予測（口頭で説明）

（S 32）　I-131 と Thyroid cancer　（同上）

（S 33）　Medical Use of I-131（同上）

（S 34）　Thyroid Cancer in the Marshall Islands　（同上）

まとめ：　Dr. Rosen から紹介された先週のウィーン会議における結論も含めて総括すると、チェルノブイリ事故後 10 年を経過した今日、放射線被ばくの影響と考えられる健康障害で著明なのは小児の甲状腺がんでありますが、原因放射線核種と疑われている I-131 に関しては、交絡因子の役割とともに今後の検証を必要とする部分が多く残されています。これらの原因究明とは別に、現地で小児甲状腺がん対策を早急に樹立すべきは当然で、これに重点を絞った国際協力が強く求められているものと考えます。

The Chernobyl Accident
Main Causes and the Safety of RBMK Plants

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1 Introduction

Nuclear power plants with RBMK, i. e. channel-type water-graphite reactors, have only been built in the Soviet Union. The main characteristics of these facilities were chosen with a view to make best possible use of the experience in designing and building isotope production reactors and of the capabilities of the machine-building and construction industries. The channel-type design of the reactor made it fairly easy to increase the unit power.

RBMK plants are generally classified into 3 plant generations. The first generating unit with a reactor of the type RBMK-1000 was commissioned on December 23, 1973, at the Leningrad nuclear power plant. Until the accident at Chernobyl, during less than 13 years, 14 units with RBMK-1000 reactors were commissioned in the former USSR (10 in Russia and 4 in the Ukraine) and one RBMK-1500 unit was put into operation at the Ignalina NPP in Lithuania. They accounted for 50% of the capacity of all Soviet nuclear power plants and provided about 60% of nuclear power in 1985.

Ten years have passed now since the accident which happened on April 26, 1986, at unit 4 of the Chernobyl Nuclear Power Plant. The events which led to this catastrophe have been investigated extensively by many teams of scientists. Although there are still some gaps of knowledge relating to details of some phenomena envolved in the accident, the insights gained in the meantime are sufficient to identify the causes and to take effective measures to prevent a repetition of such an event in the 15 RBMK units currently operated in Russia, Lithuania and the Ukraine.

2 Causes of the Accident

The accident occurred when the load-carrying capacity of turbogenerator 8 of Chernobyl Unit 4 was being tested under coasting conditions. The aim of the test was to examine the possibility of extending the time of forced core cooling

in the case of a loss of offsite power. The test conditions were characterized by a low power level, increased coolant flow through the core, and slight subcooling of the coolant at the core inlet. These factors had a direct impact on the scale of the effects which occurred during the tests.

The test programme was inadequate with respect to safety provisions. This holds in particular for the regulations for restoring reactor power after power reduction, providing the minimum permissible operating reactivity margin (ORM), and disabling the emergency protection and safety systems at an operating power unit.

In the beginning, the Soviet Union emphasized misactions and failures of the personnel as the main cause of the accident. This attitude was reflected in the conclusion of a report presented by the Soviet Union at the IAEA in 1986:

> *"The primary cause of the accident was a most improbable combination of violations of the operating procedures and rules, committed by the personnel of the unit.*
> *The accident assumed catastrophic proportions because the reactor was driven by the personnel to such an impermissible state in which the effect of positive coefficient of reactivity on the power growth was greatly enhanced".*

Nevertheless the serious deficiencies of the RBMK design causing the accident were already known at that time in the Soviet Union. The more detailed studies and investigations performed on the causes of the accident and the relevant phenomena after 1986 put more evidence on these deficiencies. This changed the view with respect to the individual guilt of the operating staff, substantially.

The results are summarized in the main conclusion of the Russian report to the International Conference "Nuclear Accidents and Future of Nuclear Power. Lessons of Chernobyl" held in Paris 1991. This report states that the accident was

caused by the coincidence of the following main factors: the positive void effect of reactivity and the shortcomings of the CPS design that resulted in positive reactivity introduction under the conditions in which the reactor had been put before the accident.

These findings were confirmed by later studies including those performed by Western experts. They permit to summarize the main causes of the accident as follows:

- severe deficiencies in the reactor core design and in the design of the shutdown system:
  - high positive void effect
  - positive scram effect of fully withdrawn control rods
  - missing incorporation of the ORM into reactor protection
- lack of safety culture in responsible organizations leading to the inability to remedy important weaknesses, even though they had been known long before the accident,
- an insufficiently elaborated and approved test programme with respect to nuclear safety,
- operation and operating equipment asking too much of the staff when assuming their responsibility,
- insufficient protection against beyond design accidents.

The design deficiencies did apply to all generation of RBMK plants, i. e. to first, second and third generation plants.

3 Safety Upgrading Related to the Causes of the Accident

3.1 Administrative Measures after the Accident

When the Soviet experts who were looking into the causes of the Chernobyl accident came up with their first findings, they gave the highest priority to organizational measures aimed at ruling out a recurrence of the status of the Chernobyl Unit 4 immediately before the accident. Rather soon a number of administrational measures were taken. For instance,

- it was forbidden to perform whatever experiments, disable reactor protections, install in the MCR whatever extra controls for reactor equipment,
- and the plant personnel were instructed to strictly follow regulations concerning operating reactivity margin, coolant/feedwater flow rate ration;

3.2 First Stage of Backfits

Then, from 1987 to 1991, a first stage of backfits was performed. These plant changes addressed the causes of the Chernobyl accident:

- The void reactivity effect was essentially reduced by
  - installation of 80-90 additional absorbers
  - increase of operative reactivity margin to 43-45 manual control rods (minimum: 30 rods)
  - increase of fuel enrichment of 2.4 %
- The efficiency of the scram system was increased by
  - elimination of water columns (elimination of positive scram effect)
  - new fast-acting shutdown system (2 ßeff in 2.5 s)
  - additional signals for safety system actuation
- Organization and operation was strengthened by:

- more frequent computation and display of the operative reactivity margin
- improved operating rules and procedures.

These upgrading measures were implemented in all RBMK reactors in a simular way. Thus, under the operating conditions permitted by the technical specifications a repetition of a Chernobyl-type accident is now rather unlikely.

Further efforts for improvement addressed areas such as plant management, training of personal (introduction of simulator training), non-destructive testing, and installation of remote shutdown stations. The status of those improvements varies from plant to plant. Some of these issues will be addressed in the following.

4 Other RBMK Safety Issues

Whereas the investigations performed in the first years after the accident focused on the causes of the accident, the objective of those studies was broadened by the time to a review of the overall safety of RBMK reactors. These investigations put evidence on a number of further design deficiencies not directly related to the Chernobyl accident and of particular importance for the 1st generation of RBMK's. These deficiencies concern for example

- the design of safety systems for assuring core cooling,
- the confinement of radioactive material during accidents,
- and the protection against hazards such as fires and floods,

Another important issue, relevant for all RBMK generations, is the possibility of intolerable consequences after a multiple pressure tube rupture. Further significant deficiencies were found with

- the quality of equipment and documentation,
- the role of licensing,
- the conduct of operation and the feedback of operating experience.

Nevertheless it was also seen that the RBMK design also exhibits some favorable safety features. Of particular importance is the relatively large thermal inertia which may be characterized by a large water inventory and a low power density.

4.1 Reactivity Control

With the first stage of backfitting the most severe deficiencies of reactivity control have been overcome. Nevertheless the still remain some weaknesses in this area which require further attention:

- Maintaining the ORM-value and the reactor power level within the range permitted by the technical specification still fully relies on correct operator response and not on automatic interlocks. Assuming a violation of technical specifications the possible void reactivity effect may reach the order of 2 - 3 ß for small ORM-values and low power levels. It is true that the possible void effect is substantially lower than in 1986. However it is still higher than the capacity of the fast acting part of the shutdown system and requires the addition of the slower acting control rods to ensure long term reactivity control. An implementation of automatic interlocks to keep the ORM and the reactor power within the prescribed range could overcome this problem. The issue needs further analysis.

- The recent investigations on RBMK safety put also evidence on the potential of a high reactivity insertion (4 - 5 ß) in the event of a complete voiding of the control and protection system (CPS) cooling circuit. This reactivity insertion due to CPS voiding is generally assumed to be slow so that it would be within the capacity of the control system. On the other hand the significance of the issue is underlined by precursors. Thus there is a common understanding that the possibility of such a large reactivity insertion has to be eliminated.

- Though substantial improvement of the shutdown system have been implement, some weaknesses are remaining. For some design basis accidents (e. g. pressure tube rupture or LOCA) there is only one scram criterion available. This requires further backfitting to assure to a reasonable extent at least two diverse signals for scram actuation for design basis accidents. Furthermore as required

by recent Russian regulations and as internationally agreed a second independent and diverse scram system is necessary for reactors with the characteristics like the RBMK to assure a sufficient reliability of the shutdown function. Different design solutions with regard to a second shutdown system are under discussion.

4.2 Safety and Support Systems

Regarding the original design of safety systems there are significant differences between the 1st generation of RBMK's on the one hand and the 2nd and 3rd generation on the other hand.

First generation plants

The first generation of RBMK plants was designed according to safety principles of the sixties. Due to substantial development of safety objectives, several safety relevant design features are now significantly below current standards. Thus, from today's perspective, the original design features in this area are characterized by large safety deficiencies.

There is a lack of redundancy and protection against internal hazards with regard to the emergency feedwater system. Other important support systems as well as the electrical supply system and the I&C are highly vulnerable to internal hazards. Furthermore first generation plants are not equipped with a separate emergency core cooling system which might compensate deficiencies of the existing emergency feedwater system.

One particular limitation of first generation RBMK compared to the 2nd and 3rd generation is that the largest design basis LOCA is restricted to a 300 mm break. In principle an upgrading of the ECCS capacity to cope with the break of the largest pipe (900 mm) would be possible. But an upgrading of the reactor building structures to withstand this large break seems not feasible. A possible solution for this problem would be to implement provision assuring such a high reliability of the

piping concerned (leak-before-break concept) that the probability of large LOCA's not covered by design can be reduced to an acceptable order.

Large scale backfitting of safety equipment is under implementation at unit 1 & 2 of Leningrad NPP. This includes the construction of a separate three-train ECCS, a three-train emergency power supply system, replacement of safety related I&C and further modifications in order to reduce the vulnerability to internal hazards. Similar plans exist for all 1st generation RBMK's. however, the realization of those plans turned out extremely difficult during the recent years.

2nd and 3rd generation units

With the second and third generation of RBMK plants, the design of safety systems and the protection against hazards have been considerably improved. These improvements are basically in line with the evolution of international safety objectives. Nevertheless there remain deficiencies compared to current standards, which may need further improvement.

Fire protection

A general weakness of RBMK reactors is related to fire protection provisions. this has been highlighted by several serious events. This main reason is that the former Soviet regulation put the main emphasis on fire fighting by fire brigades and less on passive fire protection. Large efforts have been taken to improve the situation. This includes upgrading of fire doors, covering of cables with protective coating, removal of large fire loads etc.. The status of implementation of such measures differs from plant to plant. Overall the situation with respect to fire protection is still not satisfactory and needs further improvement especially for first generation RBMKs.

4.3 Confinement Function

A specific design feature of RBMK's compared to other reactor types is the limited confinement function. First generation plants do not have a containment (accident localisation system). At Leningrad-1 and -2 a partial containment that can cope with

LOCA's up to the 300 mm break is now under construction. This partial containment is similar to the accident localization systems of 2nd and 3rd generation unit. The Russian plans for safety upgradings include those backfits at all first generation RBMK's in Russia.

2nd and 3rd generation units are equipped with partial confinements including pressure suppression pools. The design basis for these accident localization systems is the 900 mm main coolant pump pressure leader break.

The partial confinement of 2nd and 3rd generation plants is restricted to the lower part of the main coolant circuit. Therefore medium and large break in the area of the main steamlines, the upper parts of the downcomers and the feedwater line will also lead to radioactive releases into the environment. The safety significance of this deficiency strongly depends on the radiological consequence for the relevant LOCA's and on the efforts in the prevention of the respective accidents. Whereas backfitting in order to cope with breaks in the upper parts of the main coolant circuit seems not practicable, improved quality assurance in view of improved break prevention seem feasible.

4.4 Reactor Cavity Overpressure Protection System

A significant safety concern identified by the investigations carried out after the Chernobyl accident is the steam relief capacity from the reactor cavity. An excessive pressure rise in the reactor cavity could lift the upper reactor plate and thus lead to catastrophic consequences. The original design basis for the overpressure protection system of the reactor cavity is the rupture of a single pressure tube. More recent analyses show that this overpressure protection system can cope with the simultaneous rupture of up to 3 - 4 pressure tubes.

By now no plausible scenarios for simultaneous multiple pressure tube rupture have been identified. Nevertheless all plants are increasing the steam relief capacity of the reactor cavity to an extent technically feasible (up to 9 - 10 simultaneous pressure tube ruptures). In view of the potential consequences of a multiple pressure

tube rupture these efforts are of high importance. Smolensk-3, Leningrad-1 and -2 have already implemented these backfits.

4.5 Accident Analysis

Computer simulation of DBA's is essential for the design of safety provisions for NPP's as well as for the development of adequate operating procedures and proper operator training.

The scope of accident analysis in the Former Soviet Union was substantially limited due to a lack of adequate computer codes and advanced computers. This was of particular importance for RBMK reactor due to the very complex behaviour of these plants under normal and accidental conditions requiring advanced tools. Good progress has been made in this area recently. Nevertheless further efforts are necessary to validate the advanced computer codes now in use and complete the safety cases of each plant in a systematic way.

4.6 Conduct of Operation

The safety concept of soviet-type reactors strongly relies on correct operator response. Therefore adequate conduct of operation is high importance for RBMK safety. More recent reviews of operational issues of RBMK plant have high lighted an important potential for improvements in this field. The areas in question relate to management structure, feedback of operating experience, maintenance and operator training. An important part of the proposed improvement can be implemented in a short time period and with comparatively low costs. The experience of recent years shows that international cooperation in this field may be very effective.

5 Prospects

The safety of the existing RBMK designs ultimatly depends, in the same way as the safety of any nuclear power plant, on a sound implementation of defense in

depth. Thus, RBMK safety concepts need to assure appropriate redundancy, diversity, functional segregation and quality of systems assuring the basic safety function under accident conditions and appropriate precautions must be taken to exclude with extremely high confidence any accident initiator which could jeopardize all levels of defense simultaneously.

2nd and 3rd generation of RBMK's

The 2nd and 3rd generation RBMK's now basically meet most of the defense in depth objectives. Certainly there remain deficiencies and questions which need to be addressed such as

- remaining possibilities of reactivity accidents,
- the control and protection system and its interrelation between improved core design providing decreased void reactivity coefficient,
- possibility of and protection against multiple tube ruptures.

No fundamental problems have been identified so far in solving these issues. However, it must be recognized that the limitations of the partial confinement will require additional investigations and efforts for accident prevention.

1st generation of RBMK's

The safety of 1st generation RBMK's raises further questions in addition to those relevant for the more recent plant generations. There have been significant doubts in Western countries about the feasibility and the cost-effectiveness of backfits. However, the existing upgrading programs address most of the safety concerns. They include the backfitting of essential safety features such as control and protection systems, emergency core cooling systems, and partial confinement. Where "classical" approaches are difficult to implement they often rely on "compensating solutions" such as

- improved prevention of accident initiators where fully satisfactory control of accidents is not feasible or practical (e. g. leak before break concept for critical components (diameter > 300 mm),
- implementing accident management procedures where appropriate systems to assure the safety functions are available and/or specific advantages of the RBMK design provide opportunities.

When completed, such backfits will lead to significant improvements even if they will not always reproduce the technical solutions implemented in new RBMK plants. The work currently carried out at the Leningrad nuclear power station shows that those programs are feasible if financial resources are available and if safety issues receive due attention.

6 Conclusions

Summarizing it can be stated that the severe design deficiencies, which were the main causes of the Chernobyl accident, are now essentially removed in all RBMK plants. A repetition of a Chernobyl-type accident seems very unlikely.

There remain safety deficiencies, in particular with the first generation RBMK's. These deficiencies are essentially addressed by the existing upgrading programs. Many steps to be taken have been internationally agreed. The remaining deficiencies of the second and third generation plants, which are essentially improved compared to first generation plants, could be overcome in a way broadly consistent with the defense in depth objective. Implementation of the existing plans for safety upgrading of 1st generation will approximate those units to the more recent RBMK's.

The most significant RBMK problem seems to be the tremendous difficulties of the RBMK operators with a timely realization of existing upgrading concepts. Improvements in this regard are highly necessary. They will depend on new ways to emphasize safety as a factor of nuclear power plant competitiveness and to find financial resources for safety related work at these plants.

The Chernobyl Accident
Main Causes and the Safety of RBMK Plants

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The 29th JAIF Annual Conference
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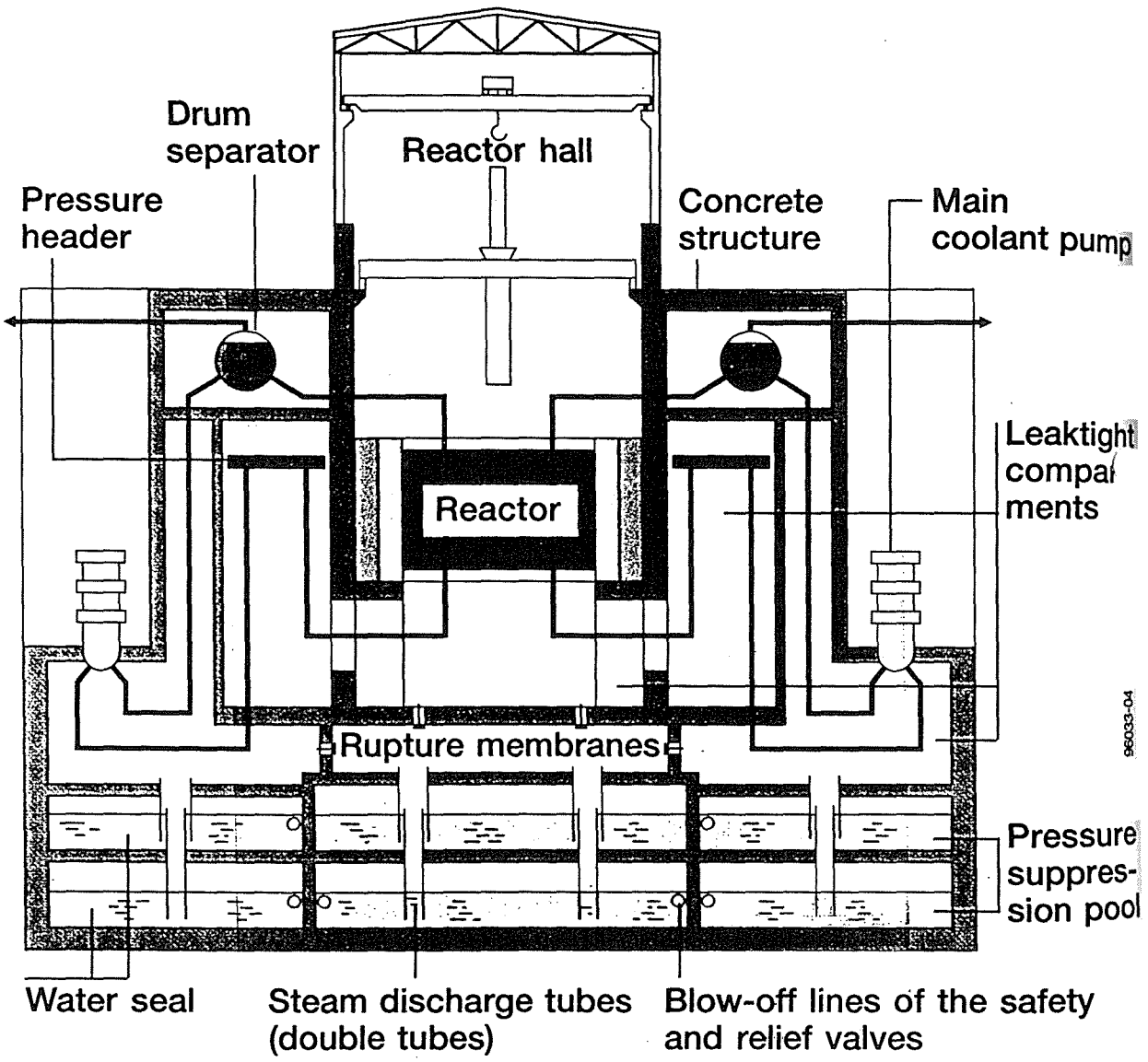
Basis of Knowledge

- Numerous investigations on accident causes and event sequences
- RBMK related programs of the European Commission, IAEA, and the EBRD
- Knowledge of Western experts still limited
  - no long term efforts on analysis and research on RBMK technology
  - almost no background knowledge in Western organisations
  - RBMK fundamentally different from Western reactor technology
- International Forum "One Decade after Chernobyl: Nuclear Safety Aspects"
  - causes of the accident
  - safety of RBMK plants
  - particular problems at Chernobyl

Relevant Questions relating to Chernobyl

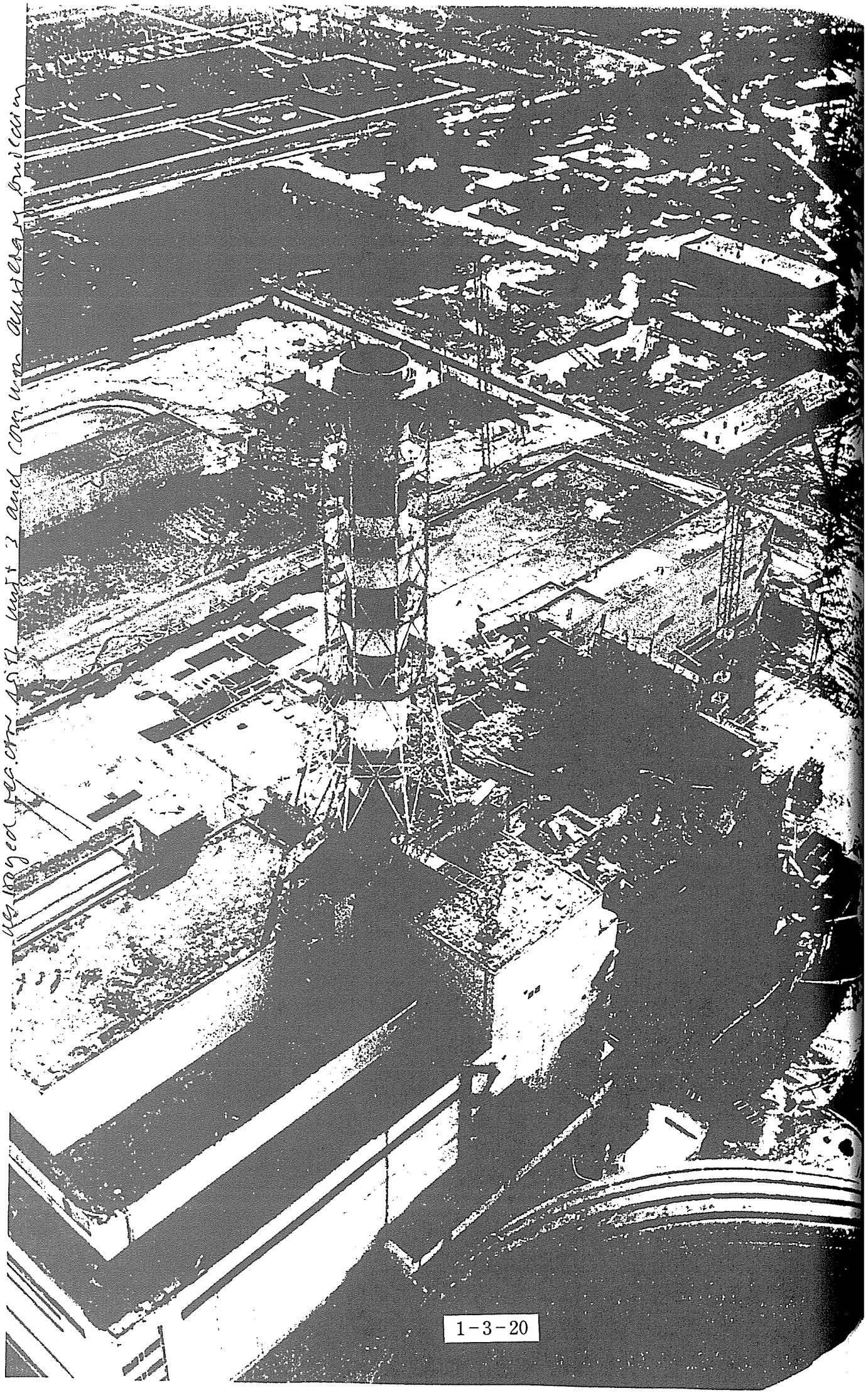
- Are the causes of the accident sufficiently understood?
- What has been achieved in RBMK safety since the accident?
- Could such a catastrophe happen again?
- What are the remaining problems regarding the safety of RBMK plants?
- What particular problems exist at Chernobyl?
- What needs to be done for RBMK safety in general and in Chernobyl in particular?



Chernobyl 4 Reactor Building (Principle Diagram)

Course of the Accident on April 26th, 1986

- An experiment to test a safety function is planned to take place during the shut-down process starting an outage of Chernobyl-4
- Due to various circumstances, the plant is brought to an extremely unstable condition before the experiment
- The coast-down of 4 coolant pumps intended by the experiment programme leads to a reduction of coolant flow through the reactor core
  => great increase in void formation
- The positive void effect and the SCRAM triggered just after result in a power excursion that is not controllable
- The associated energy release leads to the complete destruction of the reactor



Destroyed reactor with unit 3 and common auxiliary building

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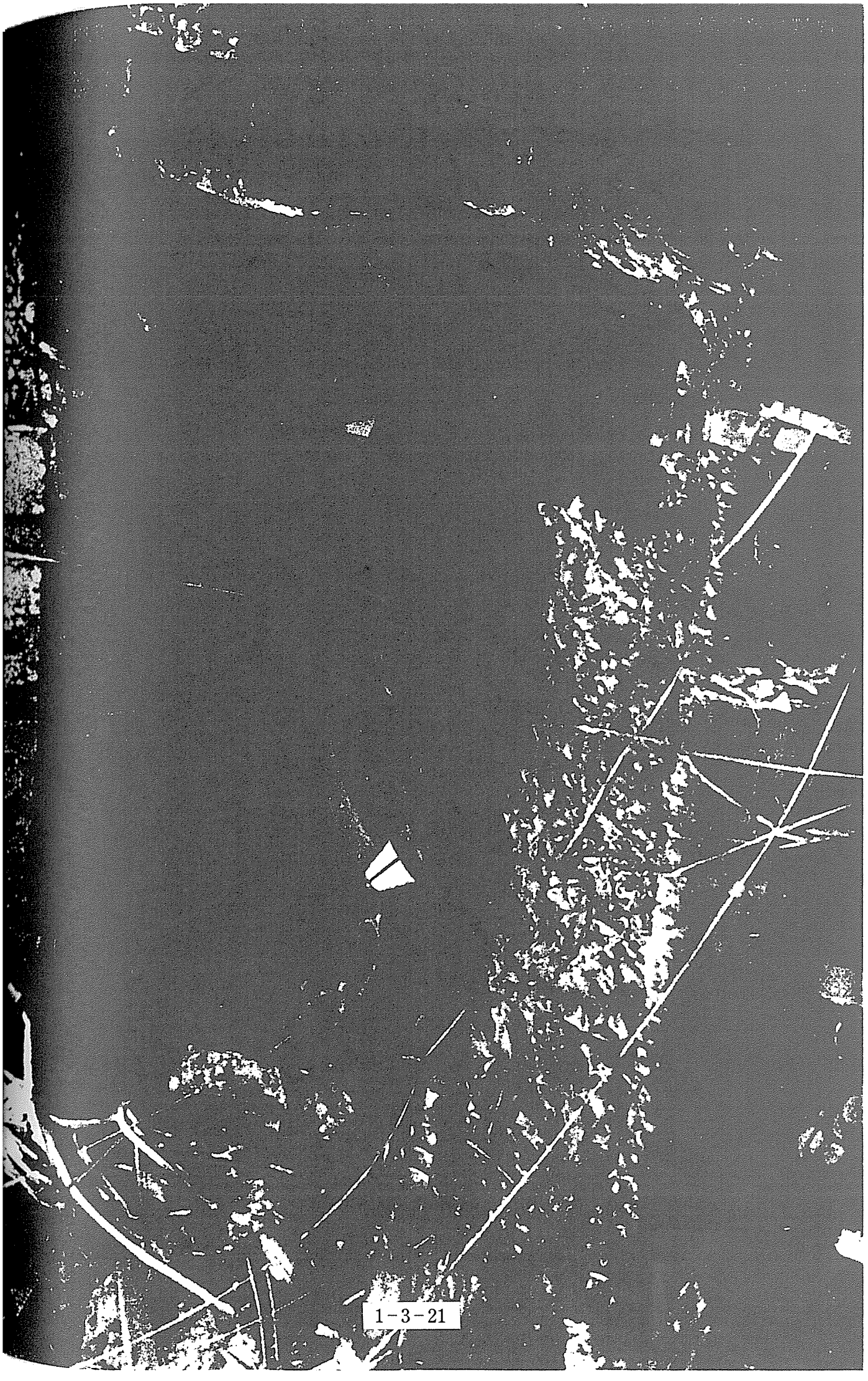
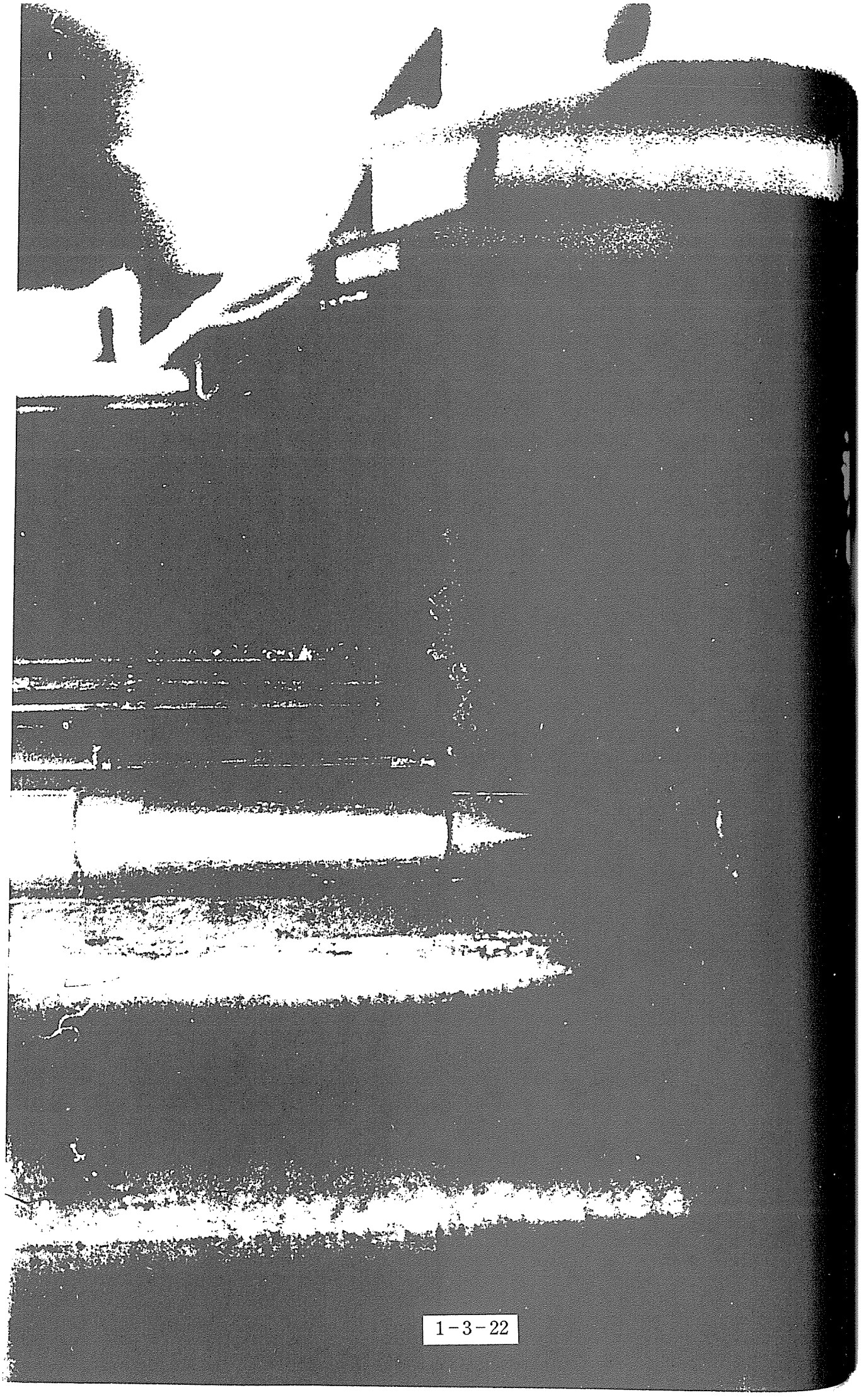




Causes of the Accident (I)
Soviet Position in 1986

The primary cause of the accident was a most improbable combination of violations of the operating procedures and rules, committed by the personnel of the unit.

The accident assumed catastrophic proportions because the reactor was driven by the personnel to such an impermissible state in which the effect of positive coefficient of reactivity on the power growth was greatly enhanced.

Causes of the Accident (II) Common Position in 1995 (International Technical Forum Vienna)

- Severe deficiencies in the reactor physical design and in the design of the shutdown facilities:
- Lack of safety culture in responsible organizations leading to the inability to remedy important weaknesses, even though they had been known long before the accident,
- An insufficiently reasoned and examined test programme with respect to technical safety,
- Violation of operating procedures,
- Operation and operating equipment asking too much of the staff when assuming their responsibility,
- Insufficient protection against beyond design basis accidents.

Causes of the Accident (III)
Reactor Physical Design and Design of Shutdown Facilities

- High positive void effect during operational conditions with high burnup 4-5 β
- Positive scram effect under conditions of the reactor before the accident 0.6 - 0.8 β*
- Missing incorporation of the operating reactivity margin into reactor protection

* up to 2 β for strongly peaked axial power distribution

Safety Features of Original RBMK Design not directly related to the Chernobyl Accident

- Generic deficiencies (all existing RBMK generations)
  - multiple pressure tube rupture
  - automation and Instrumentation and control
  - shutdown system very slow (18 - 20 s insertion time)
  - reactivity insertion of 3.5 - 4.5 ß by voiding CPS cooling circuit
- Generic favorable features
  - large water inventory
  - low power density
- First generation plants with large deficiencies
  - insufficient protection against hazards such as fires and floods
  - insufficient emergency core cooling systems
  - lack of containment
- Second generation plants significantly improved
  - partial containment concept

Generation of RBMK-Anlagen	Normal operation [actions/h]	Replacment of fuel elements [actions/h]	State of development
First RBMK plants with equilibrum load (Leningrad-1, end of 70ies)	180	500	high positive void effect (α_φ), $\alpha_\varphi = (4\text{-}5)\beta \times 10^{-2}$/Vol% no LAR system
RBMK plants in the period between 1980 - 1986	20	50	void effect still high, $\alpha_\varphi = (4\text{-}5)\beta \times 10^{-2}$/Vol% with LAR system
Smolensk-3 plant, 1993	2	50	current design with reduced void effect $\alpha_\varphi \approx 0{,}3\ \beta \times 10^{-2}$/Vol% LAR system
LAR: Local automatic power control			

Manual actions of the operator to stabilize spatial power density distribution

Safety RBMK in 1986

Safety function	Realization	
	1. generation	2.+3. generation
Reactivity control	serious flaws	serious flaws
Core cooling	significant deficiencies	deficiencies
Confinement	no	partial

Further RBMK Safety Concerns

- Quality of equipment and documentation
- Accident analyses
- Safety authorities and their support organizations
- Conduct of operation
  - plant management
  - maintenance
  - training
  - evaluation and feedback of operating experience

Thermal Inertia of RBMK Reactors

- Relatively low maximum linear heat rate:
  - RBMK-1000 - 350 W/cm
  - Western BWR (1300 MWe) - 460 W/cm
  - Western PWR (1300 MWe) - 580 W/cm
- Relatively high volume of liquid water in the "primary system"
  - RBMK-1000 - 968 m^3
  - Western BWR (1300 MWe) - 420 m^3
- Heat capacity of the graphite ~ 2000 t

➢ Potential for accident management measures, e.g. air cooling of steam/water lines and large metallic structures

reactivity

First Stage of RBMK Safety Upgrading Addresses Causes of the Accident

- All plants until 1991
- Reduction of void reactivity effect
  - installation of 80-90 additional absorbers,
  - increase in operative reactivity margin up to 43-45 manual control rods,
  - fuel enrichment 2.4 %,
- Increase of scram system efficiency
- Repetition of "Chernobyl-like" accident seems hardly possible
- Remaining possibilities of reactivity accidents
- Most design deficiencies not related to Chernobyl persist

Reactivity Coefficients of RBMKs after Reconstruction

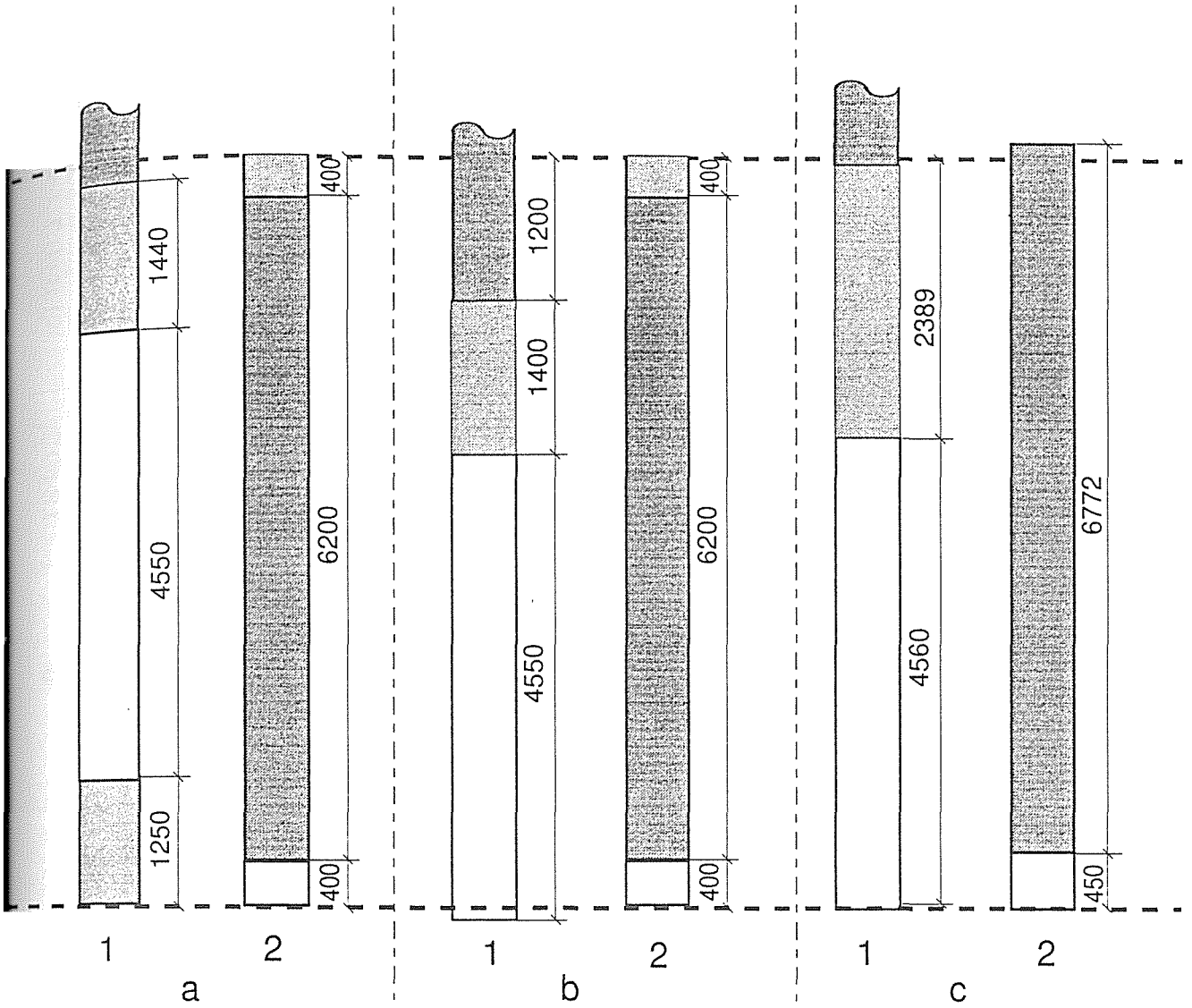
Positive total void reactivity effect: (nominal conditions, ORM= 45)	up to 1 ß
Increase of positive total void effect - low power conditions: - reduced ORM by 10 control rods:	 about 0.7 ß 0.3 - 0.4 ß
Reactivity increase by voiding of CPS-system - control rods in operational position: - all control rods fully inserted:	 3.5 - 4.5 ß 0 %

RBMK-Backfitting
Improved Efficiency of SCRAM System

- Elimination of water columns
- New fast-acting shut-down system (2 ßeff in 2.5s)
- Increase in insertion speed of control rods from 20s to 12-14s
- Integration of rods inserted from the bottom into scram system
- Additional signals for control and safety system

Current Void Reactivities and Power Coefficients of RBMK Reactors

Unit	Date of Measure-ment	Average Burnup (MWd/kg)	Addi-tional Absorbers	Fuel Elements with 2.4 % Enrichment	Void Reacti-vity (β)	Power Coefficient (E-4 x β/MW)
Leningrad-1	02/06/94	11.7	80	1520	0.8±0.2	-2.8±0.2
Leningrad-2	12/23/94	11.5	80	1474	0.4±0.1	-2.5±0.2
Leningrad-3	07/31/94	11.4	81	1579	0.8±0.1	
Leningrad-4	03/16/95	11.4	80	1579	0.8±0.2	-2.1±0.2
Kursk-1	04/11/94	9.6	99	1102	0.8±0.1	-2,3
Kursk-2	05/18/95	8.7	108	848	1.0±0.1	-1,8
Kursk-3	03/03/95	9.6	87	1075	0.6±0.1	-2,3
Kursk-4	12/16/94	10.2	84	1210	0.8±0.1	-2,1
Smolensk-1	04/21/94	11.6	81	1536	0.6±0.2	-2,8
Smolensk-2	03/29/95	11.5	81	1546	0.7±0.2	-2,1
Smolensk-3	01/24/95	10.4	93	1329	0.1±0.2	-2,7
Tschernobyl-1	04/28/95	10.6	84	1168	0.7±0.2	-2,7
Tschernobyl-3	04/14/95	10.3	93	1262	0.7±0.2	-3,5
Ignalina-1	03/18/95	7.7	52	0	*0.8±0.2*	*-2.3±0.2*
Ignalina-2	03/17/95	7.7	53	0	0.8±0.2	-1.8±0.2



- 3 Absorber

- 4 Graphite water displacer

- 5 Cooling water

a - original design rod,
b - original design rod, in an attempt to avoid possible insertion of positive reactivity
c - improved rod

1 - withdrawn rod
2 - inserted rod

The modernization of the RBMK manual control rods

sch1.cdr

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Second Stage of RBMK Safety Upgrading (After 1991) Remove Design Deficiencies not Directly Related to the Accident

- Take 1st RBMK generation to level of 2nd and 3rd generation
- Further improvements of the 2nd and 3rd RBMK generation
- National upgrading programs elaborated
  - basically consistent with findings of international investigations
  - technically feasible
  - underway only at Leningrad NPP
  - careful independent review required (safety authority)
- remaining open issues need analysis and remedy, e.g.
  - partial containment concept
  - multiple pressure tube rupture
  - remaining possibilities of reactivity accidents

Strengthening Organization and Operation (Progress Plant Specific)

- More frequent computation and display of the operative reactivity margin,
- Improved operating rules and procedures.
- Plant management
- Training of personal (e. g. simulator training)
- Non-destructive testing

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Status of RBMK Backfittings in 1996

Safety function	Improvements	
	1. generation	2.+3. generation
Reactivity control	considerable	considerable
Core cooling	partial	-
Confinement	partial	-

Nuclear Safety Problems at Chernobyl

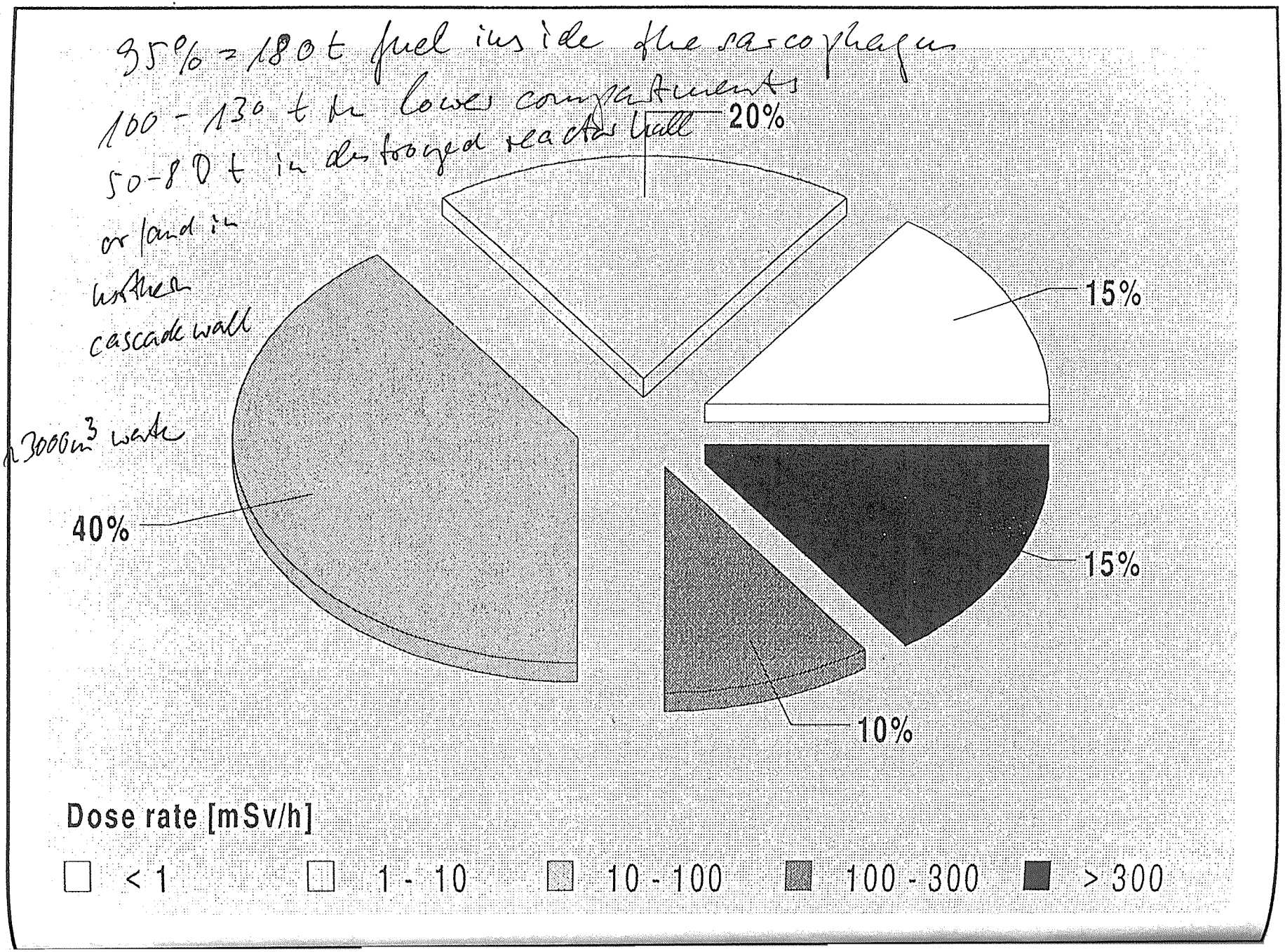
- 1st stage of backfits for running units at Chernobyl
- Further safety problems due to quality of the plant
- Negative impact of former moratorium on safety culture (up to 1992)
  - delayed safety upgrading
  - drain of specialists
  - decline of safety indicators

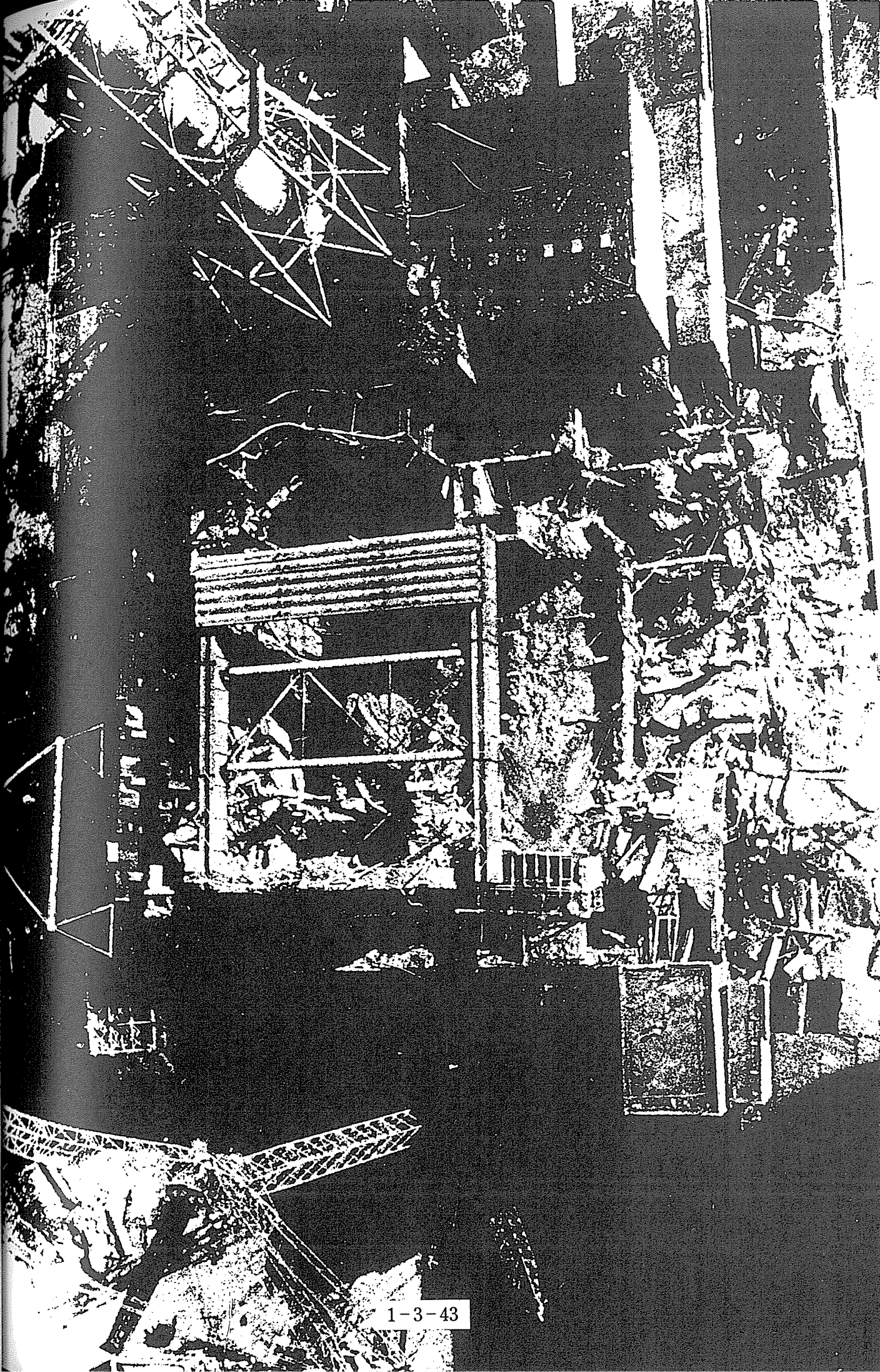
Other Problems at Chernobyl

- Stability of the sarcophagus
- High-active material provisionally buried within the grounds of the plant
  - obstacle to ecological restoration
  - long-term hazard for groundwater
- Safe disposal of Unit 4 or parts of it
- Problems are closely interrelated

Safety Issues of the Sarcophagus

- Stability
  - protective target fulfilled for ten years now
  - no permanent enclosure (risk of a collapse)
  - even in the worst case no wide-spread effects
- Penetration of water from the shelter into the environment
  - long term risk of groundwater contamination
  - less significant than contact of water with the radioactive material outside the sarcophagus
- Possibility of a recriticality
  - currently critically safe
  - recritically cannot completely be excluded when lava in contact with water
  - neither large off-site releases nor mechanical effects
- Possible interaction between the destroyed reactor and the running unit 3
  - risk generally assumed to be low
  - not yet been sufficiently analyzed


35% = 180 t fuel inside the sarcophagus
100 - 130 t in lower compartments
50-80 t in destroyed reactor hall
or land in
western
cascade wall
≈ 3000 m³ water
20%
15%
15%
10%
40%
Dose rate [mSv/h]
< 1
1 - 10
10 - 100
100 - 300
> 300



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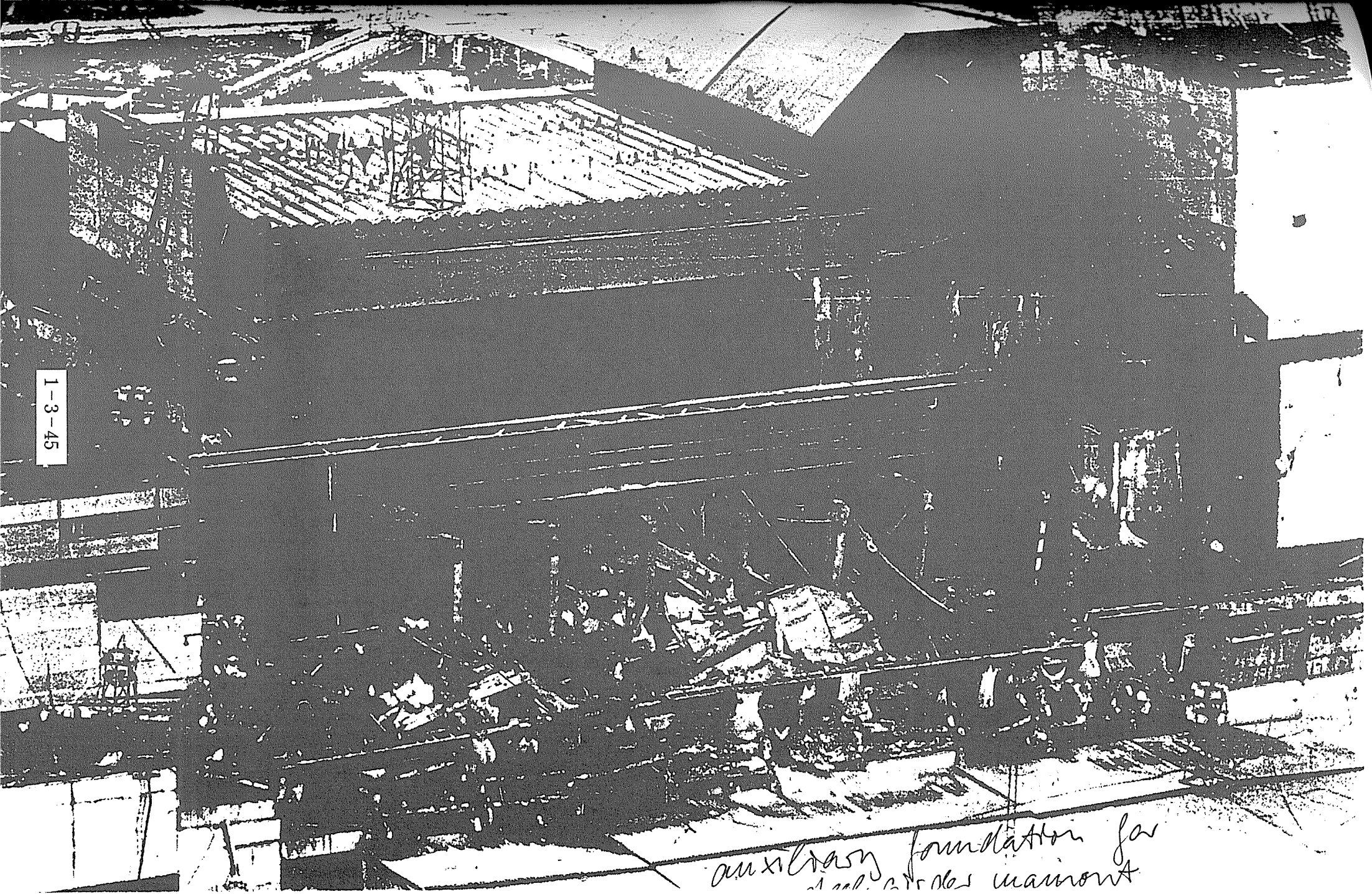

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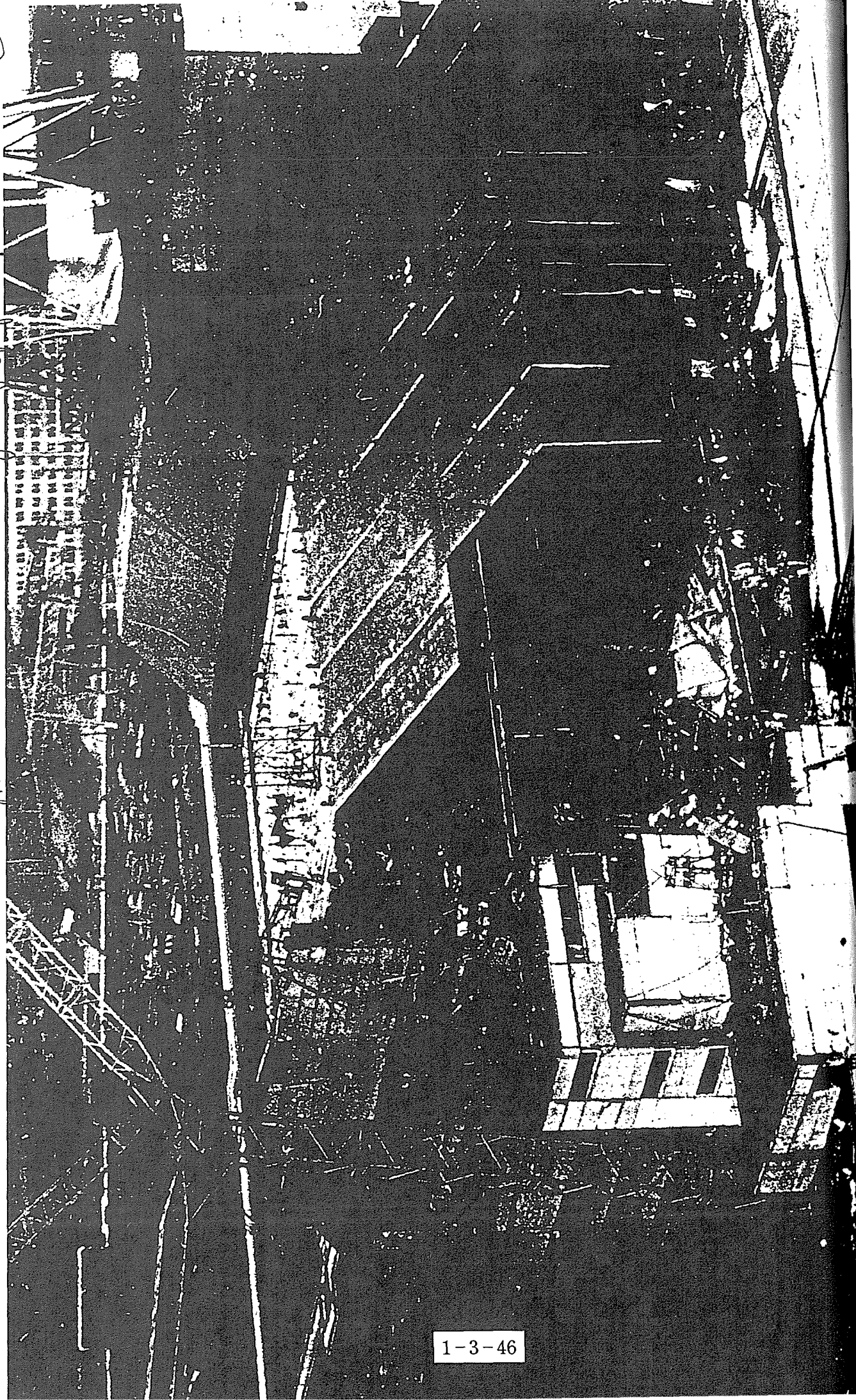

from south construction of roof (profiled plates/steel) (+)

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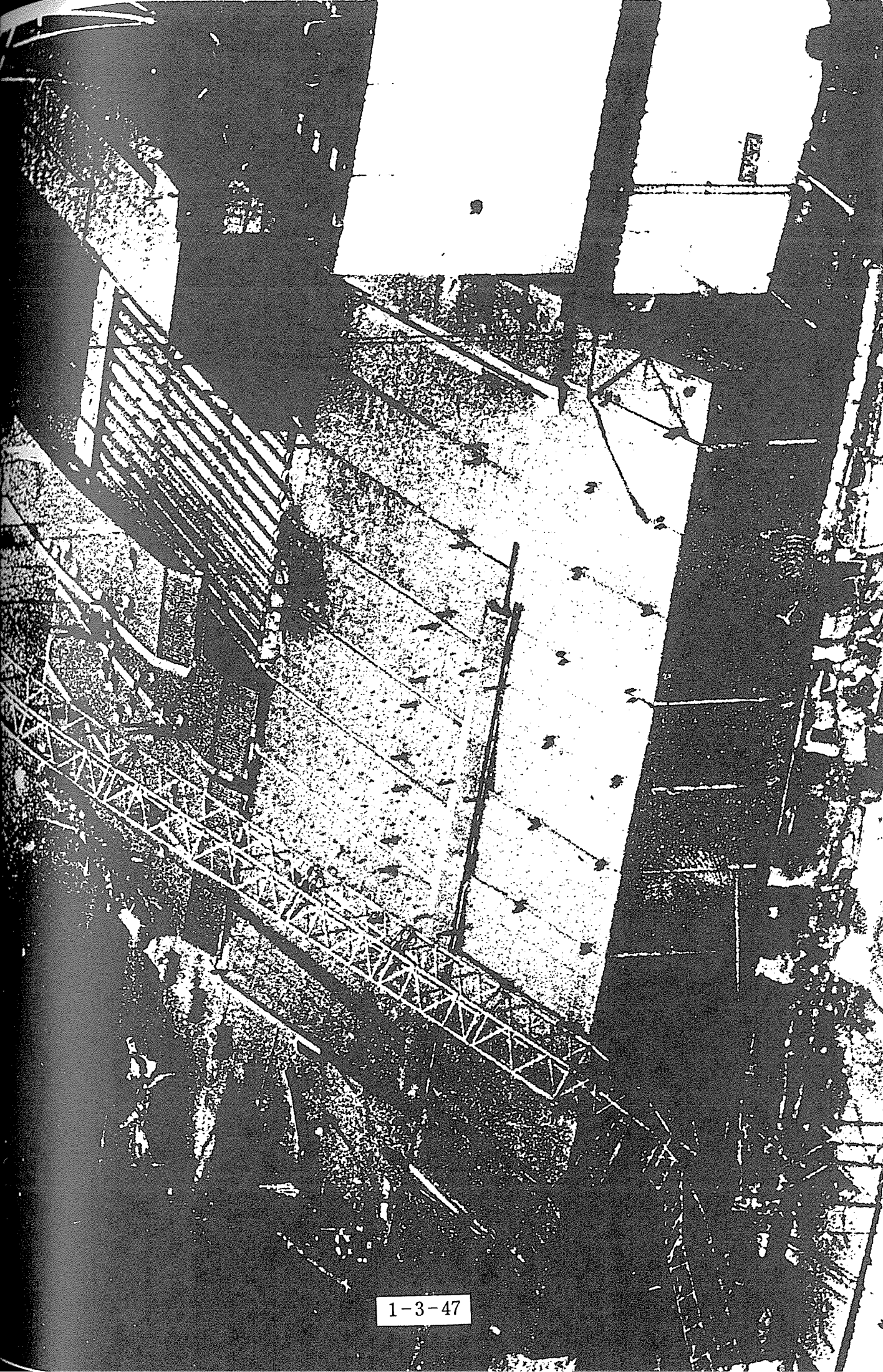
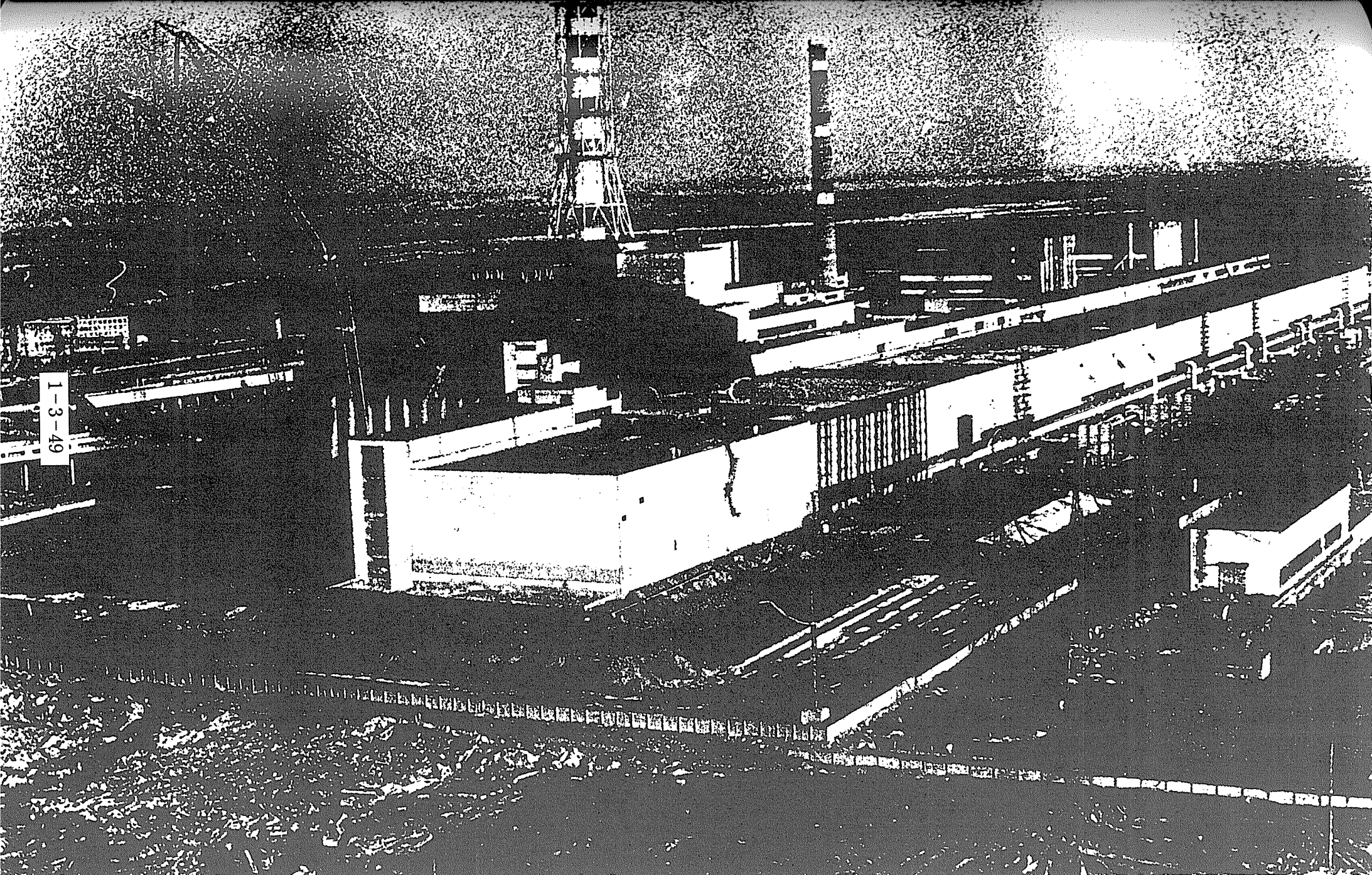


from north-west
hollow shell wall with buttresses

(9)



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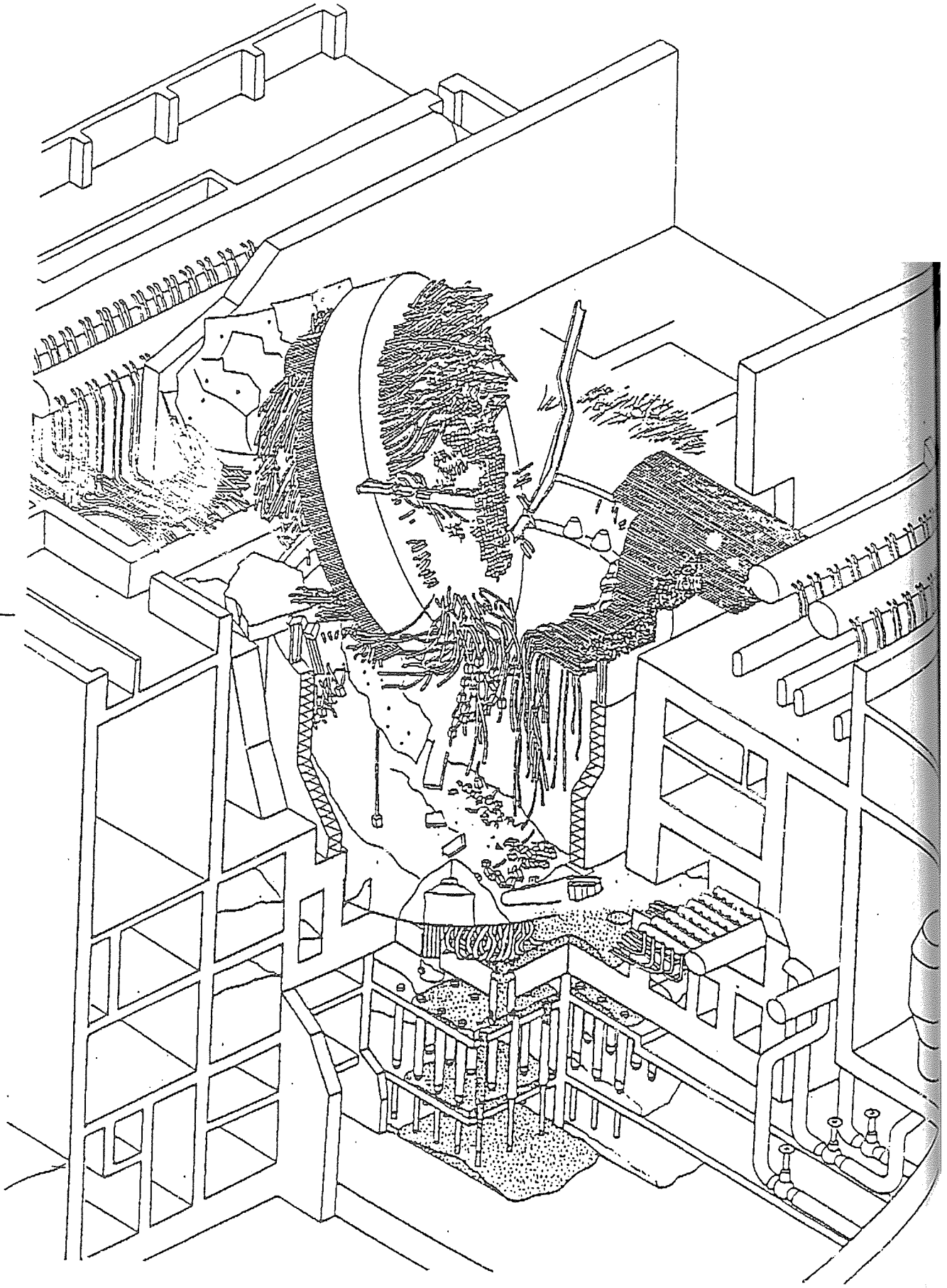

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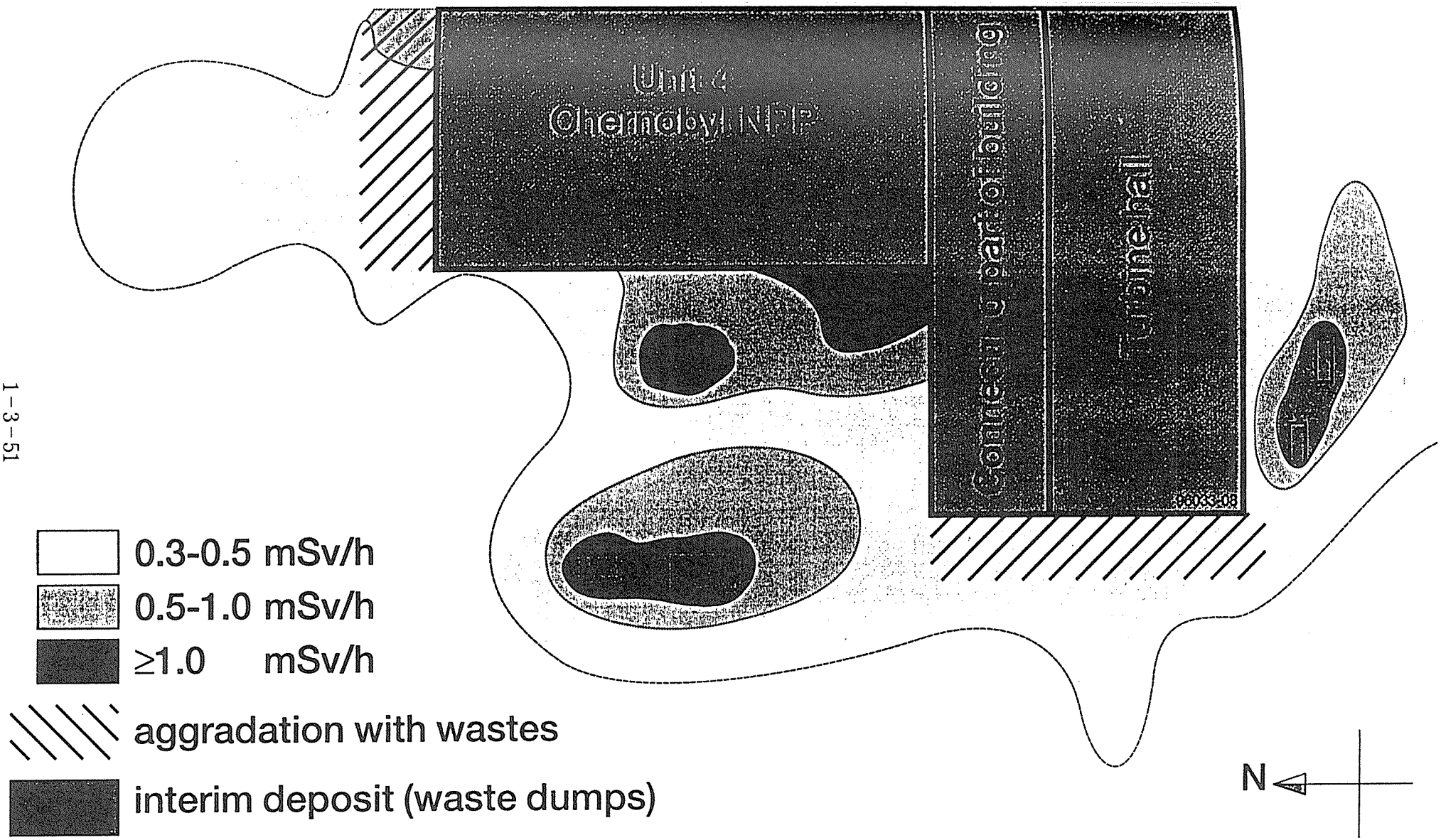

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Local Dose Rates Outside Unit 4 Chernobyl NPP

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Main Future Needs
RBMK Safety

- Major current problem: very slow pace of further upgrading (2nd stage)
  - tremendous economical difficulties of former Soviet Union countries
  - Western assistance largely limited to VVER technology until recently
- Realize a dynamic approach to nuclear safety for RBMK plants in practice
  - implementation of existing plans for further safety upgrading with high priority and independently from consideration of eventual early decommissioning of the plants
  - make available more resources for the safety of running RBMK plants
  - strenthen the status of national regulatory authorities and their support organisations
- Broader discussion and deeper analysis for qualified independent judgment of the adequacy of planned backfitting

Main Future Needs Chernobyl

- Decision for earlier closure of the plant should not result in neglecting safety needs during the remaining time of operation.
- Integrated concept based on realistic targets required
  - enhancing the stability of the sarcophagus
  - disposal of the wastes buried at the site
  - construct a new encasement of the destroyed reactor
- Stepwise implementation
  - first step: stabilization of the sarcophagus to reduce the risk of a collapse
  - use the time made available for careful planning of further measures

The Developing Nuclear Industry in China

ZHOU Yuanquan
Director General, Bureau of International Cooperation
China National Nuclear Corporation
(April 18,1996)

Mr. Chairman,
Ladies and Gentlemen,

We feel very privileged of having the opportunity to attend the 29th JAIF Annual Conference and to discuss and exchange our ideas with respected representitives from different countries on the subject issue of peaceful uses of nuclear energy. First of all, Please allow me, on behalf of the China National Nuclear Corporation, to express my heartfelt appreciation to JAIF for the inviation and the extraordinary organizaton. Best wishes are also extended to the respected guests and friends present today. Now, I would like to take this occasion to give you an outline of the developing nuclear industry in China as well as its international cooperation.

1. The developing nuclear industry in China

1.1 The strategy adjustment of the industry

Like the development of nuclear industry of the advanced nations, the nuclear industry of China started by serving the defense and proceeds to field of the national economic construction step by step. Within a short period from mid 1950s, we set up a fairly complete system of nuclear technology and industry mainly on self-reliance, which only a few countries possessed in the world. This system covers uranium resource general survey and exploration, mining and metallurgy of uranium, enrichment and processing of uranium, chemical reprocessing of uranium and plutonium, treatment and disposal of radioactive wastes, nuclear powering design, radioactive isotopes and their products, radiation technological application, etc. The coordinate trades and complete majors lay a firm technical basis for the development and utilization of nuclear energy.

At the end of 1970s and the beginning of 1980s, our government conscientiously analyzed the change in the international situation and took

the chance to adopt the reform and open policy with the focus of socialist modernization. To meet this big goal, the nuclear industry in China shifted towards the national economic construction and undertook the rigorous civilian orientation adjustment in policy and principle, management system, production scale, product and industry structure. By then, the nuclear industry in China entered the second phase of starting an undertaking focused on civilian production.

China is rich in coal and hydropower resource but with uneven distribution. In the economically advanced southeastern coast, the lack of non-recycled energy resources is the major negative factor against the economic development. The development of thermal electricity causes great pressure on transportation and harms the environment protection. In this condition, we set the peaceful use of nuclear technology and development of nuclear power as the emphasis and strategic goal. We started by building NPPs in Zhejiang and Guangdong.

In the aspect of development strategy, we stick to the concentration on nuclear combined with multi-business to develop the economic strength. We take the note of the transformation potentialities of the old enterprises to activate their advantages in techniques, equipment and personnel. Meantime, we establish some major civilian production projects including non-ferrorus metals, fine chemistry, mechanics, electronics, medicine, food, plant germination, man-made diamond, light industry and textiles, metallurgy, etc. And there are over 1500 kinds of products. The tertiary industry is also developed. The current non-nuclear production value accounts for 80% of that of the total nuclear industrial production. The civilian products, nuclear power and nuclear fuel are the three major parts of nuclear industry today. The new industrial structure is formed as the combination of military and civilian, multi-business with focus on nuclear.

1.2 The nuclear power construction enter a developing period from its stepping-up

The establishment of Qinshan NPP filled up the gap of Chinese history without NPP and made China the 7th nation to independently design and build NPP in the world. In recent years, the load factor of the unit has been increasing 66% in 1993, 68% in 1994, 84% in 1995. Daya Bay. NPP, as the result of the reform and open policy, stands as the successful example of introducing foreign advanced technology, equipment and management experience. Last year, Daya Bay NPP run beyond the goal of generating 10,000 GWh electricity. We accumulated experience and grasped the technology through the construction, safe operation and management, marking the new leap in the development of nuclear industry, possessing profound milestone-like

significance, founding the basis for the further development of nuclear power and paving a new route.

At present, the development of nuclear power in China enters a new phase. As set in the governmental planning, during the 9th five-year plan, 4 NPPs and 8 reactors totaling 6.6GW will be built. Among them are 2 heavy water reactors from Canada, 2 pressurized water reactors from France and Russia respectively and two 600MW pressurized water reactors the second-phase Qinshan Project. They will be set up in the eastern coastal areas in Zhejiang, Guangdong, Liaoning, etc. With the coordinate and speedy economic development, the construction of nuclear power will be further enlarged. By 2010, the nuclear power installed capacity is expected to reach 20GW. The prospect of Chinese nuclear power construction is promising and encouraging.

1.3 To play a supporting rote to the development of nuclear power, we have made great progress in the nuclear fuel cycle industry and nuclear energy scientific research.

China has a rich potential reserve in uranium resource. Compared to the current planning scale of the nuclear power development, the uranium resource can be guaranteed. In the aspect of uranium mining and processing, the leaching technology has new development and the heap leaching technology has been promoted. A new uranium mining and metallurgy technological system is formed with the concentration on in-situ leaching and heap leaching as well as heap metallurging assistance.

In the aspect of uranium isotope separation, besides the continuos production and further technical transformation of diffusion enrichment line, we made a lot of progress in the experimental research on the advanced uranium enrichment technology. The uranium isotope micro-separation experiment on the atom laser device, marking the step forward in the uranium isotope laser separation research in China.

In the aspect of manufacturing of the nuclear fuel elements, we first relied on our technical strength to realize the nationalization of Qinshan 300MW nuclear power fuel assemblies. The first refueling of Qinshan NPP showed that the national made fuel assembly is of good quality. With this basis, we introduced the large-scale NPP fuel assembly manufacturing and designing from France and successfully supplied the refueling assemblies to Daya Bay NPP. We realized the serialization and nationalization of the manufacturing of 300MW, 600MW and 900MW nuclear power fuel assemblies.

In order to strengthen the momentum of the development, we promoted the nuclear energy scientific research and development. We are undertaking the

research on the new-generation of sophisticated type reactor with some important phrasal results. And we seek to co-operate with foreign countries and speed up the research and development in this field. The fast neutron breeder prototype reactor was listed in the national High-tech Program 863 and the pre-construction preparation is on the way. In the research on the controlled nuclear fusion, on the independently-built Tokamak facility, the research on magnetically controlled fusion has come out with some results, and the IAEA research projects were undertaken with satisfactory results, too. Some experimental approaches were created in the research on the inertial controlled nuclear fusion. The research on the controlled nuclear fusion contributes to human beings' exploration of alternative and inexhaustible energy resources.

In addition to these, we achieved rapid development in the peaceful application of isotopes and radiation technology. By now, we can produce and supply over 800 kinds of isotope products for various application in the field of industry, agriculture, medicine, environment, resource, scientific research, etc. In the promotion of radiation technology, 5 large-scale radiation stations were set up in Chinese nuclear industry system. Its application in raw material modification, food conservation, breeding has been extensive day by day. Especially in the field of breeding, the combination of radiation and other technology cultured nearly 400 types of new crops. A new civilian nuclear high-tech industry covering isotopes and their products, nuclear instruments and meters, radiation processing, nuclear agriculture and nuclear medicine is forming.

Mr. Chairman,
Ladies and Gentlemen,

Within less than 5 years to the end of the 20th century, to meet the national goal of doubling GNP, the nuclear industry has a pressing and honorable task of reform and development. The goal for the 1990s is to maintain and develop high-tech nuclear strength to meet the nation's need, to establish new systems of nuclear power and nuclear fuel required by the nation's energy construction, to build up multi-business capacity with the civilian production and operation structure of combinations between nuclear and non-nuclear, techniques and industrial trade, old western bases and new coastal bases, to adjust structure and convert operation mechanism to build CNNC as a large-scale corporation and a share-holder on behalf of the state.

2 The corresponding international cooperation

Mr. Chairman,
Ladies and Gentlemen,

The reform and development of China's nuclear industry can not go on without the environment of world community. Our lasting principle is to enlarge the opening to the outside and strengthen the international technological cooperation and exchange. We earnestly hope to develop friendly relationship and trade tie with each country based on the principle of independence and mutual benefit in order to share merits and learn strengths to contribute to the world's peaceful use of nuclear energy.

In 1983 China became a member of IAEA; in 1984, the designated member of IAEA board of governor. In 1991, China joined the NPT. Redeeming the rule of exclusive peaceful purposes, accepting the safeguards and supervision of IAEA and non-transfer to any third party without permission of the Chinese government, we exported to Algeria the research reactor, which was built on time for due operation and was welcomed by Algeria, and to Pakistan the 300MW-PWR NPP and nuclear fuel assemblies. This project is undertaken very well with reliable quality thanks to the close co-operation between China and Pakistan and it was highly praised by Pakistani leaders and people. concerned. At present, this project is on the stage of intense installation and expected to be completed on due time. Meantime, we have signed co-operation. agreements on peaceful use of nuclear energy with a dozen of countries like Italy, Germany, France, Britain and Canada, and we have conducted economic and technical co-operation and trade activities with over 40 countries and regions.

International exchange is of positive significance to the development of China's nuclear cause and level upgrading. Through the bilateral exchange, especially with the western nuclear-advanced nations, we benefit a lot in the field of uranium exploration, uranium mining and metallurgy, nuclear fuel, nuclear power as well as radioactive medicine. We broadened our horizon, learned technology or introduced advanced instrument and equipment and meantime we enhanced to understanding and friendship with our counterparts. China vigorously participated the activities of IAEA and its branches. In 1984 China Nuclear Information Center joined its information network to provide information service to units concerned. China Nuclear Data center set up the co-operative tie with the data base of IAEA. IAEA signed research contracts with China to offer research-funded posts to invite Chinese nuclear technical personnel to various training courses, scientific investigation, academic conferences and advisor-group meetings. Also, some Chinese well-known

nuclear scientists are invited to attend the advisor-group meetings of IAEA to contribute to the peaceful use of nuclear technology in the world.

With the successful co-operation in Daya Bay NPP between Chinese and French counterpart, the second NPP in Guangdong, i.e. Lingao NPP, continues with the co-operation. The project was approved by the State Council, Linao Nnclear Power Co. Ltd. has registered to be established and the excavation of the project has begun. This project, like the first-phase, is via introduction of foreign capital, loan for construction, repayment after the sale of electricity.

The work of introducing two 700MW Candu NPPs from Canada has been preceeding well. Last October, the governments of China and Canada signed a memorandum of understanding on Candu NPP in Qinshan. CNNC and AECL signed the agreement on commercial negotiation principle. At present, the talk is under way. This project is a turn-key project with AECL responsible for all the capital, and CNNC is responsible for construction site preparation, administration and residence facilities and the cost of the owner.

The two pressurized water reactors introduced from Russia are intended for Liaoning. The project is undertaken with a small part of governmental loans and takes the form of barter trade. The related preparation and contract negotiation are under way.

The second-phase project of Qinshan NPP with two 600MW PWRs is undertaken in form of self-reliance and Sino-overseas co-operation. Contracts have been signed with suppliers for the major equipment and components of the second phase. In June, 1996, the firs tank of concrete will be poured. The two reactors will be completed for operation at the beginning of next century.

Distinguish Delegates,
Ladies and Gentlemen,

The market of nuclear power in China is promising and the opportunity for co-operation is broad. We wish to co-operate with foreign counterparts in various ways and welcome corporations, financial groups and enterprises from all countries to negotiate business and invest in China. We are sure the peaceful uses of nuclear energy will bring a more beautiful future to the mankind.

Thank you for your kind attention.

PROSPECT AND POTENTIAL OF NUCLEAR POWER PLANT IN INDONESIA

PREPARED BY :

ADIWARDOJO

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Nagoya City, Japan
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NATIONAL ATOMIC ENERGY AGENCY

I. INTRODUCTION

The main objective of the Indonesian Long Term Development Programme is to give stress to development of the national economy, through developing a more active and advanced national industry, supported by a strong agriculture, which in turn will create a strong basis for a self-sustaining growth and development in the efforts toward social justice and welfare of the people based on our Five Principles (Pancasila) ideology.

Accordingly, the development of the national industries will need the supply of an abundant amount of energy. It must be noted, however, that the growth of this development should be maintained equally and widely spread, and to assure a self-sustaining development in accordance with the principle of social justice.

This principle is an important guideline in establishing the national energy policy for the future in supporting our second long term 25 year development programme, whereas the main objective would be the creation of a high quality people, a better standard of living, a healthier environment, and a prosperous and peaceful nation.

In line with the national energy policy in promoting intensification, diversification and conservation of energy, some important steps need to be taken in order to establish alternative energy strategies which will be decisive in the formulation and development of the national energy plan in the future. At present Indonesia does not have any nuclear power plants. The introduction of Nuclear Power Plants in Indonesia is not only to reach an *optimum energy mix* based on costs and environment, but also to relieve the pressure arising from increasing domestic demand for oil and gas. Therefore, oil and gas could be used for other strategies, such as for export and feedstocks to support the take-off era towards the 2nd Long Term Development Programme. This strategy is an integral part of the overall energy strategy.

Even though Indonesia has some oil and gas resources, it has to be realized that these resources are not abundant and not unlimited. The role of Nuclear Power Plants is clearly to stabilize the supply of electricity, conserve strategic oil and gas resources and protect the environment from deleterious pollutants.

II. NATIONAL ENERGY POLICY

Indonesia has been implementing a National Development plan, whose goal is to create a just and prosperous nation. The first 25 years of the National Development plan was called the first long term national development programme. This programme was started in 1969 and consisted of Five-Year Development Programmes. One of the main objectives of the first long term national development programme is to broaden the basis of our economic structure, that is to strengthen and to promote national industrialization. The national programme on industrialization has given rise to substantial increase in the demand for energy. The energy sector is of particular importance in the development of the Indonesian economy, as Indonesia's current per capita energy consumption is relatively low compared to other ASEAN countries. The increase of population, especially in the rural areas do not

yet have adequate access to electric power, an indication of an expected high growth rate of electricity generation. Most energy resources are located outside the Island of Java, yet Java, with its large population and industry constitutes the major area of energy demand. In a way which maximizes economic efficiency and provides employment and regional development opportunities, the Government has adopted a policy of promoting development of the energy resources with a view toward more diversification.

Historically, Indonesia's energy policy and petroleum policy were synonymous. Oil had the dual role of being the nation's prime source of commercial energy and of providing both foreign exchange and Government revenue to finance economic development. By the late 1970's however, domestic consumption grew at an annual rate of up to 15 %. Domestic consumption began to divert oil from the export market. In the late 1970's, the Government embarked on an ambitious programme to move domestic energy consumption away from crude oil in order to maximize the amount of oil production available for export. The indirect result of this diversification effort was the construction of electrical generation facilities which utilize non-oil energy resources such as coal. Cement plants were converted from burning oil to using coal. Diversification also led to increasing use of liquefied petroleum gas (from gas reserves) by households. There were also plans for increasing utilization of natural gas in domestic industry and for electricity generation.

Briefly, our National Energy Policy has four main objectives. These objectives include :

1. To secure the continuity of supply of energy for domestic use at prices affordable to the public,
2. To enhance the quality of life of the people,
3. To stimulate economic growth, and
4. To reserve an adequate supply of oil and gas for export, in order to provide an important source of foreign exchange to fund national development programs.

There are three policy measures adopted by the government to meet these objectives :

1. Intensification, i e. to increase and expand exploration of energy sources available in the country.
2. Diversification, i.e. to reduce dependence on only afew sources of energy (i.e. gas and petroleum), and later to replace it with other available sources.
3. Conservation, i.e, to economize on the energy use and to increase the efficiency of energy production.

Implementation of the energy policy covers several aspects such as issuance of regulations, standards, energy pricing incentives and disincentives, and the application of appropriate technologies. The technologies that would be considered are identified as follows :

a. Technology to produce substitutes for oil, as oil is non-renewable, Gasification and liquefaction of coal could well meet the fuel needs of the future.
b. Technologies to support a more sustainable energy supply, through the

harnessing of available and renewable energy sources.

c. Clean and efficient energy technologies to support environmental concerns.

III. The Present Feasibility Study for The First NPP In Indonesia

In September 1989 the Indonesian Government through the National Energy Co-ordination Board (BAKOREN) decided to perform anew the NPP feasibility study including a comprehensive investigation of the Muria site. The study itself should be carried out by the National Atomic Energy Agency (BATAN), under the directives of the Energy Technical Committee (PTE) of the Department of Mines and Energy, and in cooperation with other institutions.

On August 23, 1991, an agreement was signed in Jakarta between the Indonesian Ministry of Finance and BATAN on behalf of Indonesia, and the consultancy company NEWJEC Inc. This agreement contracts NEWJEC for a four and a half year period to perform a site selection and evaluation, as well as a comprehensive nuclear power plant feasibility study. The principal part of the contract value will be spent on studies related to the site, which is to be sought in the northern coast of the Muria Peninsula in Central Java.

The scope of the feasibility study includes two main components

1. The non-site studies, covering energy economics and financing, technical and safety aspects, the fuel cycle and waste management, and general management aspects, among other things.

2. Site and environmental studies, covering field investigations and assessment of site selection, site qualification/evaluation, and environmental, socio-economic and socio-cultural impacts.

On December 30, 1993, two years after the starting date (22 November 1991) NEWJEC submitted the feasibility study report (FSR) and preliminary site data report (PSDR) to BATAN. At the end of the four and half year contract, a final report will be provided, including a site and environmental report, and a preliminary safety analysis report. These documents will provide the information necessary for site permit application, for the design engineering basis and other industrial infrastructure preparations. The attached Figure I shows the overall schedule of the feasibility study.

In this chapter a more general description concerning the results of the Feasibility Studies including National Energy Market Analysis, Electric Expansion Plan and the role of NPP, Economics and Financial Study, as well as Site Studies on Earthquake, Volcanology and Environmental Impacts shall be presented.

III.1 National Energy Market Analysis

The objectives of the National Energy Market Analysis are to conduct a study of the national energy development to support the long term energy demand, and to conduct

analysis of the energy system, specifically the electrical energy sector by the use of the ENPEP (Energy aNd Power Evaluation Program).

This report includes an analysis of the evolution of the energy market, evaluation of energy resources, forecast of energy demand, analysis of energy demand management options, and the formulation of an energy supply planning.

Following are some tables showing results of the Macro Economic, Energy Demand and Energy Supply projections.

a. **Macro Economic Projection**

	GDP GROWTH TOTAL (%/year)	POPULATION GROWTH (%/year)
1990 - 2000	6.50	1.87
2000 - 2010	6.00	1.35
2010 - 2019	5.00	0.85

b. **Energy Demand**

The energy demand will increased by 6 - 7% per year during the study period of 30 years (1990 - 2019).

	GROWTH OF TOTAL ENERGY DEMAND (%/year)	ELECTRICITY DEMAND GROWTH (%/year)
1990 - 2000	6.27	10.30
2000 - 2010	7.20	9.64
2010 - 2019	7.09	8.27
AVERAGE GROWTH	7.18	9.41

c. **Energy Supply**

- Share of Primary Energy Supply during the Study Period

PRIMARY ENERGY	1990	2000	2010	2019
OIL	60.21	60.79	51.14	34.34
GAS	32.52	18.60	7.01	3.41
COAL	5.72	18.21	35.55	54.29
NUCLEAR	0.00	0.00	3.92	6.18
OTHERS (hydro, geothermal)	1.55	2.40	2.38	1.79

d. **Crude Oil Projection (%)**

- Crude Oil Projection during the Study Period

PRIMARY ENERGY	1990	2000	2010	2019
OIL	60.20	60.80	51.10	34.3
(DOMESTIC PROD.)	(92.1)	(48.0)	(21.4)	(12.8)
(IMPORT)	(7.9)	(52.0)	(78.6)	(87.2)
(EXPORT)	(51.1)	(32.5)	(17.0)	(11.4)

III.2 Electric Expansion Plan and The Role of NPP

The Electric expansion studies include studies on the Electric System Analysis and Choice of Unit Size.

a. Electric System Analysis

The objective of the Electric System Analysis, is to determine an optimum configuration for the Java-Bali electric generation system with the introduction of Nuclear Power Plants including the size and its main features.

The results obtained through the optimization study in the development of the Java-

Ball electric generation system with the use of the ELECTRIC module (WASP III) of the ENPEP program, shows that the introduction of nuclear power plants in the early 2000s to the Java-Bali electric system represents an optimal solution.

b. Choice of Unit Size

The objective of Choice of Unit Size study, is to determine the nuclear power plant unit size, taking into consideration the capability and reliability of the electric network system in relation to the load flow, short circuit capacity and the stability of the network.

The results show that commencing in the early 2000s and supported by development of the electrical network, the introduction of the 600 to 900 class nuclear power plants into the Java-Bali electric system is absolutely possible, furthermore based on economic aspects, the introduction of the 900 unit size class is a better option. Meanwhile, to anticipate the increasing demand of electricity in the future, it is very necessary to conduct updating studies of the electric network system.

Based on the above studies, the following may be concluded :

> Coal fired plants will dominate the electricity generation system. Nuclear power plants will be feasible to be in operation in the early 2000s (based on current projection studies). Nuclear power plants will increase in accordance with the demand. The result of the analysis of this scope of work is used as reference for optimization studies in the development of the Java-Bali electric system.
>
> In the year 2019 the role of nuclear power plants will give a contribution of 10% to the electricity supply, an amount equal to about 12600 MW.

III.3 Economics and Financial Study

a. Nuclear Cost Estimate

This study covers an analysis of capital cost (based on vendor's overnight cost, in April 1992 US dollars) for each type of nuclear power plant, as offered by various vendors: Mitsubishi Heavy Industries (Japan), Atomic Energy of Canada Limited, Nuclear Power

International (German - French Consortium), Westinghouse Electric Company (USA), General Electric Company (USA). Comparisons of maintenance and decommissioning costs of the various designs, based on NEWJEC's method and experience are given.

b. Financial Study

The objective of the Financial Review Study, is to obtain various options and sources of viable financing for the construction of Nuclear Power Plants in Indonesia. The scope of the study consists of : 1) Conventional Financing, and 2) BOO/BOT Financing Scheme. Following are the results of the study :

1. Conventional Financing

Implementing conventional financing for the construction of 600 or 900 MW units can be done like any other construction of power plants. Feasible or viable sources of financing can be conducted for example : US component 50%-Japanese component 50%, US component 100%, French component 50%-German component 50%, and Canadian component 100%.

The results show that the energy price of the 600 and 900 MW class Nuclear Power Plant units are competitive to the energy price of similiar capacity of Coal Fired Plants using deSOx and deNOx equipment.

2. BOO/BOT Financing Scheme

The study is still very preliminary in nature.

The implementation of the BOO/BOT financing scheme for 600 and 900 MW unit nuclear power projects in Indonesia should be supported by the Government through the following instruments :

- The need of a bilateral agreement between the Government of Indonesia and the related country concerning the use of nuclear energy for peaceful uses.
- Activities related to the decommissioning and back end of the fuel cycle.
- Guarantee of fuel supply.
- Third Party Liability insurance from nuclear hazards.

Furthermore a power purchase agreement is necessary between PLN with the company, covering the following guarantees and requirements :

a. The obligation of PLN to remit payments according to the requirements, using the agreed determined exchange rates.

b. A guarantee by the Government to return loans, dividends, and other financial arrangements in the determined exchange rate and currency.

III.4 Site and Environmental Studies

Site and Environment Study (SES) for the NPP in the Muria Peninsula has been going on since end of 1991. The study consisting of general site survey, site evaluation, and site confirmation currently has reached its third or final stage. The completion of the study is scheduled for May 1996, with the submission of complete report of Site Data Report (SDR), Preliminary Safety Analysis (PSAR), Environmental Impact Analysis Report (EIAR), and the Final Report of Site and Environmental Study (FR-SES).

By far, preliminary conclusions drawn from data and information of the study show that the candidate site, Ujung Lemahabang (ULA), an area of approximately 500 hectares at the Northern part of Peninsula, is the best choice for the siting of NPP from both technical and economical point of views. There is no immediate hazard that could affect the NPP integrity and its operation.

The Site Studies concern many aspects, however, only the results of the volcanology, seismology and environmental studies will be briefly described here, as follows :

a. Volcanology and Seismology

These two aspects of SES receive special attention during the study. Networks of Microearthquake Telemetring System (MTS) consists of 5 and 3 seismometers are installed in the area. This system records every single earthquake with the magnitude of < 3 Richter. To record earthquake having M > 3-5, A Strong Motion Accelerometer (SMA) system is installed at the Ujung Lemahabang site. By far, no single earthquake that could trigger this SMA system is ever recorded.

There are two volcano systems in the area, they are, the Genuk and Muria volcanos. Mount Genuk (719 m) had activities in the age between 3.29 to 1.65 ma, and had lasted till about 0.49 ma. Mounth Muria (1602 m) that is situated in the center of Peninsula had activities between 2.1 to 0.8 ma. The last volcanic eruption is judged to have occured about 0.32 ma ago. The candidate Site, Ujung Lemahabang, has never been affected by lava or pyroclastic flows from either volcano. Careful assessment of the phreatic and gas emission phenomena at flank of Muria is still underway.

b. Environmental Studies

As mentioned before, most of environment studies in the candidate site Ujung Lemahabang are still underway. However, preliminary results in some aspects of studies further confirm the acceptability of Ujung Lemahabang.

The following parts is the highlight of preliminary results in the environment studies.

1. Evaluation based on the screening distance value (SDV) shows that none of sources of Man-Induced Event identified in near the site may affect the safety of the site.
2. No extreme meteorological phenomena such as tropical cyclone that may threaten the site is foreseen.
3. No sensitive ecological systems and communities are found within the 5 km radius from the site.

III.5 The Prospect and Public Concern of NPP in Indonesia

The prospect of Nuclear Power in Indonesia is very good both in the medium and long term future. Indonesian geography, resource distribution and population distribution have a great influence on the nuclear prospect besides environmental consideration. From the political point of view, we have got a new and stronger momentum from President Soeharto, who stated on 5 May 1995 that Indonesia should carefully plan for the nuclear power plant construction with due attention to its safety. We are now working on two main issues in nuclear power introduction, namely :

1. Public acceptance, where few important figures are still influenced by the negative information from anti-nuclear group.

2. Financing scheme, where we should choose the right scheme to make the NPP's really viable economically.

a. Public Acceptance

There have been growing concerns coming from the Indonesian public on the use of nuclear energy, especially concerning issues of NPP. Non Governmental organization and environmentalist have come up, making the public acceptance programme more challenging.

To enhance the public on the peaceful uses of nuclear technology including the aspects of nuclear power plants, an interdepartmental organization has been established since the year 1990. This interdepartmental organization, coordinated by National Atomic Energy Agency, has made efforts in promoting, giving information, and discussing openly to the public on the peaceful uses of nuclear energy and especially to the immediate environment where the feasibility site studies are being conducted. Efforts such as these will be a continuing program, as also practiced by many other countries.

This endeavor may not be enough. However, experiences from industrial countries that already have a history of NPP, may contribute positively to our endeavor, and cooperation among countries in this respect may also add to global concern on the need of NPP.

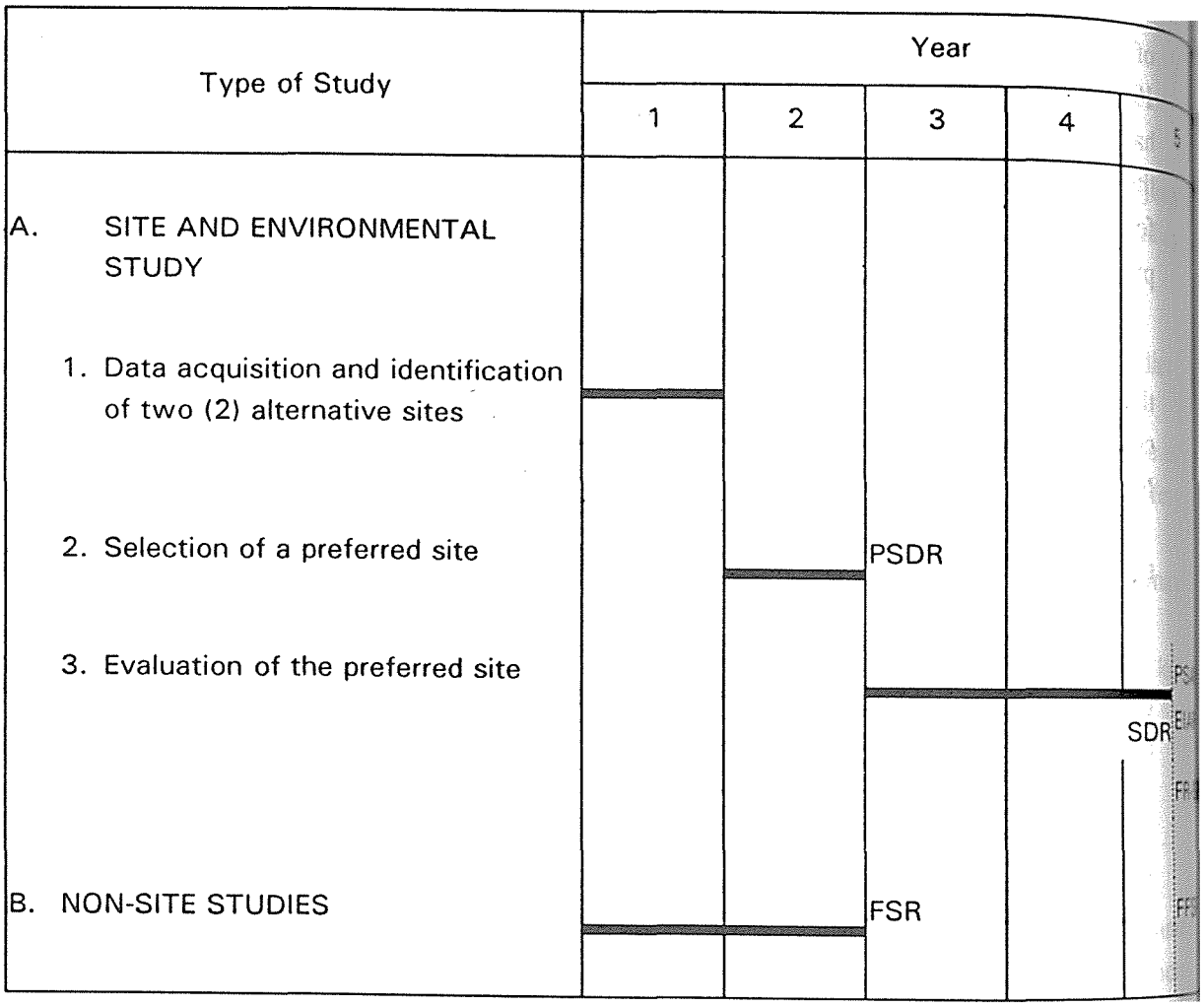
b. Financing of Nuclear Power Plants

As financing of nuclear power plants require large amounts of funding, it is necessary that funding of NPP must be considered as sound investments and being economically beneficial, not only to the NPP itself, but to expand the industrial capability and participation. Domestic industrial participation in the NPP construction assessed so far would represent around 25 % for the first units, and can increase progressively to 35 % for the third units. This means that large business opportunities will emerge in parallel with the required capabilities in the domestic industries themselves.

In case of expected substantial share of domestic participation, related domestic investments should be made available sufficiently and timely to support the required increased capabilities. These investments include also the development of human resources.

However, it will become more difficult to aqcuire funding in the future, which will be a challenge in the endeavor to build high scale projects having long investments periods. In order to prevent financial matters in becoming a hindrance, it is very important to anticipate this matter as early as possible by efforts to increase cooperation among nuclear concerned countries so that financial institutions will support and be in favour of building of nuclear power plants.

Figure-1. Time Schedule of the Feasibility Study for a Nuclear Power Plant in the Muria Peninsula Region



PSDR - Preliminary Site Data Report
FSR - Feasibility Study Report
SDR - Site Data Report
PSAR - Preliminary Safety Analysis Report (Site Part)
EIAR - Environmental Impact Analysis Report
FR-SES - Final Report of Site and Environmental Study
FFSR - Final Feasibility Study Report

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Nuclear Power Program in Korea

I. Introduction

Although the world nuclear power industry may appear to be declining, recent plant construction and continued nuclear power demand in Asia indicate future opportunities for growth and prosperity in nuclear power production and supply. Among many countries in Asia, Korea has one of the most vigorous nuclear power programs.

Korea has been an active promoter of nuclear power generation since 1978, when the country introduced nuclear power as a source of electricity in 1978. Korea now takes pride in the outstanding performance of its nuclear power plants, and has established a grand nuclear power scheme.

This paper is aimed at introducing the nuclear power program of Korea, including technological development, international cooperation and nuclear fuel management.

II. Nuclear Power Development

Nuclear Power Status

Since the commercial operation of Kori Unit 1 started in April 1978, KEPCO, the sole electric utility in Korea, has achieved rapid growth in nuclear power development. Because natural resources are not abundant in Korea, nuclear power has played a key role in the economic development of the country.

Korea now has eleven operating nuclear units, ten PWRs and one CANDU. The latest unit is Yonggwang Unit 4 (1,000 MWe), which was constructed in line with the nuclear technological self-reliance program. It began commercial operation in January of this year, three months ahead of schedule. Yonggwang Units 3&4 were awarded 1995 "Project of the Year Awards" by "Power Engineering International" magazine for

their excellence in design, construction and operation. The nuclear capacity of the eleven operating units is 9,616 MWe, or 28.9% of the country's total installed capacity.

Table 1. Status of Operating Nuclear Power Plants

Plant		Reactor Type	Capacity (MWe)	Manufacturer		Commercial Operation
				Reactor	T/G	
Kori	Unit 1	PWR	587	W	GEC	Apr. 1978
	Unit 2	"	650	"	"	Jul. 1983
	Unit 3	"	950	"	"	Sep. 1985
	Unit 4	"	950	"	"	Apr. 1986
Wolsong	Unit 1	PHWR	679	AECL	NEI-Parsons	Apr. 1983
Yonggwang	Unit 1	PWR	950	W	W	Aug. 1986
	Unit 2	"	950	"	"	Jun. 1987
	Unit 3	"	1000	HANJUNG/CE	HANJUNG/GE	Mar. 1995
	Unit 4	"	1000	"	"	Jan. 1996
Ulchin	Unit 1	PWR	950	Framatome	Alsthom	Sep. 1988
	Unit 2	"	950	"	"	Sep. 1989

Seven additional units consisting of 4 PWRs and 3 PHWRs are now under construction, and 2 PWR units are in the planning stages. A nuclear capacity of 17,716 MWe will be reached in 2004 once these units are completed in annual succession. They will then represent 27.6% of total installed capacity.

Nuclear Power Operation

Great efforts have been made to improve the availability and safety of nuclear power plants. As a result, the performance of Korean nuclear power plants has shown remarkable improvement over previous years, and in comparison to the world average. For example, in 1995, the average capacity factor for Korean nuclear plants was 87.3% while the world average was only 71.6%. Since 1984, the average annual capacity factor has been steadily maintained over the 70% level. It has been over the 80% level for the last 5 years.

A comprehensive program is utilized to improve the plant capacity factor. Short-term efforts involve reducing unplanned plant trips caused

by human error and equipment failure, shortening the refueling outage time period, and enhancing the quality of operating plants. Therefore, KEPCO has set a company-wide goal of "One Cycle Trouble Free" or "OCTF" operation. Due to several noticeable improvements, the number of unplanned trips has dropped. In 1978, when the first nuclear unit was complete, there were 17 unplanned trips to Kori Unit 1. The numbers rapidly decreased to 7.5 per reactor in 1985, and 1.6 and 1.4 per reactor in 1988 and 1989, respectively. In 1995, there were a total of 11 unplanned trips, including three ones of Yonggwang Unit 3 during the first year of commercial operation, averaging 1.1 occurrences per reactor.

Table 2. Nuclear Power Plants under Construction or Planning

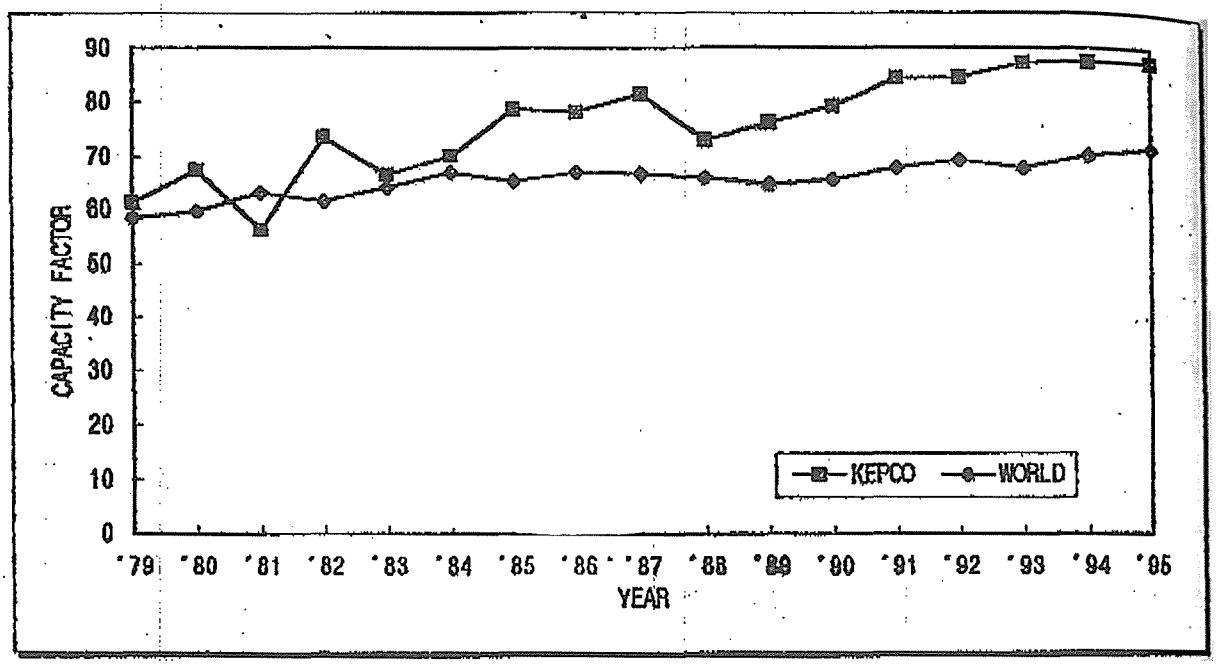
Plant		Reactor Type	Capacity (MWe)	Manufacturer		Commercial Operation
				Reactor	T/G	
Yonggwang	Unit 5	PWR	1000	HANJUNG/CE	HANJUNG/GE	Jun. 2001
	Unit 6	"	1000	"	"	Jun. 2002
Wolsong	Unit 2	PHWR	700	HANJUNG/AECL	HANJUNG/GE	Jun. 1997
	Unit 3	"	700	"	"	Jun. 1998
	Unit 4	"	700	"	"	Jun. 1999
Ulchin	Unit 3	PWR	1000	HANJUNG/CE	HANJUNG/GE	Jun. 1998
	Unit 4	"	1000	"	"	Jun. 1999
	Unit 5	"	1000	(HANJUNG)	(HANJUNG)	(Feb. 2003)
	Unit 6	"	1000	"	"	(Feb. 2004)

Additionally, in order to prevent unplanned shutdowns caused by human error, improvements were made through simulator training to enhance response ability against transient and abnormal operations. Furthermore, a Human Performance Enhancement System (HPES) was mobilized to find the root causes of plant malfunctions, and to educate operators and maintenance crews on how to avoid problems.

Long-term efforts include improving equipment and systems, operational management, and operational feedback in the design of plants under planning and construction. Also included is the adoption of an extended fuel cycle for PWR plants. A 15 month operating cycle

from shutdown to shutdown has been applied to 600MWe class plants, and an 18 month fuel cycle for 950MWe class plants started in 1993.

Figure 1. Trend of Capacity Factor



Long-term Power Development Plan

It is expected that annual growth rate of the demand for electricity will average 8.5 percent in the short-term (1995 to 2000). The average growth rate from 1995 to 2010 is expected to be 5.9 percent per annum. Therefore, the power development program of 1995 stipulates the addition of new generating facilities of some 47,367 MWe by the year 2010. Among them, 17,713 MWe will come from nuclear energy. When the program is completed, the total installed power capacity should be 79,551 MWe.

The current capacity ratio among nuclear, fossil (coal, oil & LNG) and hydro sources is 29 : 62 : 9 respectively. This ratio will be 33 : 59 : 8 in the year 2010. The share of nuclear electricity production will increase by 46% in 2010 from the current level of 36% because nuclear power plants will serve to handle the base-load.

Table 3. Long-term Power Development Program

Unit : MWe, (%)

Source	1995	2000	2005	2010
Nuclear	8,616 (26.8)	13,716 (26.0)	18,716 (27.5)	26,329 (33.1)
Coal-fired	7,820 (24.3)	15,825 (30.0)	22,025 (32.4)	21,700 (27.3)
LNG-fired	6,736 (20.9)	14,201 (26.9)	16,214 (23.9)	22,014 (27.7)
Oil-fired	5,919 (18.4)	5,135 (9.8)	5,495 (8.1)	3,525 (4.4)
Hydro	3,093 (9.6)	3,878 (7.3)	5,483 (8.1)	5,983 (7.5)
total	32,184 (100)	52,755 (100)	67,933 (100)	79,551 (100)

Nuclear Safety

KEPCO's nuclear power plants have incorporated various safety design features to prevent accidents. KEPCO strictly observes the safety principles recommended by IAEA's International Nuclear Safety Advisory Group, including safety rules and procedures necessary for preventing a potential release of radiation or radioactive materials that could significantly harm employees, the public, or the environment.

As the primary organization responsible for nuclear safety, KEPCO exerts every effort to review, monitor, and enforce plant safety. The plant safety enhancement program includes safety reviews, periodical safety inspections, quality assurance/control measures, etc. Safety reviews are executed by KEPCO's nuclear safety review boards, and all nuclear activities are severely monitored by the government from design to construction/operation stages. To enhance plant safety, improvements in safety related items and/or facilities, recommended by the USNRC as post-TMI actions, are executed for all operating units and are incorporated into new plants.

Public Acceptance

Since the cooperation of local communities is essential for implementation of the nuclear power program, KEPCO has carried out various community programs utilizing a basic policy of returning benefits to the local community.

For systematic and effective community activities, "The Act for Supporting the Communities Surrounding Power Plants" was enacted in June 1989. In accordance with the law, community activities have been implemented since 1990. The law was amended in 1995 in order to diversify and extend community programs, reflecting the change of circumstances. Along with the community activities, nuclear PA activities have also been strengthened to inform the public of all aspects of nuclear power and enhance confidence in nuclear power plant operation.

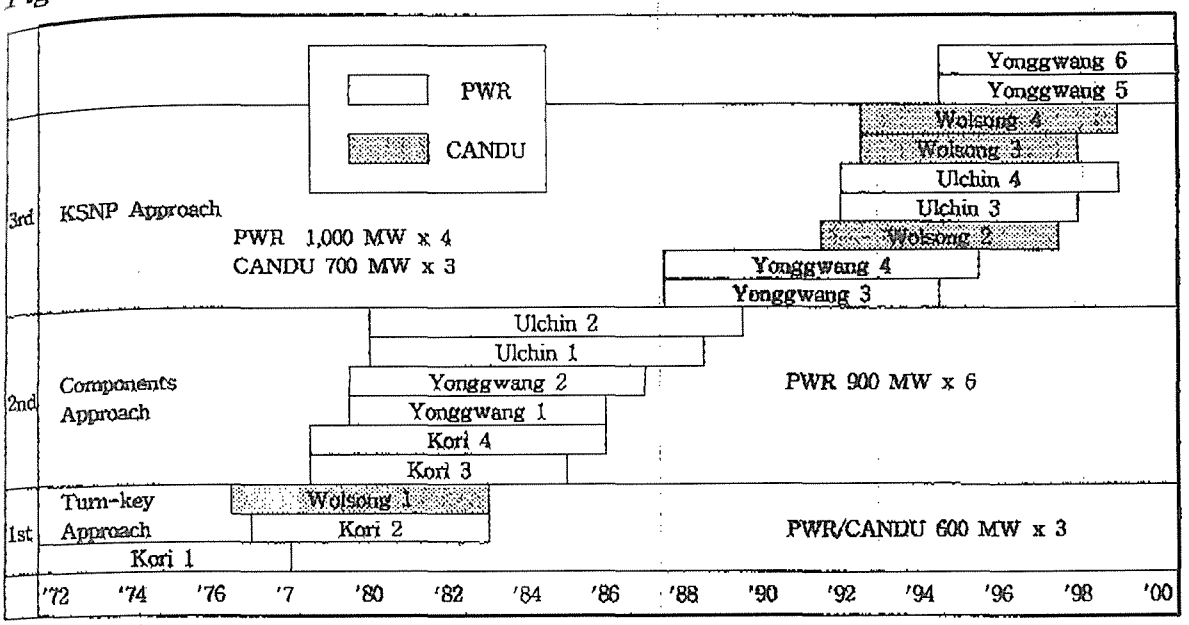
The local cooperative program is divided into two activities - basic activities and special activities. The basic activities include income-increase projects, public facilities installations, educational assistance, etc. The special activities, which have been enforced since 1995, include welfare support, industry inducement and electricity fee cuts for nearby residents. These programs are implemented for residents who live within a 5km radius of the plants, and have been established in cooperation with the residents and organizations concerned, including KEPCO and the central and local governments. Financial resources for implementing programs are provided within 0.8% of KEPCO's annual electricity sales.

III. Technological Development

Technological Self-reliance

During the first stage of nuclear power in Korea, nuclear power plants were constructed on a "turnkey" basis. In turnkey construction, the reactor vendors were usually responsible for the entire project, from design, engineering and construction to the startup and turnover of the plant to the owner. The first three nuclear units were built on this "turnkey" concept.

Figure 2. Nuclear Power Development



In turnkey contracts, the opportunities for technology transfers were very limited. Also, participation of domestic companies was limited to site preparation work. In other words, Korean companies participated as subcontractors of foreign contractors to provide small portions of field design, equipment supply and construction. In order to contribute to a more stabilized energy infrastructure, it was widely recognized that Korea should be as self-reliant as possible in nuclear power technology.

In the second stage of nuclear power, KEPCO took responsibility for project management along with direct procurement of the balance of the plant. Main contracts for supplying NSSS, T/G and engineering services were made with foreign contractors. A Korean contractor took the responsibility for the site construction, while other Korean companies were strongly encouraged to expand their roles in engineering service and equipment supply. The six units of 950 MWe were constructed under this approach, which significantly strengthened Korea's capability to deal with nuclear power projects itself.

The third stage of nuclear power development started with the aim of finalizing the nuclear technology self-reliance program. This program has been in effect since the construction of Yonggwang Units 3&4, with Korean industries as prime contractors. KEPCO has been in charge of project management and technology transfer. Several other organizations have participated in plant design, construction and management, with

assistance from foreign sub-contractors. These are:

- Korea Power Engineering Co., Inc. (KOPEC), a KEPCO-invested company in charge of plant design and engineering;
- Korea Atomic Energy Research Institute (KAERI), a national institute responsible for design engineering of NSSS and initial core fuel design;
- Korea Heavy Industry and Construction Co., Ltd. (HANJUNG), a KEPCO-invested company responsible for NSSS and Turbine Generator manufacturing;
- Korea Nuclear Fuel Company (KNFC), a KEPCO-invested company in charge of nuclear fuel.

All Korean organizations and entities which have participated in the nuclear power program have improved their capabilities through technical and on-the-job involvement in all disciplines of nuclear power technology.

The commercial operation of Yonggwang Units 3&4 signified the beginning of a new era of technological self-reliance in Korea's nuclear industry. The Yonggwang Units will serve as basic models for the development of a Korean Standard Nuclear Power Plant (KSNP). Four additional units based on Yonggwang Units 3&4 are already under design or in construction. These are the Ulchin Units 3&4 and two additional units, 5 and 6, at the Yonggwang site. Design of the two additional units, Units 5&6 at Ulchin, will start soon.

KNGR Project

In 1992, the Korean government and KEPCO launched the Korean Next Generation Reactor (KNGR) project to develop a standardized advanced light water reactor, based on previous experience acquired through the KSNP's design and technological self-reliance program of 1987. The KNGR project's goal is to complete a standardized KNGR design by February, 2000. This project will be applied to the new nuclear projects which are anticipated to begin operation in 2007.

Because developing a new design for nuclear power plants requires a great deal of resources and experience, an integrated project has been organized to maximize all experience and technology shared within

Korea's nuclear industry.

The KNGR design will meet the enhanced safety requirements and economic goals of future nuclear power plants in Korea, particularly with regard to investment protection and accident prevention. Construction is set to start in 1999, when 60% of the design will be completed.

Ⅳ. International Cooperation

Nuclear Overseas Business

Based on KEPCO's accumulated technology and international confidence built-up through its success in providing local electricity, KEPCO is now expanding its operation sphere to include the global community. Also, KEPCO is laying the foundation for global operations in the Asian region, where the demand for electricity will increase rapidly.

In December 1993, KEPCO signed its first international contract for engineering services for the maintenance of Guangdong nuclear power plant in China. In February, 1995, KEPCO signed a memorandum of understanding with China National Nuclear Corporation (CNNC) on the technical and economic joint study for the construction of nuclear power plants in China.

This year, KEPCO made an agreement with the Chinese government for a joint study on the construction of Shandong Haiyang Nuclear Power Plants, and also provided Quinshan Nuclear Power Company (QNPC) with consulting services for the contract between QNPC and AECL for Quinshan Phase Ⅲ project in China. Korea is stepping up its efforts to build a cooperative relationship with the Asian countries in the various fields for peaceful use of nuclear energy.

KEPCO also is pursuing a cooperative joint venture with advanced foreign suppliers such as ABB-CE in USA, and AECL in Canada.

International Activities

By joining several Owners Groups set up by utilities operating and/or

constructing the same type of reactors, KEPCO is continuously making an efforts to improve plant safety and availability. KEPCO has been affiliated with international organizations such as the Institute of Nuclear Power Operations (INPO) and the World Association of Nuclear Operators (WANO), in order to exchange information in the nuclear field. KEPCO is also participating in various international cooperative activities for the promotion of nuclear energy development through the International Atomic Energy Agency and inter-governmental nuclear cooperation agreements.

In addition, KEPCO has made technical cooperation agreements with thirteen foreign utilities or nuclear organizations from eight countries to promote technological development, information exchanges, training, etc. Based on the agreement's framework, various cooperation activities are being executed, including periodic meetings and regular exchanges of information.

V. Nuclear Fuel Management

Nuclear Fuel Supply

Over one-third of uranium concentrates required until the beginning of the next century have been secured by long-term supply contracts. To ensure a secure and economical supply of uranium, KEPCO has invested in overseas joint ventures development of uranium reserves, such as Cigar Lake, Dawn Lake, and Henday Lake in Canada, and Crow Butte in the U.S.A. The Crow Butte project has been in commercial operation since 1991, and supplies around 40 tons of U_3O_8 of uranium per year, corresponding to KEPCO's 10% share in the project. In addition, KEPCO has, since 1994, satisfied some demands at low prices through the spot market.

In consideration of international and economic circumstances, enrichment services have been supplied by long-term contracts with USEC of the USA, and COGEMA of France. Since 1990, the procurement of Russian products through Palmco (USA) has contributed to supplier diversification, and has kept the cost of nuclear fuel down.

A program for the localization of fuel fabrication has been

implemented by the Korea Atomic Energy Research Institute (KAERI), and the Korea Nuclear Fuel Co., Ltd (KNFC) since the late 1970s. KNFC, with a capacity of 200 MTU per year, has supplied most of the domestic demand for PWR fuels since 1989, and KAERI, with a capacity of 100 MTU per year, has supplied all domestic PHWR fuels since 1987.

In order to ensure Korea's growing nuclear power program has fuel that is safe, efficient, and economical, KEPCO is pursuing the development of advanced PWR and PHWR fuel, in collaboration with KAERI and KNFC. The commercial use of these fuels is scheduled for 2004 and 2006, respectively.

Radioactive Waste Management

In 1988, the Korea Atomic Energy Commission established goals for radwaste management. The plans included construction of a final repository for low and medium level radwastes to be built by the end of 1995, and a centralized interim spent fuel storage facility (for both PWR and PHWR fuels) to be built by the end of 1997.

As in other countries, the radwaste plan had been beset by public opposition, which has slowed the timetable. Ending several difficulties in securing an appropriate site for radwaste disposal, the Korean government, in December 1994, officially announced that a small remote island, Kurrupdo, off the west cost of Kyunggi province was selected as the final candidate, and in February, 1995, the Korea Atomic Energy Commission has finally approved the island as the site for LLW.

However, more extensive geological surveys have revealed at least two active faults within a few kilo-meters of the island that pose a significant earthquake risk. In the end, the Korean government has canceled plans to site a radwaste disposal on the island, and is reexamining its previous short list of sites.

In addition, radwastes and spent fuel generated by the power reactors are being stored on site by KEPCO until the repository and interim storage facilities open. KEPCO has chosen to use volume reduction techniques to reduce its low level waste (LLW) to one third of its former bulk. For example, drier facilities are used to reduce wet wastes

such as boric acid concentrates and spent resin, and sorting/segregation facilities and a supercompactor reduce dry active waste. For spent fuel, high density storage racks are being installed, and a dry concrete silo-type storage facility was already built at Wolsong. Also, there has been transshipment between neighboring units of a plant.

Ⅵ. Conclusion

Korea will continue to build and operate safer and more economic nuclear power plants. There is no alternative but to continue on the chosen nuclear power path, considering the current energy situation in Korea. The expansion of nuclear power in Korea has replaced the need for a huge amount of fossil fuels such as oil or coal, which are not natural resources in Korea, and are also detrimental to environmental conservation. Korean industries are now ready to contribute to our neighbor's nuclear power programs, with much experience accumulated over the last two decades.

Need for Nuclear Power in Pakistan and International Cooperation

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Need for Nuclear Power:

Pakistan belongs to the group of energy resource-deficient developing countries which are passing through an energy-intensive phase of development. Inputs of energy are needed in the coming decades for sustaining the pace of socio-economic development to satisfy growing aspirations of rapidly increasing population.The demand for energy in Pakistan has been growing very rapidly as a result of increasing pace of industrialization, mechanization of agriculture and transport, urbanization, modernization of communication and rural electrification. Even so its level of per capita consumption of commercial energy (O.3 TOE and electricity (410 kWh) is still far below the world norms ---about 1/2 of the average for developing countries, 1/6th of the world average and 1/20th of the average for OECD countries. The country is poorly endowed with energy resources. Inspite of intensive efforts to utilize indigenous oil and gas supplies over the last two decades, it has not been possible to meet more than two thirds of the total commercial energy needs or one quarter of the petroleum products demand through indigenous fuel. This

heavy dependence on energy imports has been causing serious balance of payment problems and adversely affecting the national economy.

Electric power is a key component of Pakistan's energy sector. Despite a 100 fold increase in power generation capacity over the last four decades, the supply of electricity in Pakistan is still unable to keep pace with the demand. The peak electricity demand has been exceeding supply capacity by about 15-25% for the last ten years, necessitating load-shedding of 800-1,500 MW. Apart from causing inconvenience to the general public, these power shortages are estimated to be resulting in a reduction of annual gross domestic product by about 2% with a loss of about $ 150 million per annum due to reduction in the country's exports of manufactured goods.

The present installed power generation capacity in Pakistan is about 13,000 MW comprising 37% hydro, 61% based on oil and gas and 1% based on coal and nuclear power each . The industrial activity in the country is still at a low level, while only half of the population has access to electricity.The country will, therefore, need substantial expansion in power generation capacity in order to meet future electricity needs. It has been estimated that, with the demand for electricity growing at 8-9% per annum, the power generation capacity requirements will increase to about 40,000 MW by the year 2010 and to some 80,000 MW by the year 2020.

Pakistan is endowed with about 30, 000 MW hydro power potential.So far only about 15% of this potential has been exploited. Future development of the remaining hydro power potential is constrained by a combination of techno-economic and socio-political factors. Still, according to recent estimates, the hydro electricity generation capacity is expected to increase from 4,800 MW now to some 14,000 MW by 2010 and perhaps to 20,000 MW by 2020.

It is thus clear that the country's indigenous resources of hydro and fossil fuels may at best be stretched to support about 24,000 MW power capacity in the year 2010 and possibly to some 38,000 MW in the year 2020. This would leave a large gap of about 16,000 MW in the year 2010, increasing to some 42, 000 MW in the year 2020, that will have to be filled in either by building additional thermal plants based on imported fossil fuel or by making use of nuclear power or by an appropriate combination of both. In order to avoid excessive dependence on imported fuel, it would be most prudent for Pakistan to plan for its medium to long term power generation capacity based on diversified sources of supply with an appropriate mix of hydro , oil, gas, coal and nuclear. It is in this context that Pakistan seeks to make use of nuclear power on a scale that may be technically and financially viable. International cooperation and particularly regional cooperation in the field of nuclear power technology development can, in our view, go a long way to help Pakistan and other energy resources-poor developing countries of the Asia-Pacific region

in pursuing sustainable development strategies in the coming decades.

Unlike the Greenpeace movements in many countries, there is no organized opposition to nuclear power in Pakistan, although occasionally, one does come across the opposite point of view in the national press. We, on our part, strive to keep the national media aware of the worldwide developments in the field of nuclear power.

Development of Nuclear Power in Pakistan

Pakistan made a start in the field of nuclear power as early as mid-1960s, by constructing a 137 MW plant, KANUPP, at Karachi.The plant was completed in 1971 and started commercial operation in 1972. This plant was supplied by Canada under a tri-partite agreement involving IAEA, Canada and Pakistan and is under the IAEA safeguards. However, in the aftermath of Indian nuclear explosion in 1974, the Canadian Government unilaterally withdrew its technical support for the plant and stopped the supply of nuclear fuel and spares. This forced Pakistan to develop its own facilities for the production of nuclear fuel for KANUPP. The plant was kept operational largely by indigenous efforts and has been operated all this while in accordance with international safety norms. KANUPP has completed more than three-quarters of its designed life of 30 years. It is now under refurbishment to extend the life to 40 years. Valuable safety related cooperation has recently been forged with COG, WANO and the IAEA.

In view of its energy needs, Pakistan was interested in constructing more nuclear power plants. However, this could not materialize until recently. The construction of a 300 MW nuclear power plant, CHASNUPP, was started in 1992 with the help of the People's Republic of China. This plant is expected to become operational in 1998. The plant will also be under the IAEA Safeguards. Pakistan is considering construction of a second 300 MW unit at CHASNUPP with assistance from abroad.

Having faced difficulties in its acquisition of nuclear power technology, Pakistan Atomic Energy Commission started efforts on indigenization of this technology. Besides producing nuclear fuel for KANUPP, major achievements in this direction have been (i) creation of two manpower training institutes called Centre for Nuclear Studies and Karachi Institute of Nuclear Power Engineering (ii) establishment of an Institute of Nuclear Power for developing indigenous capability in the design and engineering (iii) development of some infrastructure facilities e.g. Welding Institute and a Non-Destructive Testing Centre and (iv) gradual development and expansion of production of material needed in the fuel cycle. Notwithstanding these achievements, we feel that more effort is still required in order to make our nuclear power development programme fully effective but this will be an uphill task in view of our limited technical, industrial and financial resources. Therefore, in common with other energy resource-poor developing countries, we eagerly look forward to much enhanced international cooperation, in particular with the

countries of the Asia-Pacific region under the aegis of the IAEA.

International Cooperation

Nuclear power today accounts for about 17% of electricity generation worldwide. Its share in USA is 22% and averages to about 32% among the West European countries and to 11% among the Asian countries. The rapid growth of nuclear power in West Europe during the 1960s and 1970s owes much to the collaborative efforts of the countries of this region under cooperative arrangements such as EURATOM. It enabled these countries to pool their technical, industrial and financial resources for launching joint R&D programmes aimed at the development of nuclear power technology and related fuel cycle facilities. A number of research centres such as RISØ in Denmark, ISPRA in Italy and MOLE in Belgium were established for collaborative efforts in this direction. These joint efforts proved to be very effective in the development of nuclear power technology in West Europe. In particular, EURATOM provided the West European countries access to nuclear power technology and materials from USA, besides serving as a regional framework for ensuring security of nuclear fuel supplies as well as credible regime of safeguards. In the absence of such collaborative arrangements, it would have been a gigantic task if taken up by any of these countries individually. It has also to be realized that had East Europe been included in the fold of EURATOM, in stead of being subjected to counterproductive embargoes and restrictions,

there would have been, perhaps no Chernobyl accident and nuclear power would have progressed more rapidly world wide.

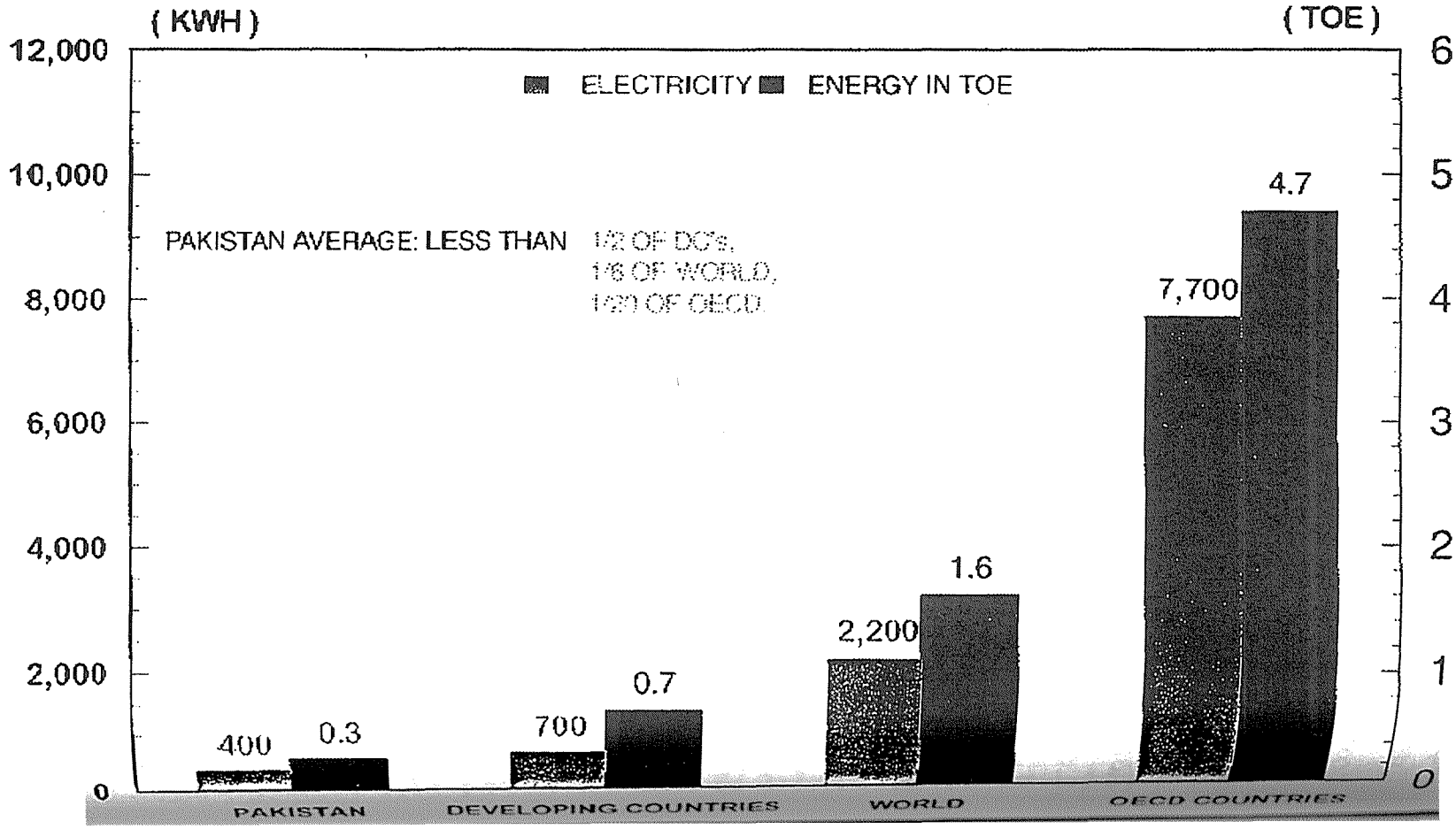
Taking the lead from Japan and Republic of Korea, a number of energy resource-poor Asian countries are now eagerly interested in making use of nuclear power in order to overcome their energy supply difficulties. Nuclear power programmes are already active in the People's Republic of China, India and Pakistan. Some other Asian countries such as Indonesia, the Philippines, North Korea, Iran, Turkey, Thailand and Vietnam are also considering introduction of nuclear power in their electricity supply systems. However, the development of this technology in most of these countries in a self-reliant and cost-effective manner is beyond their capabilities. They lack the technical and financial resources for the development of necessary infrastructure facilities and for undertaking R&D programmes for the design, manufacture and construction of nuclear power plants and related fuel cycle facilities. Although useful assistance to overcome some of these difficulties is being provided by the International Atomic Agency (IAEA) and the World Association of Nuclear Operators (WANO), in particular by the Tokyo Centre of WANO, such assistance generally falls much short of their real needs. The Asian countries, therefore, need to pool their resources like the West European countries did some 30 years ago and, thereby, create cooperative arrangement on the pattern of EURATOM to establish joint infrastructure and R&D facilities for the development of nuclear power technology in Asia. Besides

benefiting the needy countries such a cooperative arrangement will also help effective utilization of the infrastructure developed by certain Asian countries already having large scale use of nuclear power, after they reach a saturation level.

Joint collaborative efforts will not only be more cost effective, they will also lead to the development of nuclear power technology in the region in a reliable, efficient and safe manner.Such a cooperation will also promote transparency which will be helpful in building confidence among the nations about the peaceful intent of their nuclear power development. It is true that the present situation in Asia is not comparable to that existing in Western Europe at the time EURATOM was established. The World War II had then left the West Europe without major political differences, where-as strong hostilities continue to exist among several Asian neighboring countries. In view of this situation, a full-scale adoption of the EURATOM model may not be immediately practicable in Asia at this stage. However, establishment of a limited framework which may get stronger with time is most desirable. This in turn may go a long way in reducing the existing tensions and hostilities among some countries of Asia. In fact sharing of technology can play a role in cementing the relations among unfriendly neighbors. It is, therefore, proposed that (i) a regional organization, somewhat along the lines of EURATOM, may be created in Asia to jointly develop and share the know-how of design and engineering of nuclear power plants, (ii) the same organization may also set up properly safeguarded nuclear fuel cycle facilities in the Asian

region, and (iii) a common fund may be established for financing, on appropriate terms, the construction of nuclear power plants in the region. It goes without saying that a leading role in this direction will need to be played by Japan and Republic of Korea, the two countries which have already acquired a high degree of expertise in nuclear power technology.

PER CAPITA CONSUMPTION OF PRIMARY COMMERCIAL ENERGY AND ELECTRICITY



FUTURE REQUIREMENTS OF POWER GENERATION CAPACITY AND SUPPLY OPTIONS

	2010	2020
INSTALLED CAPACITY REQUIREMENTS*	40,000 MW	60,000 MW
INSTALLED CAPACITY LIKELY TO BE BASED ON INDIGENOUS ENERGY SOURCES		
HYDRO	14,000 MW	20,000 MW
GAS	3,000 MW	3,000 MW
COAL	7,000 MW	15,000 MW
TOTAL INDIGENOUS	24,000 MW	38,000 MW
GAP	16,000 MW	42,000 MW

AVAILABLE ALTERNATIVES TO FILL THE GAP:

- IMPORTED OIL
- IMPORTED GAS
- IMPORTED COAL
- IMPORTED ELECTRICITY
- NUCLEAR POWER

*Based on Electricity Demand Growth of ~ 9 % per annum

PRESENT INSTALLED POWER GENERATION CAPACITY IN PAKISTAN

TOTAL CAPACITY	14000 MW
HYDRO	37%
OIL AND GAS	61%
COAL	1%
NUCLEAR	1%

第二九回原産年次大会午餐会　　坪井政務次官所感

1．本日は、第二九回原子力産業会議年次大会にお招きいただきありがとうございます。原子力の開発利用や安全確保に携わっていらっしゃる各国の皆様方と今日ここにお目にかかる機会を得ましたことを、心より嬉しく存じます。私自身、通商産業行政の一環としてエネルギー政策に取り組んでいるところでありますが、本日は、原子力の最近の情勢につき一言申し述べさせていただきたく存じます。

2．今年は、チェルノブイル原子力発電所の事故からちょうど十年目にあたります。ますます増大するエネルギー需要や地球環境問題に対応していくため、原子力に対する期待は少なからざるものがございますが、一たび大きな事故が起こった際、周辺地域の安全のみならず、世界の原子力開発にも多大な影響を与えることを示したのが、チェルノブイル原子力発電所事故でありました。チェルノブイルの事故以降、原子力の安全確保のための国際的な取組の必要性は広く認識され、原子力事故の早期通報に関する条約や原子力事故又は放射線緊急事態の場合における援助に関する条約が発効し、また、一昨年には原子力施設の安全確保を目的とした原子力安全条約が採択される等、数々の多国間協力の枠組みが形成されてきておりま

す。とはいうものの、いまだ、一部の国々では安全性に疑問の残る原子力発電所が運転されております。また、成長著しいアジアにおいては原子力発電を新たに開発・導入しようという気運が大変な高まりを見せています。これらにかんがみ、原子力の安全確保のための国際協調、国際協力は今後ともますます重要性を増してくると思われます。さらに、国際的な放射性廃棄物の管理や原子力賠償制度の強化等への取組も強く求められております。このような世界の原子力の安全等に対する強い関心を背景に、明日、十九日からは、原子力安全等に関するモスクワサミットが開催されます。我が国からは橋本総理が出席いたしますが、各国首脳による活発な議論が展開され、一層の原子力安全の徹底を求めるメッセージが世界に発出されることを心より期待しております。

３．今年はまた、我が国初の商用原子力発電所である日本原子力発電の東海発電所が運転を開始して３０年目にあたります。この間、我が国の年間発電電力量は約５倍に増え、原子力は、その約３割を担うに至りました。安全確保のために幾重もの努力を重ねつつ、原子力は供給安定性、経済性、環境負荷の各面で優れた特性を有するエネルギー源として、着実に重要性を増しておりますが、最近、その社会との共存のあり方がクローズアップされるようになってまいりました。昨年十二月に起こった高速増殖原型炉「もんじゅ」の二次系ナトリウム漏洩事故は、この社会の動向を象徴する

かのように、単に技術の問題に留まらず、大きな社会的関心を呼ぶ結果となりました。現在、「もんじゅ」事故を契機とした原子力政策に対する国民の不信感・不安感の高まりを前に、原子力に対する国民の信頼の回復は、原子力行政を預かる者にとり喫緊の課題となっております。原子力の利用にあたっては、安全確保を最優先に考え、機器の性能等のハード面と、運転技術等のソフト面の両方の向上に不断の努力を行うのは申し上げるまでもございませんが、今後はこれらに加えて、国民各位の御理解と信頼を得られるよう、情報公開や広報活動の一層の充実強化に努めてまいる所存です。具体的には、先般橋本総理の指示を受け国民の理解と信頼を得ていくための方策につき検討を行い、原子力委員会に新たに「原子力政策円卓会議」を設置するとともに、シンポジウム等を積極的に展開し、原子力利用についての国民各位の幅広い御意見を伺うこととしています。この一環として、当省といたしましても、「一日資源エネルギー庁」、「全国公演キャラバン」等を各地で開催し、資源エネルギー庁幹部職員等と一般市民の間で直接対話を行い、できるだけ多くの生の声を伺うなど、原子力政策に関する国民的合意形成を目指して万全を期してまいる所存でございます。

また、最近のエネルギー消費の拡大や地球環境問題の深刻化を踏まえて、近く総合エネルギー調査会で総合的かつ長期的視点に立ったエネルギー政策につき、検討が開始されることとなっております。様々な場を通じて寄せられた御意見を踏まえ、エネルギー源としての原子力のあり方について

も検討が行われるものと期待しております。

４．今年次大会の基調テーマは、「原子力は期待に応えられるのか」であると聞いております。原子力がこれからも重要なエネルギー源の一つとして社会に受け入れられていくためには、社会というスクリーンに写る姿が正視されて行かねばなりません。本日夕刻、原子力関係者と市民との意見交換の会が開かれると聞いております。多くの貴重な御意見が寄せられ、原子力利用について広く国民に御理解いただくための良い機会となることを期待いたしております。

最後になりましたが、今後の原子力開発利用の円滑なる進展と御列席の皆様方の一層の御活躍を祈念いたしまして、私のごあいさつとさせていただきます。

LOCAL ACCEPTANCE AT A FUEL RECYCLE FACILITY IN THE UK AND LESSONS FOR INTERNATIONAL COOPERATION

GRAHAME R SMITH

Director UK Group

Head of Sellafield Site

BNFL

Public acceptance of nuclear power is something none of us in this industry - anywhere in the world - can take for granted. It is not given easily. Like loyalty or respect it has to be earned. At Sellafield we know. We learned the hard way. Over the past 10 years or so BNFL staff at Sellafield have worked diligently to win public acceptance in the local community around Sellafield in which we all live and work.

It has been an excellent example of team work at its best, involving the workforce and the local community. Along the way we have learned many lessons.

It has taken 10 years, a great deal of effort and finance and painstaking attention to even the most trivial of issues to gain the publics' trust. But we have made considerable progress although continuing attention to this aspect will be required.

Sellafield is unique in many ways. Located in the English Lake District - home of Beatrix Potter - a national parkland of outstanding beauty, Sellafield is situated in the western coastal

area of the county. Historically West Cumbria has had mixed fortunes from the industrial and infrastructural points of view.

In the 18th century the principal town of Whitehaven (14 miles from the Sellafield site) was an extremely busy shipbuilding base and seaport with trading connections to the New England States of the United States. But gradually the prosperity died away as other ports took over Whitehaven's role.

In the late 19th and early 20th centuries local mining industries for coal and iron ore became the principal employers bringing with them prosperity and security for people of the towns and villages around Sellafield. But this prosperity was once again short lived.

In the 1950s Sellafield gradually began to expand and with this expansion came local prosperity - prosperity based on nuclear power.

Today Sellafield and its activities underpin the economy of West Cumbria. The site employs 7,000 people directly with a further 1,000 in contracting roles. Many other local jobs are also dependent on the site. This is a lot of jobs in an area which is one of the most rural in northern England. Apart from a few small industrial plants the other principal sources of employment are agriculture, tourism, local government and the health service.

Sellafield plays an essential part to the very existence of the community in West Cumbria. Most of Sellafield's employees live in the small towns and villages within a 15 mile radius of

the site. Indeed some 70% of the workforce live in the local parliamentary constituency (Copeland).

However this dependence on Sellafield for employment and a high standard of living is not sufficient on its own to win public acceptance in the community.

Indeed in 1984 public perception of Sellafield was so badly damaged by a series of highly publicised incidents (the most severe of which was the contamination of beaches close to the site) that local opinion - and opinion amongst our workforce - was at a very low level.

Like your Monju incident - the beach incident as it became known, was not radiologically serious - still within authorised levels but the media and Greenpeace made it into a major nuclear accident. Again - like Monju - we did not have a technical problem but a presentational problem which required a communications solution.

Something had to be done to remedy this situation to repair the damage in public perception and a programme of public affairs activity was put into motion.

The objectives were simple and straight forward, to be open, honest and to be trusted. We opened the doors of Sellafield to the public; we were honest about mistakes which we made and we set about implementing procedures to ensure such events which led to that adverse publicity did not happen again. In public acceptance activities we identified our stakeholders - our audiences - who we needed to address. These fell into several categories.

Firstly, our workforce - industrial and staff trade unions. Secondly, our neighbours on the site, contractors, maintenance staff, Atomic Energy Authority. Thirdly, our publics - central government, local MPs and MEPs, local councils and the media. Fourthly our customers and competitors and suppliers and fifthly, nuclear regulators and anti-nuclear pressure groups.

Through all of these outlets we eventually come to the general public in the community at large - the people who grant us the licence to operate our plant. To win trust you have to be a good neighbour. That is and will continue to be our principal objective in all our public acceptance activities. Like all good neighbours we work closely with our publics, our stakeholders, keeping them informed of everything we do and why we are doing it. We address our various audiences in different ways - tailoring the medium to suit their requirements. However, the basic messages remain the same.

We use the Sellafield Local Liaison Committee - with a wide cross section of local community leaders - as one of the main areas to address issues which concern the community. This is a representational body of local opinion formers, councillors, health experts, local government officers, planning experts, fire, police and ambulance personnel. Representatives are elected to the Committee, which meets twice a year. Members of the public and observers including anti-nuclear groups attend. We even took the unprecedented step of handing the chairmanship over to a local politician. We address their issues and concerns openly and honestly. We report even the most minor of incidents to them. They are free to raise any issue they wish.

We have regular meetings, both formal and social occasions, with the county, local borough and parish councils and within our workforce - as ambassadors for the Company. We address their issues or concerns openly and honestly.

Some of you will recall that the UK Government carried out a review on whether the THORP plant at Sellafield would be commissioned following its construction in 1993-94. Indeed during this period many of our Japanese customers helped us by placing adverts supporting THORP in the UK media. If we in BNFL can respond by helping you with your problems on Monju I would be happy to address the issue and ways we may be able to help afterwards. Members of the workforce also wished to be involved in the campaign to have the plant commissioned. They lobbied Government departments and Ministers and made a major contribution which eventually secured a decision for the plant to become operational. It is important to encourage the workforce to take such a role.

Each month the workforce is thoroughly briefed on all issues affecting the site by use of a core information brief. Each month they receive a personal copy of the Company newspaper. Each week we issue the Sellafield Newsletter to the workforce, to the media, local community leaders, indeed to anyone who requests its. This newsletter reports all of the previous week's site activities in detail - including even the most minor of incidents.

We built a Visitors Centre in the mid 1980s. Initially a modest affair, which had proved very popular, it was replaced by a £5 million centre which was opened by HRH Prince Philip, Duke of Edinburgh in June 1988. This facility attracted over 150,000 visitors a year - as part of our 'open door' policy. It also became a major tourist attraction in West Cumbria.

In June 1995 we reopened the Visitors Centre after a £5 million refurbishment programme. In its first six months it attracted over 100,000 visitors including 39,000 in one month alone. So it has been a major success.

We also encourage visitors to the Centre to take a tour of the Sellafield site on one of two coaches. Specially trained staff provide a commentary during such tours and are of course available to answer questions.

We have introduced guided tours to plants on site. On average 10,000 people each year take the opportunity to tour the plants and are encouraged to talk to staff during such visits.

In addition we have a Speakers Panel Talks Service whereby we encourage qualified members of staff at all levels to attend venues all over Cumbria and give talks to schools, clubs, associations on what BNFL does at Sellafield. On average each year some 70 talks are given. We also answer thousands of letters with requests for information or for queries to be answered.

We meet formally and socially with all sectors of the community - police, church leaders, educationalists, industrialists from other industries, landowners, farmers, fishermen, in fact anyone who wishes questions answered or have points to make.

We encourage staff to be involved in community activities. Many are elected to local councils and hold senior office; many are school governors.

We provide substantial sponsorship to a wide range of charitable organisations in the community.

We respond favourably to media requests to visit Sellafield and are eager to assist the media in following up enquiries. We work particularly closely with the media in our community.

We invited Greenpeace to the site in the late 1980s and they spent two days touring the plants and questioning our staff.

In terms of international cooperation our links with Japan go beyond commercial boundaries. We have welcomed a number of Japanese local government parties to Sellafield and recently our local civic head - the Mayor of Copeland - visited Japan to meet civic heads. We have also encouraged trade union officials at Sellafield to establish links with their opposite numbers in Japanese utilities. These exchange visits are particularly good ways we have found of exchanging information on the impact nuclear installations have on local communities.

I mentioned earlier that the Visitors Centre is a major tourist attraction. This has had a two-fold benefit. Firstly it has allowed BNFL to become involved in local tourism initiatives and is perceived by the local community as bringing people - and consequently business into the area - and secondly it has helped the local tourist industry to grow and develop.

Trust is a two-way street. We have won the trust of many in the local community because we are now seen to be an open and reliable source of information. On occasions we have given

elements of the local community, in confidence, information which is sensitive. They have respected that confidence.

The second part of our community programme relates to money and the financial aid we have given to the local communities.

BNFL's community support programme until 1988 was mainly in the form of one-off projects and infrastructure support, which while appreciated by the recipients, created resentment in those areas or organisations which did not benefit, and more importantly did not address the real problems of Cumbria and merely perpetuated BNFL's dominant position in the local economy.

In 1988 the West Cumbria Partnership was formed as an alliance between BNFL, the local and county councils, government agencies and private industry. The Partnership's aims are to address West Cumbria's key problems through the regeneration of the local economy, in particular by focusing on job creation and business development in the locality.
It was clear that by taking the then current spend of over £1m per annum that BNFL gave to the community and directing that spend into a fund to which the local councils also donated, the money could be used more strategically for the good of the totality of West Cumbria. The money could also attract additional financial support through matching national and European funds. This scheme was further backed by BNFL through identifying technology on the Sellafield site that could have wide applicability beyond its current use and be commercially developed into a local small or medium sized enterprises.

Achievements of the West Cumbria Partnership to date have included the creation or safeguarding of over 3,000 jobs, and over 500 business start-ups. The flagship scheme of the Partnership is the Westlakes Science and Technology Park which is a developing success focused on the growth of knowledge-based business and academic excellence in the area. Westlakes has attracted 20 firms, employing over 250 people in total on the Park, and through the Westlakes Research Institute is developing environmental commercial research underpinned by academic understanding, towards the growth of business enterprise and university status in West Cumbria.

By assisting West Cumbria in this way BNFL is helping the area in the way that is most productive in meeting the short and long term needs of the locality. The money donated receives added value through the attraction of additional grants; the benefit from the schemes reaches all of West Cumbria and across the county, bringing wide local and political support; any improvement to the image of the area benefits BNFL and the reduction of dependence on the Company in the locality aims to avoid the on going requests for funds, putting BNFL in a more healthy position of being a 'commercial partner' in the economic community of West Cumbria. Most importantly from BNFL's point of view it involves the Company working in close partnership with the principal opinion formers in the community providing as a result a very substantial improvement in relationships.

We have assisted in encouraging sporting activities, in helping regenerate the Georgian architecture of Whitehaven, in the field of arts.

Winning public acceptance in our rather remote community cannot be attributed to one single factor but to a combination of factors and to painstaking attention to detail. Continuously communicating with people, gaining their confidence, winning their trust.

Our role in the county is to underpin the economic fabric of West Cumbria through on going employment, combined with our financial help through the West Cumbria Development Fund. But that is only part of the equation. Everything we do in our activity is geared to retaining and gaining public acceptance.

It is important that action does not wait until there is a public acceptance problem. Nurture relationships so that when there are difficulties you can go to the people and explain honestly and openly what went wrong. It takes time and effort to win that support. But it is time and effort well invested. Make use of the good times to prepare for the bad.

Don't be shy to counter Greenpeace and other anti-nuclear groups if they attack you - defend yourself. Don't be tempted to adopt a low profile - it will came back to haunt you.

Public acceptance is perhaps for us, in the nuclear industry, the one single fundamental area of operation we must have. If we do not have this support we will lose our licence to operate.

I hope the sharing of our experience at Sellafield is helpful and contributes to your deliberations on improving public acceptance to the nuclear industry.

CURRENT STATUS OF FAST REACTORS AND OUTLOOKS FOR THEIR FURTHER DEVELOPMENT

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Report to the 29th annual Atomic Forum of Japan conference,
April 17-19, 1996, Nagoya, Japan

ABSTRACT

The paper presents a concise survey of the fast reactors current status and programs of their further development on the world.

Forecasts are given of the future Nuclear Power development in Russia. Necessity of fast reactors introduction into the Nuclear Power System has been demonstrated, not only in the terms of the natural uranium resources deficiency, but for the sake of other problems solution as well (efficient plutonium utilization, decrease of the spent fuel radiotoxicity, etc).

There is in the paper a brief description of experience gained in the process of operation of fast reactors in Russia. Analysis is given of their safety level and the position of Russia on fast reactors in short-term and long-term perspectives is presented.

INTRODUCTION

The current situation on the uranium market and slowing-down of the nuclear power growth in all the world resulted in conditions under which the main feature of fast reactors - ability to fuel breeding became unnecessary. That is why, construction of fast reactors in the nearest decades can be economically justified if other than breeding fast reactors advantages would be needed - such as high degree of safety, ability to solve some ecological and other problems by means of actinides incineration and plutonium utilization.

Deployment of fast reactors in the nuclear power system is necessary if its development strategy will be focused on the closed fuel cycle with repeated use of separated uranium and plutonium. The current level of fast reactors technology development and the fuel cycle technology chosen as well as disposable natural resources, will determine the degree of fast reactors "participation" in the program of nuclear power development in any country.

1. SHORT SURVEY OF THE CURRENT STATUS AND PROGRAMS OF FAST REACTORS DEVELOPMENT IN VARIOUS COUNTRIES

France

PHENIX reactor has finished its 49-th cycle April 7-th 1995 at the power level of 350 MW(t). The plant was ready to begin its 50-th cycle in October 1995. Presently the reactor is shut down: repairement and back-fitting of the secondary coolant system are going on.

A program has been worked out, aimed at prolongation of the reactor's life for the next 10 years.

The program pursues 3 main object:

- achievement of high burn up for the oxide fuel;
- performance of the special experiments in support of the CAPRA project (increased plutonium consumption) and of SPIN program (separation and incineration of the long-lived waste);
- getting additional operating experience, particularly, for better comprehension of the incidents with negative reactivity, and of the reactor's structures ageing processes.

At present, Superphenix reactor is being operated at about 50% level of its nominal power.

June 11, 1994 P.Minister of France has issued a new decree giving the plant legitimate existence and confirming the new reactor's orientation, which pursues three aims:

- to demonstrate the possibility of a fast reactor to produce electricity at the industrial scale taking account of operator's possibility to survey various regimes of the fuel, systems and components behaviour and make an inspection;
- to evaluate the ability of such reactor type as a plutonium consumer in two directions: transition from the breeder state to the burner's one and analysis, using full-scale subassemblies, of the technical decisions included in the CAPRA project;
- to study the possibilities of long lived waste destruction in three directions; to confirm fast reactor's ability to incineration, to confirm technical ability of fulfilment the task, and to demonstrate the compatibility of two approaches - plutonium burning and actinides transmutation.

Germany

The new law accepted by the both Chambers of the Federal Parliament stressed the importance of direct final radioactive waste

disposition, that is waste disposal without preliminary spent fuel reprocessing.

MOX-fuel fabrication by the firm Simens at the plant near Hanau will be not renewed. Land Hessen Government, where this plant is located, is at all against any activity connected with nuclear power. Dismantlement of the fast reactor SNR-300 is continued. The reactor's ready-made subassemblies are still looking for their customer.

Japan

The test reactor "Joyo" delivered a vast experimental material since the moment of the first criticality achievement in 1977. "Monju" prototype reactor became critical in April 1994 and in June 1995 began delivering electricity to the network. But the recent incident at the reactor with sodium leakage from the secondary coolant system and all the next related events, may influence the sodium cooled fast reactors development in the nearest future.

Design of the demonstration fast reactor (DFBR) was being conducted during the last years and earlier a decision has been accepted to begin this plant construction early in the next century.

China

One of the objects of advanced reactors development in China consists in construction and achieving the first criticality of Chinese experimental fast reactor CEFR-25 in the year 2000. The proper decree of the Government was adopted March 14, 1992. The program of nuclear power development in China began with LWR type reactors which are not able to ensure the necessary level of electrical power because of limited uranium resources. Enough to note that electricity production growth during last years amounted to about 15 GW per year. For this purpose fast reactors play very

important role in the large-scale development on nuclear power for maximum replacement of coal fired plants.

India

Indian fast experimental reactor (FBTR) having electrical power of 13.2 MW(e) became first critical in October 1985. Since that it was operated at various power levels but not higher than 10.5 MW(t) where - as its design nominal power is 40 MW(t). Preliminary design of a fast reactor prototype (PFBR) with electrical power 500 MW(e) was performed in the year 1985. The reactor concept was based on the design decisions of those times large fast reactors. Its costs parameters were higher than those of LWR and in the year 1993 it was decided to focus efforts on the capital costs reduction. The project was thoroughly revised and in the existing its advanced version the number of components was essentially reduced.

Switzerland

Motivation of a small research program on fast reactors consists in the maintenance at a proper level the knowledge on safety problems of fast reactors and particularly of the Superphenix. In the West part of Switzerland, mainly in the Geneva region, there is widely spread fear of a possible accident at the Creys- Mallville plant, located about 100 km down stream of Rona river, but in the wind-rose directed mainly toward Geneva region. Information, which is being obtained from the research program allows to estimate the risk of the NPP existence over here and to compare it with the risk from other sources.

Italy

As a matter of fact Italy has not its own program on fast reactors. Italian scientists collaborate with the American General Electric company

on the reactor PRISM MODB oxide fuel core optimization, particularly on the seismic stability problem. Besides, Italian scientists ere included in FRAMATOME-Novatome collective which deals with the repeated start up of SPX-1 reactor.

Brazil

After many discussions, scientists have persuaded the Government in the necessity of long-term program on fast reactors for Brazil. The program, called REARA, has as its objective creation and start up, within the nearest 25-30 years, an experimental reactor, which will be used for carrying out the necessary research program.

Korea

Fast reactors development program of Korea consists in the development, design and construction of the fast reactor prototype toward the year 2011. Reactor power will be chosen as 150-350 MW(e). The first commercial fast reactor is supposed to be commissioned by the year 2025.

2. NUCLEAR POWER IN RUSSIA

Presently in Russia there are 9 NPP with 29 operable units. Among them 13 VVER units; 6 VVER-440 and 7 VVER-1000, 11 RBMK units, 1 BN-600 unit and 4 EGP-6 units at the Bilibino NPP having power level of 12 MW(e) each. During the year 1995 the NPPs have produced 99.3 billion kilowatt-hours of electricity, what is 101.5% of 1994 production. During the year 1995 the average load factor amounted to 53.4%. In the year 1995 there were 3 incidents, registed according to the international scale INES, two incidents of the level 1 and one of the level 2. In 1994 there were 8 incidents:

seven of the level 1 and one of the level 2. Altogether there were 95 infringements in the NPP operation in the year 1995, what is by 33 less than in 1994. Radioactivity releases in 1995 were in the frames of allowances.

3. FAST NEUTRONS REACTORS

Currently in Russia there are three operable fast reactors: two experimental BR-10 and BOR-60 and one semi-industrial power reactor BN-600. Russian specialists developed and commissioned BN-350 reactor at the territory of Kazakhstan, nowadays Russian specialist are performing the author's surveillance on the reactor. BN-800 reactor design has been modified, and now it is the most grounded design of a nuclear reactor and it has passed all the stages of examination, including examination on ecology. The commenced reactor's construction at the Sauth-Ural NPP site was stopped and now is frozen.

Reactor BN-600

BN-600 became critical in the year 1980 and since 1982 the unit is operated at the nominal power level. The average load factor over all operation period amounts to 70 %. Reactor operation life time is 30 years. Thus, the reactor has worked by now half of ifs life time.

A program has been worked out for the reactor back-fitting, connected with the necessity to restore life time of certain components and to take measures for meeting safety rules, renewed in the last years.

Principal measures of the program consist in:

- increase of the installation seismic stability in connection with the increase by one point of the region, where NPPis located, seismic category (maximum design earthquake was 6 points MSK-64 scale);

- arrangement of air heatexchangers for emergency cooling;
- replacement of steam generator's evaporators after their life time expiration;
- replacement of the reactor control instruments and the fuel reloading system after their life time expiration;
- replacement of the control rods drives after their life time expiration.

In the BN-600 reactor tests of experimental subassemblies including subassemblies with MOX fuel are under way. According to requirements of new codes all NPP of Russia must now get a licence for operation. Beloyarskaia NPP has got such a licence for 5 years in the year 1995.

Reactor BN-350

Design life time of the reactor was accepted to be 20 years. This time expired in 1993. At present, works are going on for grounding of the reactor life time prolongation, which include two principal directions:

- analysis of the equipment and systems of the reactor and replacement of those with expired life time;
- analysis and removal discrepancies to requirements of up-to-date codes.

On the results of the work a list of discrepancies to the requirements of codes and correcting measures was prepared, a part of these measures have been already realized.

In the year 1995 the report on the reactor safety was prepared, where possibility of the reactor operation prolongation is substantiated.

In compliance with the acting in Russia safety requirements for reactors of the first generation such a report should be issued annually. On the base of this report conclusions Gosatomnadzor of Kazakhstan has given permission for the reactor operation till July 1996.

4. OUTLOOKS FOR FAST REACTORS DEVELOPMENT IN RUSSIA

The long-term objective of Nuclear Power is determined by a common to various countries strategic aim: to solve the problems of energy resources and of ecology, caused by the inevitable growth of energy demand and conventional organic fuel deficit.

Prospects for fast reactors development in Russia depend upon a number of factors, main of them are as follow:

- availability of natural uranium resources and situation in the uranium market;
- forecasted nuclear power development rates for the short-term and long-term periods;
- other important, besides breeding, problems which can be solved nowadays by means of fast reactors, particularly, utilization of excessive plutonium and transmutation of radioactive waste.

Let us analyse the situation which is being formed in the Nuclear Power industry branch of Russia, proceeding from the projections of its development taking into account above mentioned factors influencing the prospects of fast reactors development.

For the nearest future the Nuclear Power industry of Russia will be based on the third generation of thermal reactors. Nevertheless limited uranium resources do not allow growth of the Nuclear Power to a considerable scale and during long time using these reactors. Even in the version of Nuclear Power development, when NPP power amounts to 80 GW(e) in the year 2030 and is supported at this level during the next 20 year, uranium deficiency will be 30-50% ("Энергетическая стратегия России"). When NPP's power will grow and ensure about 50% of electricity production in Russia after the year 2050 and to the end of the next century (160-180 GW(e) of installed power) additional 2 million tonne of natural

uranium will be needed. This figure is next to the amount of the total estimated natural uranium resources on the territory of Russia. Taking into account that the share of profitable uranium reserves is equal to about 25% of the total uranium resources, to ensure above mentioned uranium demand by means of national resources will be impossible. It is worthy to note that according to foreign estimates by the years 2030-2040 all world profitable uranium reserves will be exhausted.

Thus, the large-scale Nuclear Power development in Russia based on uranium fuel is limited by the available natural uranium resources. Besides, usage of thermal reactors only does not allow to solve completely all problems of Nuclear power related to NPP's safety, utilization of stored civil and weapons plutonium, as well as problems connected with radioactive waste.

To solve these problems a new technology should be created. Studies carried out in Russia in the last years have shown that entirety of these requirements can be ensured by the nuclear technology, realizing the fast neutron reactors concept with closed fuel cycle. Fast reactors fundamental feature - breeding of nuclear fuel can solve the problem of the Nuclear Power industry - fuel supply for a very long historical period of time. Principles of physics the fast reactors are based on make it possible to create such a technology in which the inherent safety properties of these reactors are being used to a maximal degree. In this respect fast reactors are passing ahead of other types of reactors.

An important problem the fast reactors can cope with is the task of plutonium utilization, both civil and weapons. In different countries exist various opinions concerning plutonium. On the one hand it is a dangerous radiotoxic material on the other hand it is a valuable power industry raw material. One gramme of plutonium is about equal by energy content to one tonne of oil. Besides radiotoxicity, plutonium availability creates danger of

nuclear terrorism and of the fissile materials non-proliferation principles violation. In USA, for example, non-proliferation problem is put on the first place and thermal reactors spent fuel is proposed to be buried without reprocessing. In other words, plutonium will be transferred into, so called "standard of spent fuel". In this way will be buried a large energy potential for the living generations and birth given to a huge problem difficult to solve for future generations. Russia has another approach to the plutonium problem: to utilize the huge energy potential of plutonium and do not create large problems for the future generations. For this purpose all plutonium (civil and weapons) is proposed to be "passed" once through the BN-800 reactors and then the spent fuel will be stored till the moment, when high enough reprocessing capacities will be commissioned and in this way closed fuel cycle arranged. Thus, the danger of non-proliferation regime violation will be removed and energy potential be well preserved. Estimates show that three BN-800 units can "pass" through them for 30-40 years all separated civil and released weapons plutonium in Russia.

Besides plutonium problem fast reactors can solve as well the problem of long-lived waste, which are being accumulated in the process of operation of all reactor types.

In the fast reactor due to the hard neutron spectrum, many nuclides and particularly, minor actinides - neptunium, americium, curium subject to fission and by this way will be transformed into stable or short-lived isotopes. Estimates show, that existing in project BN-800 reactor can utilize minor actinides of 3-5 VVER-1000 units without any considerable modifications of the design.

Presently in Russia on the base of existing BN-800 reactor design works are conducted on the reactors - burners of plutonium and minor actinides. They have plutonium utilization rates several times high than that in the existing design of BN-800 reactor. Thus introduction of fast reactors

into Nuclear Power industry in Russia is connected not only with the limited resources of natural uranium, but the necessity to solve arising problem with plutonium and waste as well.

5. FAST REACTORS SAFETY

Characteristic feature of fast reactors is to a great degree the principle of inherent safety. This is explained by the core physics (stability of neutron fields and heat generation, stable reactivity negative feedbacks, small probability of the secondary critical mass formation etc.). Essential influence on the safety has low pressure of the coolant and its high thermal capacity.

Practical experience in Russia on fast reactors operation (BR-10, BOR-60, BN-350, BN-600) is in the whole positive. For example, NPP with BN-600 reactor demonstrates high reliability and safety. Average load factor during the last 15 years amounts to about 74% and some years it was higher than 80%. Unplanned load factor losses for the same period made up 2.7% (average over the world for the NPP, it is not less than 3.9%). Average collective dose of personal irradiation at the NPP BN-600 is not higher than 1.0 manSv/year, that is essentially better than average figures for other NPP's. Inert radioactive gases release for the years of the reactor operation was not higher than 1% of allowance and long-lived and short-lived nuclides release was absent. The amount of the low level radioactive waste (LLW) was not higher than 60 m^3/year.

Further development the safety questions obtained in the of NPP with BN-800 reactor. The reactor core has zero sodium void coefficient, in the main protection systems passive principles were used. For example in the safety system hydraulically suspended rod is used, and in the emergency cooling system both in sodium and air circuits natural circulation is applied. Beyond design basis accidents analysis has showed that at the BN-800

reactor in the case of simultaneous loss of system and emergency power supply, simultaneous failure of safety system active elements and emergency cooling system, sodium boiling, fuel elements destruction and radioactivity release do not occur. High safety level of the NPP with BN-800 reactor was confirmed by conclusions of several examination groups even in the year 1992. In the year 1995 the repeated examination was carried out by the Ministry for emergency situations of Russia. Conclusions were made that it is worth while to continue construction of the NPP with these reactors.

Nowadays, when safety questions are being discussed special attention is paid to the problems of sodium fires. The performed experimental studies, as well as experience of NPP's operation in Russia show, that the designed fire extinguishing systems are efficient enough and can localize sources of fire in the case of sodium leakage from the circuit.

At the BN-350 reactor, during 20 years of its operation there were noted 15 sodium leakages from the secondary coolant system. At the BN-600 reactor during 15 years were noted 27 leakages from the secondary coolant system and one leakage of radioactive sodium from the auxiliary system of the primary circuit. In the most of them the volume of the sodium leaked was not higher than 1 l, maximal quantity ~ 1 m^3. In all cases the leakages were detected in a proper time and localized and did not cause disturbance of the radiological or ecological situation at the NPP.

Further R&D works in Russia in the area of fast reactors safety, which results will be used in advanced NPP are focused on the four principal directions:

- Studies aimed at making more precise current information with the purpose to optimize technical solutions, ensuring the NPP safety and improvement of its economical efficiency. These studies include advancement of calculation codes, out-of-reactor studies of processes under conditions of severe accidents (interaction of molten fuel with sodium,

sodium boiling, sodium fire, etc.) experiments on reactors (critical assemblies, reactors BR-10, BOR-60).

- Studies and development of safety systems and devices based on the passive principles of action and enhancement of the inherent reactor safety properties (emergency cooling systems, safety rods etc.).
- Safety studies of reactor cores intended for plutonium and minor actinides burning, where MOX-fuel is used.
- Safety studies of the advanced fast reactors cores with the dense fuel (nitride, metal).

CONCLUSION

1. Design and operation experience of experimental facilities, semi-industrial and industrial NPPs with sodium cooled fast reactors has chown that the Nuclear Power direction is technologically mastered and is able to ensure the necessary level of reliability and safety.

2. At present conditions exist for generalization of the experience obtained and conducting R&D works aimed at the considerable improvement of NPP's with fast reactors economical parameters. At the same time it is necessary to foresee certain measures, ensuring conservation of "know-how" as well as its further development having in mind new tasks of fast reactors (plutonium utilization, incineration of minor actinides and fission products).

Under conditions of Russia the short-term future in the area of NPP's with fast reactors is connected with BN-800 units construction.

3. As far as long-term future is concerned, there is necessity to develop and design NPP with a large power fast reactor (up to 1500 MW(e)) which having high safety level will be, at same time, economically competable. This work should be based on the wide international co-operation as far as

development and construction of these NPP's are concerned. These Russia positions are determined by the firm belief in fast reactors good outlooks in terms of their principal physical advantage - fuel breeding realization and at the same time having high safety level under conditions of the closed fuel cycle the most promising for the Nuclear Power.

Can We Live With/Without the Breeder Reactor?

by
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Prepared for Presentation
at the
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Introduction

Nuclear power, as embodied primarily in the LWR, is now a significant source of electricity in many industrialized countries. However, its future is very uncertain because of continuing public concerns about reactor safety, especially after the Chernobyl accident, and radioactive waste disposal. Such concerns have led to difficulties in siting new reactors and waste disposal facilities even in countries where the cost of new nuclear generation is still competitive with that from sources using imported fossil fuels. In addition, the fear - first expressed at the dawn of the nuclear age in the Acheson-Lilienthal Report (1946) - that international safeguards alone would be inadequate to prevent the misuse of peaceful nuclear activities to make nuclear weapons - has grown recently. This is because of recent events in Iraq, North Korea, and Iran, as well as the plans of the nuclear establishments in such countries as France, Japan, and Russia to press forward with plans to use plutonium breeder reactors in order to minimize potential problems associated with greenhouse warming, cutoffs in the supply of imported energy resources, and eventual exhaustion of

fossil fuels.[1] We comment on these rationales for the breeder briefly in the following.

The Nuclear Solution to Greenhouse Warming

The case for the breeder reactor as a hedge against potential greenhouse warming due to fossil fuel combustion is based on the view that available terrestrial uranium resources are insufficient to support the large nuclear capacity required if the reactors are converters such as the LWR. For example, the nuclear-intensive variant of a low carbon dioxide-emitting energy supply system recently developed by the Intergovernmental Panel on Climate Change (IPCC) envisions a growth in installed global nuclear capacity from the present 330 GWe to about 3,300 GWe in 2100.[2] If the reactors are LWRs operating on a once-through fuel cycle, the cumulative uranium requirements through 2100 are comparable to current high estimates of uranium resources including those in the former Soviet Union.[3] Thus, introduction of breeder reactors toward the end of the next century would be necessary to make a sustained contribution to minimizing the risks of greenhouse warming.

However, it would be both naive and dangerous to expect that the current system of international safeguards would suffice to prevent diversion of significant quantities of plutonium from flows - on the order of 3 million kg.- corresponding to 3,000 GWe of installed breeder capacity. Only a regime in which all sensitive facilities

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[1] With regard to the possible linkage between peaceful nuclear activities and the proliferation of nuclear weapons, note that this linkage includes both the use of a peaceful program as a convenient cover to gather resources for a separate, covert weapons program, as well as the diversion of nuclear materials in peaceful use by both states and sub-national groups.

[2] **Intergovernmental Panel on Climate Change, Second Assessment Report, Working Group II: Impacts, Adaption, and Mitigation Options**, Chapter 19: Energy Supply Mitigation Options, Cambridge University Press, 1996 (in press).

[3] See **Uranium: 1993 Resources, Production and Demand**, OECD, 1993, pp. 23-29.

would be clustered together in heavily guarded "nuclear parks" under international control could reduce the risks of proliferation and sub-national diversion to a sufficient degree. But placing the nuclear component of their electricity supply under international control would run counter to the major rationale for deploying breeders in countries such as Japan: energy independence.

Moreover, it is highly unlikely that the publics in democratic states would accept large-scale deployment of reactors - including breeders which have added safety issues not associated with LWRs - whose safety is based on the validity of probabilistic risk assessments made by nuclear establishments which have lost the trust of much of the public. In this connection, note that even a small core-melt probability, e.g., 10(-5) /reactor-yr, in a 3,000 - reactor world implies a core-melt every 30 years, which is clearly unacceptable. Rather, a necessary but not sufficient condition for public acceptance of nuclear power on a large-scale is that the reactors be reliable and that their safety against core melts caused by accidents or malign intent be convincingly demonstrated, probably by full-scale, worst case test.[4]

In addition, it would be prudent not to have to rely on draconian security measures to minimize proliferation risks. At present, this favors reactors operating on once-through fuel cycles using low-enriched uranium. Although the uranium utilization of such cycles is low, mining history, the lack of strong economic incentives to look for higher cost uranium reserves, and recent discoveries of very rich uranium deposits in Canada and elsewhere all indicate that current estimates of uranium resources are minimum quantities. In particular, mining evidence suggests a 300-fold increase in the

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[4] For a further elaboration of this argument, see Lawrence M. Lidsky, "Nuclear Power in a World With Options", presented at the Symposium on (R)Evolutionary Reactor Types, Almelo, NL, May 1991; available from the author @ The Department of Nuclear Engineering, Massachusetts Institute of Technology.

estimated amount of recoverable uranium for every ten-fold decrease in ore grade.[5]

Moreover, experience with the mining of other elements such as copper indicates that advances in mining and milling technology can compensate for decreased ore quality to minimize the cost of extracting lower-grade ores. Thus, there is probably enough uranium for large-scale deployment of reactors fueled with low-enriched uranium on once-through cycles for many years, even without mining the large uranium in seawater resource base which is feasible at costs which imply electricity generation charges comparable to those for breeder reactors.[6]

With regard to the issue of security of supply, Japan should decrease its dependence on oil imports for electricity generation by using more natural gas in combined cycles as well as for cogeneration of electricity and heat.[7] Also, for energy security through stockpiling of fuel, nuclear has the major advantage of much lower costs and volumes compared with coal for equivalent

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[5] Kenneth S. Deffeyes and Ian D. MacGregor, "World Uranium Resources", **Scientific American**, January 1980, pp. 66-77.

[6] See, J. Collins, J. Delene, and C. W, Forsberg, "Are Economic Uranium Resources A Constraint for Large-Scale Use of Nuclear Power?", Draft, Oak Ridge National Laboratory, September 1992.

[7] Natural gas is difficult to transport, requiring either liquefaction or pipelines from producer to consumer. However, gas is plentiful in Asia, and the construction of pipelines within the region would reduce the dependence on Middle Eastern oil. Note, too, that once a pipeline is in place, it is much less likely that the producer will cut off supplies to the customer, since selling the gas elsewhere is not as easy as diverting oil supplies. (I thank Robert Williams for this observation.) In the next century, methanol or hydrogen derived from municipal solid waste can also become a major domestic source of transportation fuels in Japan. See, Eric D. Larson, Ernst Worrell, and Jeffrey S. Chen, "Clean Fuels from Municipal Solid Waste in New York City and Other Major Metropolitan Areas", Report No. 293, The Center for Energy and Environmental Studies, Princeton University, January 1996.

Japan should play a leading role in developing and promoting the required nuclear technologies and institutional frameworks as part of a broad energy strategy which gives equal weight to reducing energy demand via greater efficiency in generation, transmission and end-use, as well as renewable energy sources and "climate-friendly" uses of fossil fuels.[11] In particular, Japan can help build both a safety and a non-proliferation "culture" in East Asia in cooperation with its neighbors, perhaps through a regional organization devoted to implementing sustainable energy strategies. Such cooperation would have the added benefit of building confidence between the parties. In the long run, we will need energy sources to replace fossil fuels. The possibilities include renewables derived from the sun, "hot rock" geothermal energy, and nuclear, both fission and fusion. Both of the latter have lost favor recently with governments, electric utilities, the scientific community, and the public, being widely perceived in their current forms to be large, complex, expensive, and potentially dangerous. It is important for nuclear establishments to rethink and revise strategies based exclusively on development of the plutonium breeder and the tokamak. We need a long-term nuclear option, but will not achieve it if we hide our problems and are unwilling to seriously consider new ideas.

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the Environment, Annual Reviews Inc., Palo Alto, CA, 1994, p. 17. The counter-argument is that the public in countries where there is a tradition of centralized control and ready social compliance such as Japan and the former Soviet Union will continue to accept nuclear power on the basis of assurances by the authorities that its safety and proliferation risks are minimal. On the contrary, I believe that the publics in all democratic states will increasingly question such assurances.

[11] Such "climate-friendly" uses include increased use of natural gas, and, in the next century, hydrogen derived from both natural gas and coal, with sequestering of the separated carbon dioxide in depleted natural gas fields.

energy. Furthermore, uranium, unlike coal or oil, will not degrade in storage.[8]

The Future of Nuclear Power

The evolution of nuclear power after World War II, including the development of the LWR and plans for early introduction of the breeder, was strongly influenced by the Cold War. In particular, the strong post - World War II demand for uranium for nuclear weapons occurring at a time when the formation of uranium deposits was not well understood, as well as the operation of military reprocessing plants without adequate processing of waste streams lead to the perception that uranium was scarce and reprocessing was cheap. In addition, the notion that reactor-grade plutonium could not be used to make reliable, light-weight, high-yield fission weapons became conventional wisdom in the nuclear industry.

All these assumptions have proven to be incorrect.[9] The human, economic, and environmental costs of both the Cold War and the Chernobyl accident were very high. People in all countries do not want to live in fear of nuclear weapons and reactor accidents. If nuclear power is to be used on a large-scale it must be economic, demonstrably safe and not contribute to the proliferation of nuclear weapons.[10]

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[8]See J. Collins et al, op. cit.

[9]For the useability of reactor-grade plutonium in weapons, see, e.g., Theodore B. Taylor, "Nuclear Disarmament and Peaceful Nuclear Technology - Can We Have Both?", in **New Technologies and the Arms Race**, Edited by Carlo Schaerf, Brian Reid and David Carlton, Macmillan, 1989, pp. 202-203, and **Management and Disposition of Excess Weapons Plutonium**, National Academy of Sciences, Washington, D.C.. 1994, p. 33.

[10] In this connection, note the prophetic warning made by Enrico Fermi during World War II, as paraphrased by Alvin Weinberg: "It is not certain that the public will accept an energy source that produces vast amounts of radioactivity as well as fissile material that might be used by terrorists." Alvin Weinberg, "From Technological Fixer to Think-Tanker", **Annual Review of Energy and**

The 29 th JAIF ANNUAL CONFERENCE

April 17-19, 1996

Speech by Maurice ALLEGRE
Chairman of ANDRA

Please allow me to introduce myself :

Maurice ALLEGRE, Chairman of ANDRA (national radioactive waste management agency)

This agency is a public establishment, responsible for designing, building and operating installations for the disposal of radioactive waste, on the surface or underground, depending on its characteristics.

Thanks to the intervention of Mr Bataille, a Member of Parliament assigned as Mediator by the Government, ANDRA has been able since January 1994 to resume its work of looking for the most favourable locations in which to set up underground laboratories.

Mr Bataille was to make a speech describing his work as Mediator, which he carried out with remarkable success. At the last moment, he was unable to come to Nagoya, so he has asked me to read the speech to you.

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Mr Bataille's speech

Nuclear waste management in France :
The dialogue resumed

Unlike many other industrialised countries, France still has no overall legislation governing civilian nuclear activities.

However such activities are subject to a whole series of government regulatory provisions whereby the use of atomic energy is extremely strictly controlled.

Notwithstanding this, parliament had not really been consulted, prior to 1991, about the introduction of a nuclear industry which today is clearly one of the world's largest and which generates nearly 80% of the electricity consumed in France.

At the end of the 1980s ANDRA, then no more than the nuclear waste management department of the French Atomic Energy Commission (CEA), had undertaken to select four sites in France for laboratories to conduct research into storing high-level activity wastes in deep geological formations.

Although the aim was merely to set up laboratories in which no wastes would be stored, the public affected by the projects reacted vigorously and even violently at two of the planned sites.

In February 1990, in view of the confrontations between the protesters and the police, the government decided to suspend ANDRA's geological research programme and instructed the parliamentary scientific and technological evaluation Office to investigate the management of high-level activity nuclear wastes.

The Office, whose function is to advise parliament regarding decisions in science and technology, requested Mr Christian Bataille to prepare a report on the subject. Mr Bataille, a professor of literature before being elected to parliament, had no special knowledge of the subject and was tackling it for the first time; he therefore decided to interview all concerned - excluding nobody - particularly the protesters at the sites which had been selected by ANDRA.

Thus this approach - like all the investigations conducted by the parliamentary scientific and technological evaluation Office, lay somewhere between politics and technology, the aim being to provide parliament with a report setting out in simple terms the reasons for the disagreement between the specialists and the public affected.

One year later, the report was submitted to parliament on behalf of the Office, and

departmental and regional Councils, which are the three types of local authority in France;

- creation of local committees to gather information and monitor progress, made up of councillors, representatives of trade unions and local associations, some of which are opposed to the plans to build laboratories;

- creation of public interest groups together with the local authorities concerned, in order to ensure that the supporting measures determined for each region affected by a project are managed as effectively as possible.

Thus the procedures established by the Act differed from the approaches followed earlier by introducing the possibility of real democratic debate.

The essential criterion in the choice of the laboratory site became the project's social acceptability, with the experts' opinion as to the technical validity and feasibility of the project being given lower priority.

Of course the measures provided for in the Act had yet to be applied in practice.

Here again the government decided on a new approach, and entrusted the task of finding agreement on the sites for underground laboratories to an independent mediator with no direct link to the organisations responsible for nuclear waste management.

The mediator appointed was the parliamentarian, Christian Bataille, who had presented the first report of the parliamentary scientific and technological evaluation Office and who had been charged with getting the draft bill through the National Assembly.

In his role as arbitrator, Mr Bataille visited eight départements where suggested

sites were located, the geological suitability of which had previously been confirmed by ANDRA and the geological and mining research Bureau. He contacted all the political and socio-economic leaders (councillors, chairmen of chambres consulaires (chambers of commerce), farming representatives, trade unions, officers of associations, and so on), and introduced the project, the guarantees given under the Act and the planned supporting measures.

He also supplied information to all who sought it (in the form of basic documents, information booklets, questions and answers on the project) and forwarded any special requests of a technical or economic nature to the appropriate government departments.

Before, during and after the mediator's visit to each département, a small staff directed by a former regional Prefect collected the questions, comments, views and expectations of all those concerned and detailed some aspects of the project for their benefit. The team outlined a local development project with some of those contacted. The mediator took all these factors into account in his report.

The four départements which had earlier been approached by ANDRA were consulted in writing. Thus all the political and socio-economic leaders received documentation setting out the new guarantees provided for in the Act, together with a letter inviting them to make their position known to the mediator. The replies received show some movement although not a radical change in views.

The reactions of the different persons interviewed by the mediator varied widely but may be summarised roughly as follows:

- Most councillors tended to be in favour, although they stressed the importance of ample information. Their attitudes were unrelated to their political views. In some cases the matter became a local political issue while in others it went beyond political colour and focused opinion across the political spectrum of the councillors in a département.

However "Green" and "Ecologist" councillors were mostly opposed to national

energy policy and came out in favour of wastes being stored on the surface at the sites of production.

- Representatives of employers' organisations were interested mostly in the economic aspects of the laboratory and the slipstream effect it might have on regional development, notably as a high level research facility. Some made concrete proposals and sought to keep their usual contacts informed.

- Representatives of white collar trades unions did not feel very involved in the subject and few came down on one side or the other. In most of the départements the trade union representatives mostly "took note" of the facts presented by the mediator and stressed the importance of keeping the public informed.

- Leaders of agricultural trade unions generally expressed concern that the research should make progress and were aware of their responsibilities in this field. They emphasised the importance of preserving agricultural land wherever the site was chosen and the problems of water supplies.

- Most of the ecological associations declared themselves against the project. The most hostile were the anti-nuclear associations, all of whom criticised national energy policy. However certain environmental protection associations, and representatives of hunting, fishing and tourism promotion associations, welcomed the mediator's approach, calling for information to be provided on a continuous basis so that the public might be fully aware of the situation.

During his discussions with these different groups, the mediator did not conceal the fact that at the end of an experimental period one of the sites selected for the construction of the laboratories could, with the express agreement of parliament, ultimately accommodate a centre for the underground storage of high-level activity nuclear wastes.

However he also emphasised the advantages that the chosen regions could expect to stem from the installation of a research laboratory, the necessary funding being

provided by individual waste producers in proportion to quantity.

The establishment of the laboratories would have a direct impact on the regions involved. Investment in each laboratory amounted to 1.5 billion francs, with an operating budget of 70 million francs a year excluding experimental costs. Each laboratory would employ some 150 people including about 30 scientists. The mediator pointed out that priority would be given to the local area for recruitment and placing orders. Each laboratory would take about 5 years to build and would involve about 300 people. Finally, the underground laboratories would be subject to the business tax.
The regions will also benefit from the supporting measures and the development projects. In fact it is planned to allocate 60 million francs a year to each laboratory for supporting measures and local development. During the consultations this inflow of funding was occasionally criticised but the mediator pointed out that it was entirely justified since the reverse - an installation cut off from its economic environment - would not have been acceptable.

Finally, so that this investment might have the greatest possible impact it must be integrated into an overall development approach. The initiatives that might accompany the laboratory would be defined by the local communities concerned. In fact certain local authorities had already submitted precise proposals for local development.

Amongst the possible measures, higher education has a special role to play. The laboratories will constitute research instruments unique in France and would have to sustain close relationships with the universities and training establishments.

Work on the geological characterisation of the sites was carried out on schedule and ANDRA will shortly submit to the government a comprehensive application to build the underground laboratories.

Parliament, which has remained very attentive to this issue of management at the tail-end of the nuclear fuel cycle, has instructed Mr Christian Bataille to conduct a further study reviewing the application of the measures provided for in the 1991 Act.

Mr Christian Bataille submitted his report on 20 March 1996. In this document he notes that in general the law has been properly applied and points out in particular that research into the transmutation of actinides and fission products has been reactivated.

If progress continues to be made, parliament will decide in 2006, as provided for in the Act, on the ways and means to be adopted to find a definitive destination for high-level activity nuclear wastes.

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That is the end of Mr Bataille's speech. Allow me to add a few words to tell you the rest of the story.

For nearly two and half years now, in the four départements recommended by the Mediator and selected by the Government, ANDRA has been carrying out intensive exploration surveys, extensively using geology and geophysics, and including several drilling campaigns. Never during this period have the demonstrations against the underground laboratory been strong enough to hinder the progress of our work.

Last year, we realised that two of the selected zones concerned the same geological formation, and were in fact only one, thus bringing the number of zones explored down from four to three.

We have just given a report to the Government stating that in none of the three zones examined have we found unfavourable circumstances which would disqualify it. Under these conditions, all three zones (two in clay, one in granite) would be suitable and we are getting ready to rapply for three licenses to build underground laboratories.

It will then be up to the French Government to decide on these requests, as soon as possible so that ANDRA can be on time for the grand rendez-vous of 2006, laid down by the Law of 1991.

Building and Maintaining a Working Public Consensus:

A Necessary Condition for Sustainable Progress in

High-Level Waste Management in the United States

Susan Wiltshire, JK Research Associates, Inc.

During the late 1970s and early 1980s, there was a major effort in the United States to develop a national consensus about the management of spent fuel and high-level waste. A working consensus did develop that resulted in the passage of the Nuclear Waste Policy Act of 1982. However, there has been little subsequent effort to sustain that consensus.

This paper explores the need for maintaining a working consensus, discusses the difficulties in doing so, and suggests some means by which a working consensus might be achieved and maintained.

A working consensus is necessary for sustained progress in high-level radioactive waste management in the United States. The U. S. program for high-level waste management, established by federal law, is managed and regulated by several federal agencies. The program is subject to numerous legal requirements for review, comment, and involvement by other federal agencies, state and local governments, and the public and for extensive, external technical oversight. The program's funding is appropriated annually by the U.S. Congress, ensuring that the program will be reviewed by Congressional committees at least once a year. Nuclear electric utilities, which collect fees that fund the program and which are most affected by its progress, can make their opinions and influence felt through the political process, as

can other affected parties--states, tribes, public interest, environmental, anti-nuclear, and disarmament organizations, and the public. Since so many people and institutions are able to influence the conduct of the program, there must be a working consensus on the program's direction if the United States is to make sustained progress toward solutions.

A working consensus is difficult to achieve and maintain. Some characteristics of radioactive waste management make developing and maintaining a working consensus particularly difficult to achieve in the U.S. political system. These characteristics include the nature of the problem (highly technical, very controversial, involving radioactivity, concerning very long-time periods, faced with inevitable residual uncertainties); the nature of the process (long times between decisions, need for adaptive learning in an iterative process); and the inevitable changes in the political, economic, and social context that will occur over the life span of the program.

A consensus is most likely to be achieved and maintained if an effort to do so is carefully planned and implemented. The paper concludes with suggestions of approaches that can help build and maintain a working consensus about the direction and conduct of the high-level waste management program. It is important that these efforts allow for development and periodic reexamination of agreed upon goals, be as carefully planned as the technical program, take into account changes in society and in technical information, establish mechanisms for continuing two-way communication with external parties, and evidence respect for the points-of-view and responsibilities of all parties.

Building and Maintaining a Working Public Consensus: A Necessary Condition for Sustainable Progress in High-Level Waste Management in the United States

Susan Wiltshire

JK Research Associates, Inc.

INTRODUCTION

The high-level radioactive waste management issues being debated in the United States Congress sound all too familiar to those who long for progress toward a complete high-level waste management system. The debate reopens issues such as whether spent fuel should be considered waste, whether priority should be given to storage or disposal, who should regulate the facilities and what standards should be used, who should pay for what services, and what role state, tribal, and local governments and the public should play in decision making.

Similar issues were the subject of debate in 1982, when the U. S. Congress passed the Nuclear Waste Policy Act. Many were reassessed in 1987 when the act was amended and again in 1992 when the Energy Policy Act was enacted. The recurring reexamination and redirection of the program seems frustrating and inefficient to many who are concerned about progress toward solutions. However, this sequence is *not* simply going around in circles. Each iteration of the debate incorporates new knowledge and experience and takes place in a

changed social context. Review of the evolution of technical and public policy in U. S. high-level waste management leads to the conclusion that reexamination and change are inevitable given the nature of the technical and scientific problem and of the society and government that are faced with solving it. Since the program will evolve, the challenge is to create a management process that allows this periodic reexamination to lead to progress toward solutions rather than to change that seems sudden, arbitrary, and unsustainable to many.

This paper will briefly review the history[1] of the search for technical and policy solutions and the public's involvement in civilian high-level waste management, discuss the current situation, and recommend a process that can help build and sustain an evolving working consensus to support progress toward solutions.

HISTORY

EARLY DEVELOPMENT

During the early development of nuclear power in the U.S., high-level radioactive waste management received very little sustained attention. The first nuclear power plants were built with limited storage space for spent fuel. Electric utilities assumed that the spent fuel would be stored underwater at reactor sites for a brief cooling period and then be shipped away for reprocessing. The useable material would be fabricated into fuel and the resultant high-level

waste would be solidified and disposed of in a repository. However, such a complete system did not materialize.

Reprocessing of some commercial spent fuel did take place from 1966 to 1972 at a facility near West Valley, New York, but reprocessing soon ceased because technical problems and regulatory issues made the operation uneconomic. A plant built at Morris, Illinois, never operated and a third reprocessing plant, constructed at Barnwell, South Carolina, was never used because of design and political problems. Uranium was more plentiful and less expensive as a fuel source than had been predicted when the closed nuclear fuel cycle was first envisioned, so there was little incentive to overcome these obstacles.

Reprocessing also raised issues of nuclear weapons proliferation. The once-through fuel cycle, without reprocessing, treats spent fuel as a waste. The uranium fuel is in a form that cannot be used easily for nuclear weapons and, since plutonium is never separated from the fuel by reprocessing, it never appears in a form accessible for nuclear weapons. Due to concerns about proliferation, reprocessing was banned in the U. S. for a period. However, even after the ban was lifted, U.S. private industry did not pursue reprocessing because of continuing unfavorable economics, uncertainty about future government policies, and the world-wide abundance of uranium for fabricating reactor fuel.

As early as 1957, a National Academy of Sciences report to the Atomic Energy Commission, a predecessor of the Department of Energy, recommended the burial of high-

level and transuranic waste in geologic formations. Over the years, federal researchers investigated geologic formations of basalt, tuff, and crystalline rock as potential nuclear waste disposal sites and considered shale, alluvium, and argillite formations in more preliminary studies.

In 1970, the Atomic Energy Commission tentatively selected a full-scale repository site in salt deposits near Lyons, Kansas. The site was chosen without a formal search, mainly because it had been used in Project Salt Vault, a test of the effects of heat on salt caverns. After becoming the subject of considerable political and technical controversy, the Lyons site was abandoned two years later because of concern that nearby salt mine drilling had compromised the geologic formation's integrity. The government then switched program emphasis from finding suitable underground conditions to developing engineered aboveground structures for storing the waste for an extended period. After strong objections by the public and concerned state governments that such storage facilities might become permanent repositories by default, in 1974 the federal government again began a search for possible permanent repository sites, surveying underground rock formations in 36 states and looking for promising sites on government-owned land already dedicated to nuclear use. The tug of war in policy between long-term storage and disposal had begun.

Attention to the need for a complete system for civilian high-level waste management increased during the mid-1970s as a result of the federal government's attempts to site waste management facilities, increasingly strong environmental and anti-nuclear movements, concern

about nuclear weapons proliferation, and efforts to link the continued development of nuclear power to progress in waste disposal. In 1978, President Carter appointed an Interagency Review Group, composed of high-level representatives from a number of federal departments, to advise him on overall policy for radioactive waste management. More than 200 scientists from academia and national laboratories contributed to the analysis. The resulting multi-volume report was released for public review and comment and discussed at well-attended open meetings across the country. The report concluded that there were no insurmountable barriers to geologic disposal and no reason to delay moving ahead. The emphasis became less a focus on salt than on investigating a number of geologic media with emphasis on the performance of a total system .

During this same time, the Congressional Office of Technology Assessment[2] conducted a study of high-level waste management under the supervision of a broad-based committee. Several major independent projects were organized to explore the issues and develop policy recommendations. These projects brought together scientists, government officials, and representatives of environmental, anti-nuclear, and public interest groups and industry. Through extensive multi-interest discussions, people were able to sharpen their own understanding of what mattered to them, become better informed about opposing views, identify a range of options, and form alliances. The result was clear agreement on some issues and increased understanding of possible trade-offs among competing interests for others.

The Random House *Dictionary of the English Language* defines "consensus" as "[g]eneral agreement or concord; harmony." An experienced labor leader once defined a "working consensus" as occurring when people who have the power to stop you decide they don't want to. What the nation had achieved in 1982 was a working consensus, and that was enough to pass comprehensive legislation in the Nuclear Waste Policy Act of 1982--an act that has been referred to as more of a treaty than a law because of its careful balance of interests. There was not complete agreement, but the disagreements had been narrowed and were understood. As later events show, however, the agreements were essentially agreements among national interests only. Local interests and states that were not yet targets of serious investigation for waste management facilities were not paying attention.

Situation. Broad-based agreement existed among those who were paying attention to the issue, mostly national groups, industry, scientists, and federal government officials. There was a general sense of optimism that progress could be made.

Policy agreements. Spent fuel could be considered a waste since it was not being reprocessed because of economic, regulatory, and non-proliferation concerns; priority was to be given to developing a repository, but some provisions for limited short-term storage could be considered; the U. S. Environmental Protection Agency should set standards and the U.S. Nuclear Regulatory Commission should implement them; the users of electricity generated by nuclear power should pay for waste management facilities; and, state and tribal governments should have a clear role in decision making. In addition, the program should be open to public

participation and review. Above all, most participants agreed that the generation that created the waste had a moral obligation to provide for safe long-term management of the waste. For most environmentalists, that meant disposing of it for once and for all.

NUCLEAR WASTE POLICY ACT OF 1982

The Nuclear Waste Policy Act, signed into law by President Reagan in January 1983, provided a framework for making decisions about high-level waste management and assigned responsibility for implementing them. The act gave highest priority to permanent disposal in geologic repositories and set a schedule for siting two high-level waste repositories and for constructing and operating one; established the Office of Civilian Radioactive Waste Management in the Department of Energy (DOE); authorized DOE to develop a proposal to construct a monitored retrievable storage facility on a firm schedule; set requirements for interactions between the federal government and states, local governments, and Indian tribes; and gave states and tribes the right to veto a site on their lands although this objection could be overridden by Congress. The act established a fund to cover nuclear waste disposal costs paid for by user fees on electricity generated by nuclear power. In return, DOE was to sign contracts to take possession of the utilities' spent fuel by 1998. The act emphasized the responsibilities of the owners and operators of civilian nuclear power reactors to maximize the effective use of existing storage facilities and add new on-site storage capacity if needed for interim storage. DOE was authorized to provide only very limited federal storage capacity in cases of extreme need.

Under the act, DOE was to study at least three sites before selecting one for a repository. In February 1983, the DOE formally identified nine potentially acceptable sites located in Louisiana, Mississippi, Nevada, Texas, Utah, and Washington, and held hearings near each site. Citizens and officials turned out in large numbers, most opposed to DOE's action. In December 1984, DOE issued draft environmental assessments recommending further study of sites at Yucca Mountain, Nevada; Deaf Smith County, Texas; and Hanford, Washington. The draft environmental assessments were also the subject of formal hearings held nationally, regionally, and near each site. People also commented in writing. As with any environmental assessment, DOE was required to prepare a comment-response document detailing how the department had taken public comments into account.

Although a few local groups welcomed the prospect of site characterization for potential economic benefits, all three state governments opposed the study of sites within their states and many local citizens and national environmental groups opposed the recommendations as poorly founded. Indeed, a committee of the National Academy of Sciences was highly critical of DOE's preliminary decision process. However, President Reagan approved DOE's recommendations and the department began work during 1986 to prepare site characterization plans and to attempt to establish working relationships with the host states and communities. DOE was learning through painful experience the need to be open and responsive to the public and was developing public information and involvement programs to meet that need.

Meanwhile, the department was also preparing a proposal to Congress for the

construction of a centralized long-term storage facility. The report recommended the construction of such a facility and proposed consideration of three sites in Tennessee. The department's preferred site was near Oak Ridge, Tennessee. Although the city of Oak Ridge concluded that the storage facility would be acceptable under certain conditions and the Governor of the state conceded that the facility could be operated safely, the state sued to block final submission of the report to Congress arguing that DOE had failed to consult the state before choosing a site. The courts denied the petition, but the point had been made as subsequent Congressional action proved.

In addition to the mandate to construct a first repository and to consider constructing a storage facility, the Nuclear Waste Policy Act of 1982 required the Department of Energy to identify a site for a second high-level waste repository. Although not explicitly stated in the act, the intent of the requirement was to provide some regional equity, with the understanding that the first repository was likely to be in the west while the second would be in another part of the nation. Indeed, the search for a second site centered on granite formations in 17 eastern, southern, and midwestern states. Learning from controversy during the selection of first round sites, DOE actively sought the participation of state geologists in the technical work. Subsequent events showed that the agreements reached with technical experts were not acknowledged or reflected in the positions taken by state policy makers.

DOE issued Draft Area Recommendation Reports in February 1986 and held hearings to discuss the reports throughout the 17 states. Most of the hearings were contentious and

packed with citizens who were well organized, well informed, and dead set against further consideration of areas in their states. Governors and members of Congress were alarmed at the uproar, and in May the Energy Secretary announced that the department was "indefinitely deferring" the "second round" repository program, thus upsetting the act's tenuous regional balance. The Secretary also announced the decision to proceed with studies at the "first round" sites, angering three states. During this same time, DOE submitted the report proposing a centralized long-term storage facility in Tennessee to Congress--submission had been delayed a year by the court suit--bringing that state's grievance to the forefront again. The agreements that had lead to the passage of the Nuclear Waste Policy Act were coming apart.

Subsequently, the irate "first round" states allied with the still-uneasy "second round" states to eliminate all funds in the 1988 federal budget for studying the first round sites and for siting the second repository. The siting program ground to a halt as Congress sought a solution to the impasse. Faced with the continuing controversy over Department of Energy decisions and with growing concern about the slow process and increasing cost of finding a site, Congress passed the Nuclear Waste Policy Amendments Act of 1987, significantly revising the 1982 policies.

Situation. The consensus of 1982 had eroded and there was no basis for understanding how to reconcile the competing interests of industry, affected state, tribal, and local governments, interest groups, and concerned, recently aroused citizens. This was not

surprising since, after the 1982 act had passed, most participants in the discussions leading up to the passage of the act had turned their attention to other issues, relieved that the question of how to manage radioactive waste had been resolved. And, unfortunately, the industry and DOE paid scant attention to updating and maintaining the underlying national agreements reached in 1982.

Congress was discovering that the siting process was more difficult and contentious than proponents had originally thought and more costly, as predictions of the cost of characterizing all three sites began to escalate.

Policy agreements. Spent fuel was still considered a waste, although proponents of nuclear power kept alive their hopes of eventual reprocessing. Disposal was still the priority, but as the date for opening a repository receded into the future, the need for increased storage became more acute for some utilities. Utilities continued to pay money into the waste fund and feared that the contracts DOE had signed to take title to their spent fuel beginning in 1998 would not be honored. Industry wanted progress toward solutions and a return on their investment. So did Congress. State governments wanted DOE to leave their states, although some local governments were more supportive. State and local governments and citizens wanted to be heard. People were beginning to wonder whether "once and for all solutions" were to be had. Environmental and anti-nuclear organizations called for halting the program, creating a Presidential Commission to reexamine the issues, and requiring an act of Congress to restart the program. When DOE broke the fragile agreement contained in the act by ending

the search for an eastern site, everything opened up for reconsideration.

NUCLEAR WASTE POLICY AMENDMENTS ACT OF 1987

The 1987 act directed DOE to characterize only a site at Yucca Mountain, Nevada, to determine whether it is suitable as a repository site; cease characterization studies at the sites in Washington and Texas, as well as all other repository siting activities; and postpone consideration of the need for a second repository until the year 2007. It authorized the construction of a monitored retrievable storage facility subject to certain conditions that link the operation of the facility very tightly to the construction of a repository. The act provided for financial incentives for states or Indian tribes on whose land a repository or storage facility is sited. It also increased external oversight by establishing the Nuclear Waste Technical Review Board, authorizing on-site oversight representatives of host states, Indian tribes, and localities, and providing for increased local government participation. The act established the Office of the Nuclear Waste Negotiator to try to negotiate an agreement with a state or Indian tribe willing to host a repository or monitored retrievable storage facility.

The state of Nevada strongly objected to being singled out by what they viewed to be a political rather than a scientific process and refused to issue permits necessary for DOE to begin site characterization. After unfavorable rulings by the U.S. Court of Appeals and the U.S. Supreme Court, the state agreed to process the necessary permits, but it has remained opposed to the DOE's continued efforts to study the site. Indeed, Nevada has refused to

discuss entering into a benefits agreement, which would require the state to waive its right to disapprove the site when it is formally proposed to Congress. The state and affected localities receive grants from DOE to assist them in independent oversight of the program. Counties and some citizens have taken a less adversarial position than the state. DOE has developed an extensive program to provide the public with information and with some opportunities for involvement at hearings and meetings.

In 1987, as required by law, DOE submitted a site characterization plan to the state and to the Nuclear Regulatory Commission and held public hearings. In 1991 the department began conducting surface studies at the site and prepared to dig an exploratory tunnel. However, progress was slow. The department's estimates about the year the repository would be open become more and more distant and the costs of characterization continued to climb.

The Nuclear Waste Technical Review Board was established by Congress to provide independent evaluation of the scientific and technical aspects of DOE's waste management program. Members are appointed by the President from a list of scientists and engineers nominated by the National Academy of Sciences. The Board regularly issues technical reports containing its views and recommendations about DOE's activities. The Board has also issued letters and special reports addressing broad policy issues from time to time.

The amendments act authorized two processes for siting a centralized storage facility--one to be conducted by DOE and one by the Office of the Nuclear Waste Negotiator. Having

failed once, the department decided not to actively seek a storage facility site, but rather to hope for a volunteer to emerge from the negotiated process. Meanwhile, the Negotiator set out to find a state or Indian tribe willing to host a high-level waste management facility and to negotiate an agreement specifying benefits and conditions. In spite of an energetic and innovative process and some interest from several tribes, the Negotiator failed in his efforts and provisions setting up the Office were allowed by Congress to lapse.

The Environmental Protection Agency (EPA) is charged with setting environmental protection standards for a repository. The agency issued standards in 1985 setting limits on radiation releases to the general environment and exposure to humans. However, ruling in 1987 on a lawsuit brought by environmental groups and states, the U.S. Court of Appeals for the First Circuit instructed EPA to reconsider some parts of the standard because of inconsistencies with the Safe Drinking Water Act and inadequacies in the standard governing individual exposures. By mid-1992, EPA had circulated for comment a series of drafts of proposed revised standards but had not issued final standards. The Nuclear Regulatory Commission had issued regulations (based on anticipated EPA standards) for a mined geologic repository as early as 1981. These standards have been amended several times and are to be revised, if necessary, to be compatible with an EPA standard when one is final.

Situation. Although site characterization made progress, Nevada and DOE remained unreconciled, and scientific controversies kept arising. DOE pointed to unrealistic or uncertain regulatory requirements as being one source of difficulty. Utilities were concerned

about lack of progress and lack of certainty about how much temporary storage they need to provide, for how long, and at whose expense. The environmental groups were concerned about lack of EPA standards. Congress was exasperated at lack of progress, escalating costs, and continued controversy.

Policy agreements. Most discussions were now two-party discussions: industry with Congress, Congress with DOE, Nevada with Congress or DOE, environmentalists with industry, or Congress, or the courts, regulators with DOE, and scientists among themselves or with DOE. There was a lot of frustration about the lack of progress, but little general consensus about what direction the program should take. Nuclear energy proponents (hoping for reprocessing), environmental organizations (wanting flexibility to correct any mistakes in an untested system), and anti-nuclear groups (hoping to derail nuclear power) increasingly agreed that no "once and for all" action should be taken. Any spent fuel that was disposed of should remain easily retrievable. This was now the moral imperative: take no irrevocable action that will limit choices in the future.

ENERGY POLICY ACT OF 1992

The Energy Policy Act of 1992 mandated a new process for issuing standards specifically for a repository at Yucca Mountain. It directed the National Academy of Sciences to form a committee to provide "findings and recommendations on reasonable standards for the protection of public health and safety" and the Environmental Protection

Agency to issue standards for the Yucca Mountain site consistent with these findings and recommendations. Many environmental groups and the state of Nevada objected to having specific standards for Yucca Mountain, fearing that they would be less protective than the generic standard for repositories. The National Academy Committee conducted an open process and received a great deal of expert and public comment. Their recommendations, immediately controversial, were released in 1995, and the Environmental Protection Agency is preparing a standard specifically for Yucca Mountain.

Meanwhile, the technical program has progressed. The exploratory tunnel is down to repository depth and the program is more focused on what needs to be known for determining site suitability rather than on studying all that could be known. Although costs have stabilized, progress still seems slow and the state of Nevada continues a running battle against the site. Congress is once again considering revisions to the program.

Situation. Interests increasingly diverge. Industry wants certainty about storage, although they still give second-hand support to the repository. The Clinton administration wants the focus to remain on developing the repository. Many environmental and anti-nuclear groups are calling for the program to be shut down and the entire approach to be reconsidered. Congress wants to get a return on all the money invested, for policy to be settled, and to cease having to deal with a program in disarray. The state of Nevada still wants the program to leave. Many members of Congress are new to the issues and do not understand the need for or the history of the high-level waste management. This Congress is

much more sympathetic to states rights issues than to supporting large federal programs.

REQUIREMENTS FOR SUSTAINED PROGRESS

Both the technical program and the public policy process must take a flexible, incremental approach if the U. S. is to identify solutions for high-level waste management that can be agreed to and implemented. The policy process should be one that builds and maintains the working consensus needed to allow the program to move forward.

A FLEXIBLE APPROACH

The technology for storage and transportation of spent fuel is fairly straightforward. There is a great deal of experience to draw on. This is not the case in repository development. In its 1990 report, *Rethinking High-level Radioactive Waste Disposal*, the Board on Radioactive Waste Management of the National Academy of Sciences concludes that although deep geologic disposal is recognized world-wide as the best option for disposing of high-level radioactive waste, the U.S. repository program as it is now structured is unlikely to succeed:

> The current approach, in which every step is mandated in detail in advance...is poorly matched to the task at hand. It assumes that the properties and future behavior of a

geological repository can be determined and specified with a very high degree of certainty. In reality, however, the inherent variability of the geological environment will necessitate frequent changes in the specifications, with resultant delays, frustrations and loss of public confidence. The current program is not sufficiently flexible or exploratory to accommodate such changes.[3]

The DOE Task Force on An Alternative Program Strategy reached a similar conclusion. In its 1993 report, *A Proposed Alternative Strategy for the Department of Energy's Civilian Radioactive Waste Management Program*, the task force indicates that the repository program must be incremental. That is, rather than follow a rigid process with each step and milestone proscribed in advance, the program should remain flexible and open to learning and adapting.

An additional justification for an incremental approach to repository development comes from another perspective--the need to earn public confidence by bringing the language used in legislation and program plans in line with the reality of the program. Although legislation and program plans have set very firm deadlines for waste acceptance and very certain progress toward that goal, DOE's technical program has actually evolved incrementally.

Through the years, the program has had to accommodate changes, with the result that milestones have slipped and plans have altered. Unfortunately, when these changes have occurred--that is, when the program has made changes that may have been wise and necessary from a scientific or policy point of view--the rigidity of the legislated mandates and program

plans have made it appear as if the program were failing. This appearance of failure has resulted in a further loss of public confidence. Continued commitment to firm deadlines and unrealistically ambitious, all-or-nothing program goals will raise expectations unrealistically, obscure progress, and further the sense of failure for the program and distrust by the public. Congress and DOE need to align legislation, policies, and program plans with an incremental approach, evaluating each step or decision and adjusting plans and objectives based on what has been learned.

As the technical program has evolved, so has society's thinking on the topic. For example, the tenor of discussions about the current generation's ethical responsibility to future generations has changed. In the late 1970s and early 1980s, discussions among many environmentalists about radioactive waste disposal centered on two basic tenets: that the generation that benefits from the waste-generating activity must "solve" the waste problem and that the best solution is to dispose of the waste once and for all. In the 1990s, discussions about society's obligation to the future reveal a growing recognition that it may not be possible or desirable to solve such a long-term problem in one fell swoop, once and for all. Rather, many now argue that we must manage waste so that it does no harm, implement solutions that can be monitored and tested over time, and leave future generations options about how to proceed. This way of looking at things supports taking an incremental, step-wise approach in the technical program.

A WORKING CONSENSUS

The program needs to maintain continuing discussion with all interested parties--Congress, the scientific/technical community, environmentalists, industry, and affected citizens. As described above, the technical program and public opinion naturally evolve as more is learned and conditions change. Inevitably goals will need to be reassessed and technical work redirected. Decision makers will have a better basis for making changes if there exists a working consensus[4] about program goals among those affected by or concerned about high-level waste management. A working consensus can provide an understanding about where trade-offs among interests may lie and help ensure that decisions once made are implementable because they have broad-based support.

MAINTAINING A WORKING CONSENSUS

A working consensus could be developed and maintained by taking a two-part approach that provides for continuing, regular review of technical work and emerging policy issues and periodic critical reevaluation of program goals. Both efforts should involve the full range of concerned and interested parties.

Providing continuing public review and periodic reexamination of program goals, research results, and accomplishments should allow the program to evolve incrementally

without pressure developing for change in an adversarial atmosphere. When policy makers hear comments from competing interests one at a time, it is difficult for them to identify possible areas of common interest and options that could command broad support. On this point, in its April 1984 review of DOE's *Mission Plan* the National Academy of Sciences' Board on Radioactive Waste Management said about DOE's review of individual comments about the *Plan*:

> Although this [review] may give the responsible officials familiarity with the range of opinion, any consensus the DOE infers from its compilation of independent comments may differ dramatically from that which would result from direct discussions among proponents of the full range of conflicting interests. This suggests that face-to-face consultation can provide useful assurance that DOE has correctly identified institutional problems and emerging issues. DOE should organize meetings for extensive discussion among representatives of various interests. Only in that way will members of the public have an opportunity to understand how their own interests and those of other concerned parties interrelate and might be reconciled, and DOE will have a better basis for identifying areas of possible agreement.

CONTINUING REVIEW

There is unlikely to be public support of any technical proposal unless the scientific and technical work is, and is seen to be, sound. The technical research and its results need to be

widely understood and recognized as valid in the scientific community so there will be a basis on which to build policy. The best way to achieve that is to provide for regular outside peer review of technical research and to require that major results be written up and submitted to peer reviewed journals for publication. These procedures would help ensure that the scientific community beyond those directly involved in the research will be aware of and have an opportunity to evaluate the quality of the technical program.

Similarly, program managers need to stay aware of policy discussions and understand changes in institutional, political, and public thinking that apply to high-level waste management. Research on the implications of current and proposed policies and regulations for waste management should also be encouraged, and the results should be published.

As part of its efforts to build a general understanding of the program, the department should include in discussions not only those directly affected by proposals to site a facility or transport wastes, but also those who will be affected if problems are not solved such as residents near power plants and other nuclear facilities and electric rate payers. Those participants can help keep the focus on finding solutions. They should not be expected to, nor should they, become automatic advocates of any particular solution.

PERIODIC REEXAMINATION

The program has ended up at a contentious impasse every five years. That may have

occurred because there are now no provisions for regular reexamination of the program's goals and approaches. People or organizations who feel that goals need changing have no way to effectively advocate for change short of provoking a crisis and getting the attention of high-level officials or Congress. Periodic public debate about program goals and assumptions that are regularly scheduled and inclusive should be more productive than Congressional hearings in a crises atmosphere.

To stimulate public evaluation and debate, the department could conduct an open, annual critical evaluation with participation by representatives of all interests. That would help the program identify needed mid-course corrections and help it keep in touch with outside opinion. Then every four or five years there should be a more complete process providing broad participation and stimulating multi-interest debates about the program's course. DOE could initiate and partially fund such a process, but it should be independently managed to increase the credibility of the outcome.

CONCLUSION

The working consensus that existed in the early 1980s has been lost because no one paid attention to updating and maintaining it. Sustaining broad based agreement about goals and a societal commitment to long-term projects requires effort. But if societal goals and commitment are lost, a program loses its sense of a larger purpose, begins to focus on internal

organizational goals, and gradually loses external understanding and support. As the history of the U. S. high-level waste program shows, the result can be abrupt program redirection.

A process that combines regular focussed public technical and policy debates with periodic, broad-based critical reexamination of program goals would make a virtue of the step-by-step approach inherent in the program and would be in accord with the U. S. system of open, democratic government based on the consent of the governed.

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NOTES

1. The discussion in the history section draws on information in the League of Women Voters' publication *A Nuclear Waste Primer: A Handbook for Citizens*. The author of this paper wrote the 1993 edition of the *Primer*.

2. The recommendations from this study are contained in the Office of Technology Assessment's April 1982 publication *Managing Commercial High-Level Radioactive Waste*.

3. The author was a member of the National Research Council Board on Radioactive Waste Management in 1990 and participated in writing *Rethinking High-Level Radioactive Waste Disposal*.

A phased strategy towards implementation of a Swiss high level waste repository

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Abstract

For more than 15 years, Switzerland has been pursuing a phased strategy towards implementation of a deep geologic repository for high-level radioative wastes (HLW) and long-lived wastes (TRU). The modest quantities of spent fuel or HLW arising from a small nuclear power programme and the requirement for a long intermediate storage period to allow adequate heat decay together imply that a strategy extending over several decades is appropriate. It is, none the less, important for technical and public acceptance reasons that intermediate goals and milestones are established and worked towards.

The programme phases are in part delineated by the necessary technical steps in a geologic siting procedure: resulting in phases of regional surface exploration, localised surface exploration, full site characterisation and repository implementation. In part, however, the objectives of the phases are coupled to the requirement to increase in a stepwise fashion the confidence of the regulators and the public that an adequately safe repository system can indeed be implemented in Switzerland. This approach poses more subtle questions; since the most convincing demonstration of safety can be achieved only in the final phases of the programme, intermediate goals are required. These are of necessity less rigorous and to assess their fulfillment requires extensive use of human judgement.

The overall issue of disposal feasibility has been broken down in Switzerland into separate questions concerning constructability of deep facilities, siting possibilities and overall safety (especially long term). A phased programme requires that these questions be repeatedly posed and technically addressed in increasing depth as the programme advances. The current status of disposal planning is that all three topics are being addressed for two potential host rocks (crystalline rock and clay) at a technical level determined by the availability of localised data gathered by exploration from the surface at siting areas in both potential host rocks.

The paper addresses the technical issues involved and also covers the socio-political implications of communicating the above strategy to the scientific community, regulators and their experts, politicians and the public.

Nuclear Energy Policy

On a worldwide basis, the Swiss nuclear power programme is relatively small, making up only 1% of the installed capacity of all operating nuclear power plants. The five Swiss power plants are, nevertheless, significant in terms of domestic electricity supply, making a total contribution of 39% to power production in 1995. In view of the fact that Switzerland has no fossil fuels, opting in the sixties for nuclear energy was an obvious step towards ensuring a safe, sufficient and environmentally friendly power supply.

In the meantime, the continued use of nuclear energy in Switzerland has become an open question. Although local acceptance of nuclear power plants is high, since the seventies the issue of nuclear power has increasingly become the subject of political discussion at a national level. In the last 20 years, four national referenda have been held on the subject of continued use of nuclear energy. In the last referendum in 1990, the Swiss electorate voted against opting out of nuclear power, but a ten-year moratorium on construction of new nuclear power plants was declared. Apart from the issue of the safety of the power plants, the question of nuclear waste management was - and still is - an important pawn in the strategy of the opponents of nuclear power.

Nuclear Waste Management Concept

The following principles applying to nuclear waste management have been embodied in federal legislation:

- Wastes should be retained as far as possible at the place of their production, re-used wherever possible and the remaining residues should be processed to a form suitable for disposal.
- Permanent, safe disposal of wastes in suitable geological formations.
- Reprocessing of spent fuel (the option of direct disposal of fuel spent elements by the power plant operators is currently being kept open).

- Producer principle: together with the Federal Government, which is responsible for radioactive waste arising from medicine, industry and research, the power plant operators set up the National Cooperative for the Disposal of Radioactive Waste (Nagra) in 1972. Nagra is responsible for all research and development work connected with waste disposal. The management costs are incorporated in electricity prices.
- Regulation based on the Protection Objectives formulated by the safety authorities (restricting individual doses).

Two types of repository are foreseen:

- Repository for short-lived low- and intermediate-level waste, mainly from the operation and dismantling of the Swiss nuclear power plants and from medicine, industry and research. Emplacement will be in mined, horizontally accessible caverns. The facility requires to provide long-term safety without any monitoring.
- Repository for high-level and long-lived intermediate-level waste from the reprocessing of spent fuel abroad and for direct disposal of spent fuel without reprocessing.The repository will be located in a deep geological formation and will take the form of a tunnel system with access via a shaft or ramp.

Strategy and Required Actions for Disposal of High-Level Waste

Implementation of the overall management concept for high-level waste (HLW) requires provision of sufficient interim storage capacity for HLW and spent fuel elements, as well as formulation of a targeted research and development programme for subsequent disposal. To this end, the following strategy is being pursued:

- Construction of a centralised interim storage facility: this is not simply a transitional solution to the problem of waste storage until such time as a repository becomes operational, but is also essential in view of the fact that, because of its heat generation,

high-level waste requires to be stored for around 40 years at the surface prior to disposal.

At the end of 1992, the Federal Government's "Bundeszwischenlager" (BZL) for waste from medicine, industry and research became operational. As the first reprocessing waste will be returned to Switzerland from abroad towards the end of the nineties, it is planned to have the centralised storage facility ZWILAG operational by 1999. The Federal Council granted the necessary general licence in 1993 and this was ratified by the Swiss Parliament in 1994. The nuclear construction licence, which is granted by the Federal Council, is expected for the middle of 1996.

- Preparations for a repository for high-level and long-lived intermediate-level waste and spent fuel.

  The next significant step in the programme is the "Entsorgungsnachweis" (demonstration of feasibility of disposal), which should be submitted around the year 2000; this will include a demonstration of siting feasibility ("Standortnachweis"). Actual construction of the repository is foreseen for the time period 2030-2050, although the option of disposal within the framework of an international project is being kept open.

The need for a phased approach with intermediate milestones

Despite this far-future date, and despite the fact that more optimised disposal within a larger joint project remains an option to be pursued, it was at the end of the 1970's judged necessary to initiate and vigorously pursue a long-term phased strategy to ensure that suitable HLW disposal facilities will be available at the appropriate time. The reasons for moving ahead were to some extent technical. It was recognised that a long time would be needed to build up appropriate expertise and to carry out the extensive technical and geological investigation programmes. Moreover, other countries - especially those with nuclear power programmes - were also intensifying their R&D projects and it was considered valuable to be able to take part in this common effort.

However, an equally important reason for investing heavily in the progress of HLW disposal technology was the political and sociological pressure being put upon nuclear power producers to demonstrate that waste disposal by geologic disposal (as had been proposed for many years) was, indeed, a feasible and safe solution. In Switzerland laws and regulations were enacted to ensure that further expansion, or even continued use, of nuclear power could be allowed only if convincing projects for safe disposal were presented to the government.

The technical requirements for developing repository concepts - and in particular for siting the facility - led to the phased procedure described in the following section. The long development timescales, the high up-front investments, and the public debate on nuclear power have all provided grounds for introducing into the technical development intermediate milestones at which the general level of confidence in the emerging disposal plans can be reassessed, with participation of all interested parties. These milestones, past and future are described in following sections.

The phased strategy

It was decided early that a phased siting and implementation approach was appropriate for any potential host rock option. These phases are as follows:

I regional investigations (e.g. widely spaced single boreholes, 2D seismics, regional hydrogeology)

II localised investigations (e.g. multiple boreholes, 3D seismics)

III underground exploration (shafts, galleries, in-situ experiments)

IV construction

V operation and closure

The choice of host rock(s) followed preliminary desk studies and reviews of existing data. Emphasis was placed on the crystalline basement underlying the north of Switzerland and on sedimentary formations also in the north. The first intensive phase of field work (1982 - 1988) concentrated upon the crystalline option, although extensive data on clay was also gathered in the field investigations.

This siting strategy was in accordance with the recommended procedures of the international community as recorded, for example, in numerous guidance documents published in the 80's by the IAEA. More recently there has been, in some countries, a noticeable tendency to give more emphasis to non-geological factors in siting; engineering, economic and sociological issues are discussed more and weighted more heavily during the early selection phase. A specific potential repository site can then be chosen earlier and its geological suitability subsequently investigated in detail. It should be recognised that both approaches (or a combination) can lead to acceptable disposal sites, providing only that sufficiently objective, traceable methods are available for characterising the site and for assessing the achievable levels of safety for a specific repository system at this site.

Technical and regulatory milestones in the HLW programme

As already mentioned milestones can serve to delineate technical programme phases or can have a regulatory or political function. Ideally both requirements should be taken into account in deriving an appropriate set of goals and deadlines for milestone projects. The major milestones in the Swiss HLW programme are listed in Tables 1 and 2. It should be noted that final decisions on the licensing steps mentioned in Table 2 have not been taken. These future steps are, however, identical or very similar to licensing milestones proposed by international organisations (e.g. IAEA) and established in most national progammes. The earlier milestones in the Swiss system are more specific to the national framework.

Table 1: Past HLW Programme Milestones

PROJECT	CONTENT/RESULT
Concept report (1978)	• Reviewed options for repository concept and also available host rocks
Project Gewähr (1985)	• Based on extensive field work in the crystalline bedrock and on a robust repository design, technical feasibility and safety in principle was demonstrated. More work on siting possibilities in crystalline and in sediments was recommended
Intermediate reports on sediments (1988, 1990, 1994)	• Various sediment options reviewed; narrowed down to Opalinus Clay (OPA) and fresh water molasse (USM); OPA given first priority; most - promising areas for field work identified
Kristallin-I Synthesis (1994)	• Synthesis of all data on crystalline basement; basis for selection of field programme and location(s) for further work

Table 2: **Future HLW Programme Milestones**

PROJECT	AIM
Siting feasibility Project (Entsorgungsnachweis) (≥ 2000)	• Enhanced level of confidence in siting feasibility in clay and/or crystalline. Development of plans for Phase III (shaft, galleries)
General license application	• Fixes preferred repository site and design concept; is based on site characterisation data from programme of underground exploration
Construction license application	• Specifies design and layout
Operational license application	• Specifies precisely inventory and operational procedures based on final safety assessment using data from all previous phases
Closure license application	• Incorporates all new data gathered in operational phase; fixes concepts for sealing, monitoring

Important early milestones in Switzerland

A first step in field investigations which necessitates public debate and political consensus at an early stage is the granting of a permit for even preparatory drillings in connection with repository investigations. This permit must be granted at the highest political level (Council of Ministers) after two rounds of public comments. The positive aspect of intensive public consultation is, of course, to be set against the inflexibility of planning and the delays in technical programmes.

A very significant project milestone was Projekt Gewähr 1985 in which an analysis of the basic feasibility of implementing safe disposal facilities in Switzerland was presented by

Nagra and judged thereafter by the regulatory authorities. The result of this major project was that safe disposal for low- and intermediate-level wastes was judged feasible with no reservations; for high-level wastes, engineering feasibility and basic safety were both judged to be achievable. However, more convincing evidence of the existence of potentially suitable sites within Switzerland was required by the authorities.

This led to the Government placing a requirement on the repository planning organisation, Nagra, to initiate a further project aimed at demonstrating more clearly the feasibility of siting a deep repository (Projekt Entsorgungsnachweis). This project represents a further incremental step in the process towards the long-term development of a repository. It is a complement to Projekt Gewähr 1985. The questions to be addressed - for both crystalline and clay host rocks - concern the engineering feasibility, the long-term safety and the siting potential of a deep repository for HLW and TRU or spent fuel. The extensions relative to Projekt Gewähr 1985 are the inclusion of clay as a host rock and the increased weight on the issue of siting.

Plans have been drawn up for the project work, including localised field investigations (boreholes and seismic) at field sites in both host rocks. During review of these plans by government authorities and experts, it became increasingly clear that the siting question at the present project stage is subtle. The aim is not to identify a definitive disposal site nor to produce a final safety report of the quality that can only be achieved following exploration from underground. The aim of the current siting feasibility project is rather to significantly increase our ablity to judge the chances of success in a national repository programme by better characterisation of geologic formations in potential siting areas.

Confidence-building as an incremental process

The conclusion of the Projekt Entsorgungsnachweis - given positive geological results - should be an increase in the level of confidence of implementers, regulators and public that

safe disposal in Switzerland is a practicable option should such a step be decided upon some decades from now. Given the long timescales, why is there a need to move actively forwards in the near future? The answer is that the continued use of nuclear power in Switzerland can be justified by our society only if it is confident that the disposal of resulting wastes does not present an insuperable problem.

This understandable ethical requirement, coupled to the long timescales before disposal becomes technically necessary or even practicable, has led directly to the formulation of intermediate project steps aimed at public consultation and consensus. It is obvious that assessing the success of achievement of such intermediate goals will require considerable subjective judgement. Accordingly, extended discussion and debate is to be expected and it is important that aims be defined in advance as clearly as possible and that expectations remain realistic at each project step. This is no small challenge in such a controversial area where subjective judgements are strongly coloured by prior opinions.

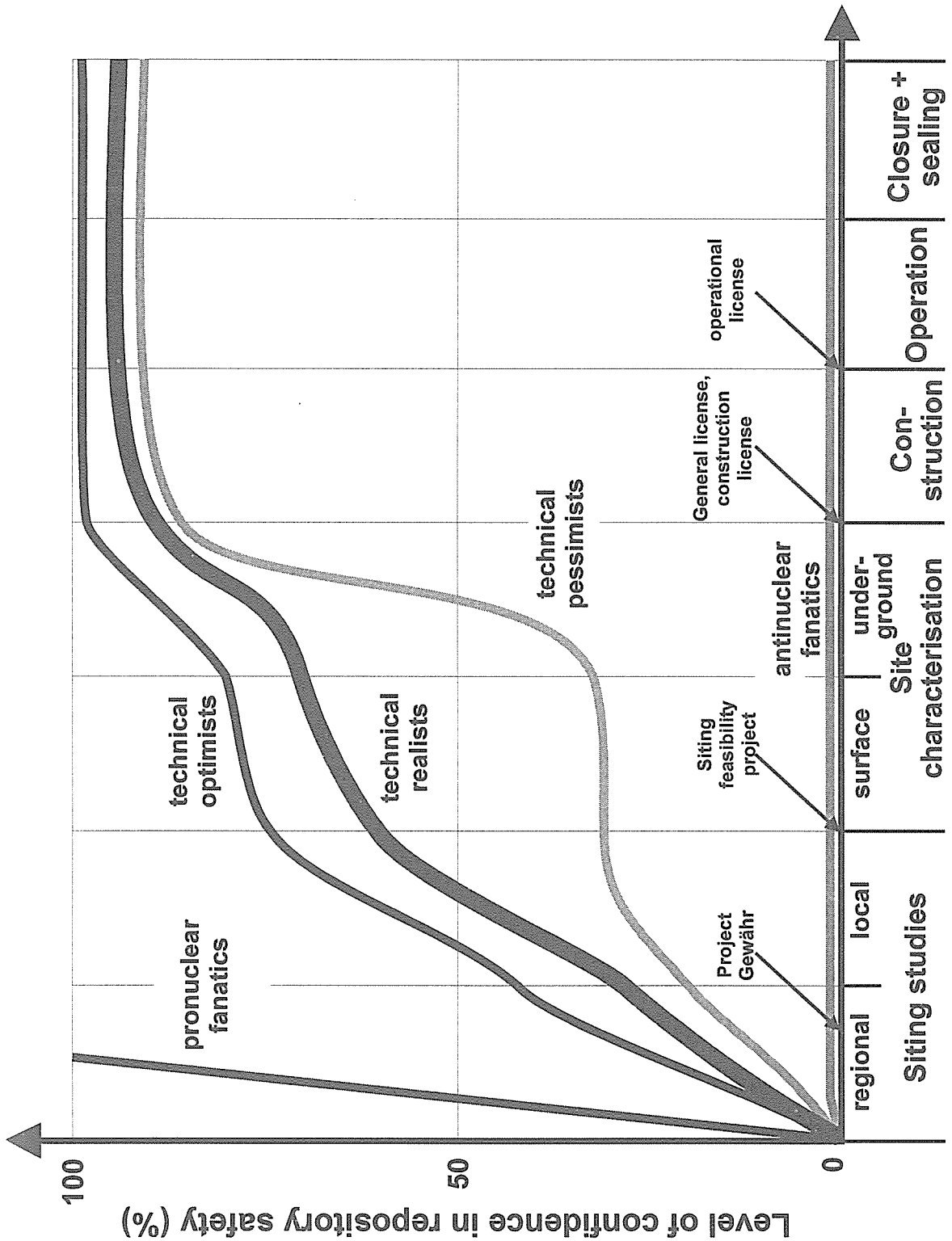
An interesting graphical display of the problems of incrementally increasing confidence in deep disposal (developed in an early report from the US National Academy of Sciences) was adapted to the specific Swiss system as illustrated in Fig. 1. The figure makes clear that confidence should increase stepwise, with the fastest rise occurring during active investigation periods. It also shows that the perceived level of confidence at specific project milestones will vary according to the preconceptions of the reviewer/assessor. Accordingly, conflict resolution or consensus finding strategies will be of great importance at each decision point. In the Swiss system there is public and political participation at each stage even of these preliminary steps towards repository implementation.

Conclusions

The timescales for implementation of a deep geological repository in Switzerland are long because of the 40 y cooling period, the low rate of waste accumulation and the Swiss interest in more economic joint projects. During the long preparatory phases, it is important to provide reassurance that safe disposal is feasible. A phased programme with intermediate milestones at which the level of confidence in deep disposal can be increased in a stepwise fashion is being implemented. The introduction of early milestones and decision points implies that a significant degree of subjective judgement will be involved in the corresponding decisions. It is therefore necessary to provide appropriate opportunities for discussion and debate in different fora, ranging from technical experts to political bodies and the general public.

Following the long preparatory period there is a licensing phase, which is also incremental, allowing public participation and input to the decision processes. All of these steps together will stretch for a period of around one hundred years. Accordingly, moving ahead with disposal plans as foreseen places no restrictions on society's freedom of choice for many generations into the future.

Figure 1


Level of confidence in repository safety (%)
100
50
0
pronuclear fanatics
technical optimists
technical realists
technical pessimists
antinuclear fanatics
Project Gewähr
Siting feasibility project
General license, construction license
operational license
regional
local
surface
under-ground
Siting studies
Site characterisation
Con-struction
Operation
Closure + sealing

セッション４「高レベル廃棄物－研究開発と合意形成へのステップ」
土田村長のコメント（案）

本日第２９回原産年次大会に参加する機会をたまわり、高レベル廃棄物の研究開発と合意形成へのステップをめぐるセッションの中でこれら取扱いに対する夫々のお話を大変感銘深く拝聴させていただきました。そのうえ皆様が国のため、また地球上の人類のため日々腐心されておりますことに心から敬意を表するものであります。

それでは、ご指名をいただきましたので、ただいまのお話に関連して、私の考えを若干述べさせていただきます。

私の住んでいる六ヶ所村では、１９９５年から高レベル放射性廃棄物の一時貯蔵がスタートしております。皆さんご承知のように、フランスのＣＯＧＥＭＡ社から返還された高レベル廃棄物が、最終処分地へ搬出するまでの３０～５０年間、村内にある日本原燃の「高レベル廃棄物貯蔵管理センター」に貯蔵管理されることになっております。

しばらく前、この施設について、『最終処分地も決まっていないのに、何故最も危険な高レベル廃棄物の一時貯蔵に関する安全協定を締結したのだ。』という多くの声が私のもとに寄せられました。この意見は、筋からすると、分からないわけではありませんが、この問いかけに対する私の考えは、

私たちが今日の恵まれた文明を享受しているのは、必要なだけのエネルギーがあってこそのことだと考えております。そしてこの文明を放棄することなく、人間としての尊厳を保ちつつ、次の世代に遺産として残していくためには、新しいエネルギー源も当然に開発していかなければなりませんが、一方で、われわれが作り出したエネルギーを便利に利用した後に生ずる不要な物を、同じわれわれの手で始末しなければいけない。これは現在に生きる人間の義務であると考えております。同時に私はアメリカにおける原子力発電の第一人者でありました故ケヴィン・リンチ博士の著書に

記されておりました「近代社会においては心理的な分業の原理に支配され、創り出すものが肯定され、廃棄されるものが否定される。つまり必要とするものの創造に気を取られすぎ、当然発生する廃棄物に意を注がなかったと述懐されておられる部分を重く受け止めなければならないと存じます。したがって、高レベル廃棄物の一時貯蔵施設についても、将来にわたって確実に管理できる設備が、多重防護、耐震設計など安全設計の思想に基づいて作られなければならない。私は、身近に、しかも各段階ごとに、こういった考え方による施設が建設されていく様子を、つぶさに目にしていたからこそ、安全協定に調印させていただいていた。・・・と申しあげてよいかと思います。

昨年の１０月下旬、１０日間ばかりにわたって、フランス、イギリス、ベルギー、スイスの４か国で、ガラス固化体をつくっている再処理工場と高レベル廃棄物の処分研究施設を視察してまいりました。

その際、ヨーロッパではようやくアクチニドリサイクルの研究が始まったばかりなのに、軽々に最終処分の道を決めるべきではない、少なくとも今の一時貯蔵を続ける中で、研究開発を行うべきだといった話をうかがいました。また、スイスのアルプス山中のグリムゼル地点での花崗岩質の研究施設も、誠に立派なものでしたが、私たちの住んでいる地球の地殻部分は、卵でいえば殻の部分にあたり、アルプスの山も、ごくわずかではあっても動いていることなどを考えると、さらに研究開発を継続していく必要があるとの話もございました。

私の印象ではありますが、原子力におけるヨーロッパの先進国では、安全性に対して相当に厳しい注文を国や事業者に求めるかわりに、最終の結論を出すことについては、拙速にではなく、かなり寛大、ゆったりとしたところがあるように感じました。

一方わが国は、世界で唯一の被爆国であり、また、有数の地震国であることも加わって、原子力に対する一般の認識は、どこの国よりも神経質であります。さらに、私たち六ヶ所村において再処理工場が稼働し始めると

高レベル廃棄物やプルトニウムのランニングストックが発生することも、国民の間の不安、不信のもとになっているといったこともあると思います。私たちは、このことを事実として受け止め、真摯にいろいろな疑問に答えていくことが、これまで以上に求められているといっても過言ではないでしょう。

原子力といえば、先端技術の固まりみたいなもので、ただでさえ分かりにくいのに、設計内容やいろいろなデータ類について、一般大衆が理解できるような情報の提供がなされていないといった声にも、心して耳を傾けていくべきであります。

さて、原子燃料サイクルの立地点の村長の立場で、施設の安全が確保されているかどうかの着眼点について、私が考えておりますことを申しますと

第一に、研究開発が常に中立的に、かつ継続してすすめられていること。

第二に、耐震設計に基づいて忠実に施設が構築されていること。

第三に、多重防護の思想に立って、放射能が拡散されることのないような仕組みが確立されていること。

第四に、ヒューマンエラーを起こさないような管理体制が整っていること。

などであります。

このことを本日のテーマであります高レベル廃棄物の問題について申しますと、第二、第三、第四の視点を踏まえたうえで、とりわけ第一の研究開発が最大の課題であり、それで得られた成果が一国の壁を越え、世界共通の基盤の上にたって、中立的に活用されていくこと、さらには、技術開発の内容、進み方を一般の方々に知ってもらう努力を続けること、すなわち、こうして広く国民の合意形成に努めることが何にもまして大切であると考えております。

さらに申しますと、私が常々青森県とともに六ヶ所村が、「制御された核融合」つまりＩＴＥＲの実験炉やアクチニドリサイクルを始めとする消

減処理の研究施設等の誘致を強く各方面にお願いいたしておりますのも、今後の原子力の発展は、技術開発を基本におかねばならないことと、われわれ立地点の、ひいてはわが国のサイクル事業の成功に、このことが深くかかわってくると考えていてるからにほかなりません。

私は、原子力を、平和利用のため、生活に必要なエネルギー源として、これまでにした人間の叡智をもってすれば、高レベル廃棄物処分にしても、人々の理解が得られるような未来への道が必ずや開かれるものと確信するものであります。

私たち六ヶ所村民は、原子燃料サイクル事業が地域振興に大いに寄与するものとして受け入れた経緯があります。言ってみれば、このサイクル事業が成功するかしないか、将来に対する期待と不安の扉の前に立っているわけでありますが、この事業が国のエネルギーの安定確保のうえに役立つよう、地域住民一人一人との相互信頼関係を大切にしながらサイクル事業を成功させることこそ、地域の発展、向上につながるとの思いをもって日々過ごしているところであります。

また同時に、高レベル廃棄物の処分については、わが国では２０３０年から２０４０年代後半には、処分場の操業開始を予定していると聞いておりますが、立地点ばかりの問題ではなく、幅広く国全体、さらには原子力を利用している世界の国々共通の問題として認識し、本日のようなセッションをはじめ、いろいろな場を通じて、関係者が幅広く、率直な意見交換を進めていくことが何にもまして大切であるという思いを、本日、さらに強くした次第であります。

以上、専門的な知識を持たない者ではありますが、こういう諸施設が進められております地域の意思決定者の一人として失礼を省みず感想を申し述べさせていただきました。

The Post-Cold War World and Nuclear Weapons Proliferation

by

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Plutonium and Proliferation:
A 1996 Personal View

Richard L. Garwin

Abstract. The highest priority of civil nuclear power, the safety of the public, would be at risk if nuclear weapons were to proliferate to sub-national groups or to terrorist nations by theft or sale of separated fissile material, by acquisition of spent fuel and separation of Pu from it, or by the open or clandestine misuse of enrichment facilities to produce weapon-usable uranium containing more than 20% U-235 (90% is typical). The massive ongoing reduction in nuclear US and Russian nuclear weaponry will involve the removal from warheads of at least 50 tons of weapon Pu on each side by the year 2003. In January 1994 a report from the National Academy of Sciences identified this separated weapon Pu (and a larger amount of high-enriched uranium) as a "clear and present danger" and called for urgent action to provide safe, secure interim storage for the separated weapon-usable material and to begin its conversion to a form that would be no more available than spent fuel from power reactors-- the "spent-fuel standard"; it called for urgent implementation BOTH of a U.S. program to burn this excess W-Pu in reactors of existing type AND a program to begin to vitrify the W-Pu together with high-level fission product waste. A 1995 report from an international panel of the American Nuclear Society endorsed the "clear and present danger" and the "spent-fuel standard"; it urged likewise the burning of the separated W-Pu in reactors of existing types and noted that next-generation reactors could also be useful. The ANS report agreed that Pu separated from normal power reactor spent fuel could also be used in nuclear weapons. The ANS report went beyond the NAS report in emphasizing the proliferation hazard of spent nuclear fuel itself, concluding that there is no need for fuel cycle uniformity among nations-- both stow-away and reprocessing options being appropriate IF they are conducted in a safe and proliferation-resistant fashion. ANS urged that nations choosing the once-through (also known as "stow-away") option move the spent fuel through safe and secure storage into a repository expeditiously. However, neither the U.S. nor Russia has accomplished much in the two years since the CISAC report, either in "transparency" or in choice of actual modes of disposition. This paper provides some personal recommendations for action, by the U.S., by Russia, and by the international community.

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Introduction

For the last half century, thinking people in all nations have recognized the necessity to control nuclear weaponry, and those involved in the nuclear power industry are well aware that their activities must be safe, environmentally acceptable, and cost competitive if they are to prosper. An important aspect of "safety" is to secure the nuclear power industry against the transfer of materials to sub-national groups that might use them to make nuclear weapons, or to nations that would do so in violation of their international obligations.

That this problem is real is demonstrated by the experience in Japan with the Aum Shinrikyo-- one of the largest and most technically aggressive terrorist groups that has come to light.

The good news is that there is a strengthening consensus against proliferation, as evidenced by the fact that 175 nations in May 1995, without exception, achieved the indefinite extension of the Non-Proliferation Treaty, by which they all voluntarily deny themselves the development or possession of nuclear weaponry except for the five nuclear weapon states-- Britain, China, France, Russia, and the United States. India, Israel, and Pakistan are widely believed to have nuclear weapons (even if unassembled), and they are not signatories to the NPT. In exchange for this self denial on the part of the non-nuclear weapons states (NNWS), the NWS have undertaken to agree a Comprehensive Test Ban Treaty (CTBT) in 1996, and in principle to take other measures to reduce the grossly excessive destructive power of nuclear weaponry that exists in the world today.

I will briefly review what would be needed to acquire nuclear weapons, the mechanisms for preventing or countering such acquisition by sub-national groups, the new problems of the post-Cold War world, and specific actions by various nations or groups of nations or international organizations that might help to prevent or to counter proliferation of nuclear weapons.

There is much that can be done not only by the G-7, but by other nations, and even by nongovernmental groups such as the Pugwash movement, which shared the 1995 Nobel Peace Prize with one of its founders, Professor Joseph Rotblat, largely for its efforts and considerable success in helping to limit proliferation and use of nuclear weapons.

To acquire a nuclear weapon.

A group could acquire an intact nuclear weapon by theft or purchase, or it could design and manufacture it. For this purpose, the group would need not only the will but the resources-- including people to carry out the physics and engineering design, to obtain the fissile material, to fabricate and to assemble the components, including the fissile material, to provide an appropriate neutron source, and the like.

But the world has changed enormously since 1945 when the United States exploded over Hiroshima a fission bomb yielding some 15,000 tons of high-explosive equivalent (15 Kt) of energy, destroying the city. Four days later, the city of Nagasaki was destroyed by a 21 Kt fission bomb.

The Nagasaki bomb contained approximately 6 kg of plutonium (almost pure Pu^{239}), while the Hiroshima bomb had as its fissile core some 60 kg of high-enriched uranium (HEU) about 95% U^{235}.

The refinement of nuclear weaponry proceeded rapidly in the 1950s, after the Soviet Union exploded its first atomic bomb in 1949, with the result that nuclear weapons have been built weighing tens of kilograms instead of tons, and with yields from 20 tons of high explosive to 60 megatons or more.

The United States has conducted 1149 nuclear tests, the Soviet Union some 1100, Britain 45, France 210, and China 43 (to the end of 1995). In addition, India conducted one nuclear test in 1974.

Many of the nuclear weapons in the five NWS consist of two-stage systems in which the explosion of a "primary" nuclear explosive leads to the assembly of a "secondary" charge usually containing both fusion fuel and fissionable material-- U^{235}, Pu, and/or U^{238}.

Over the last half century, computer technology has evolved so that even the smallest PC has more computing capability than the largest computers that were used to design the nuclear weaponry of the 1940s, and the general evolution of technology has made simple many of the operations required to produce a nuclear weapon. The control over the proliferation of nuclear weapons, in my judgment, must be exerted in two ways-- over the will to build nuclear weaponry, and over the necessary fissile material.

In addition to the general evolution of technology, there exists in 1996 a nuclear industry that is widespread and that handles enormous amounts of fissile materials. Furthermore, as a result of the 1955 Atoms for Peace Initiative, education and training in nominally peaceful aspects of nuclear power has been widely available, including the techniques required to obtain plutonium from spent fuel. Of course, such Pu has a perfectly legitimate function in "recycle" in order to reduce the amount of uranium and enrichment services required for the operation of a nuclear reactor system; unfortunately, with the current availability of low-cost uranium, such "reprocessing and recycle" appears to cost more in every country than would direct disposal of spent fuel into a mined geologic repository.[1]

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[1] See Special Panel Report of the American Nuclear Society "Protection and Management of Plutonium" (August 1995) page 53. Citing data from the OECD fuel cycle study, the ANS report notes that reprocessing and recycle "R/R" would cost less than the once-through "OT" cycle if the cost of U_3O_8 rose to $80 per kg; however, uranium price has remained in the range below $25/kg for the last 5 years.

With the end of the Cold War and the elimination of the enmity between the United States and the states of the former Soviet Union, it became abundantly clear that the nuclear weapon stocks of the US and the CIS were grossly excessive. At its peak, the US stock was some 33,000 warheads, while the Russian holdings were some 45,000. Accordingly, both formal arms control agreements (START I and START II) were accelerated as well as less formal agreements between US President Bush and Presidents Gorbachev and Yeltsin, with major consequences.

All US tactical weapons were removed from ships, and with other tactical weapons were brought back to the United States-- many of them to be destroyed. All Soviet tactical weapons were returned to Russia from the other former Soviet states, and all strategic warheads are committed to return to Russia-- the only ones remaining outside Russia being those on missiles in Ukraine-- these warheads to be returned to Russia in 1996??. This was not a minor force, with some 1900 strategic warheads and another 600 warheads on cruise missiles in Ukraine at the time of dissolution of the Soviet Union in 1991!

So Russia is the sole nuclear heir to the Soviet Union, and the other former Soviet states have joined the NPT as NNWS.

In conjunction with these weapon reductions and dismantlements, more than 50 tons of weapon plutonium is expected to be made surplus from the US inventory by the year 2003, and at least as much in Russia. Arms reductions thus pose a new aspect of the proliferation danger, since W-Pu has been transformed in just a few years from a valuable commodity in short supply to a material in surplus. Similarly, those nuclear weapons slated for destruction have lost their status as a scarce and valuable resource; instead, they are a costly[2] and dangerous problem.

For planning purposes, the US DOE authorized the statement[3] that US nuclear weapons to be dismantled contain on the order of 4 kg of W-Pu each. Instead of multi-ton weight, such weapons may be in the tens or 100 kg class. The major improvement over the 1945 weapons arose from the adoption of a "hollow pit" instead of a solid mass of Pu, enabling the Pu to be not only assembled by the explosive but also more readily compressed, thereby not only reducing the amount of Pu needed but also improving the safety of the unexploded weapon.

The first Chinese fission bomb was tested in 1964 with a yield of some 22 Kt and weighed some 1550 kg. It was an implosion device using U^{235}, and could therefore use less fissile material than the gun assembly method.

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[2] There is legitimate profit to be made in the safe disposal of waste, but only if governmental subsidy, open or concealed, is introduced at some point in the process. Rather than resort to open subsidy, governments often resort to regulation-- thus shifting the cost to the industry and hence to the consumer of the product.

[3] "Management and Disposition of Excess Weapons Plutonium," Report of the National Academy of Sciences, Committee on International Security and Arms Control (January 1994), p. 68. ("CISAC-1")

South Africa recently revealed that prior to joining the NPT it had constructed six gun-assembled uranium weapons, which have all been dismantled and the U^{235} blended down so that it is no longer HEU (to below 20% U^{235}).

Proliferant production of weapon material? A look at the simple energetics of fission shows that a megawatt of thermal energy for a day[4] is obtained by the complete fission of about one gram of material. And a look at the neutron economy in normal thermal spectrum reactors using natural or low enriched uranium shows that about one gram of Pu^{239} is formed by capture on U^{238} for every gram of fission. More precisely, this "conversion ratio" is typically 0.6 in an LWR and 0.8 in a CANDU reactor.

Thus, if the fuel is removed at relatively low burnup (as is necessary in any case in a natural-uranium reactor) the requisite 6 kg of Pu would be obtained from something like 6000 MW(t)d or from about 17 MW(t)-year of reactor operation. So a 17 MW(t) reactor will produce about 6 kg of Pu^{239} per year.

This is a very large amount of thermal energy[5] for an ordinary householder, but not enormous for a substantial industrial operation. If such a reactor were used to produce heat at temperatures high enough to produce electrical power at about 30% efficiency, if would provide 5 MW(e) or about 40 million kWh in a year, which at $0.05 per kWh would be worth some $2 million per year. Alternatively, if the reactor were used simply to heat river water, with a 40 C temperature rise, one would need about five tons per minute of coolant.

Taking the U^{235} route to an implosion weapon and assuming that some 20 kg of 90% U^{235} would be needed, one can calculate that some 176 kg of natural uranium would be required per kg of product, and some 230 SWU[6] per kg of product. At $20 per kg for natural uranium, the feed material would cost some $80,000, but the 4600 SWU at about $100 per SWU would cost some $460,000. By taking a commercial price for separative work from either centrifuge or gaseous diffusion plants, we are considering plants that are amortized over years of operation. The investment for a proliferator to make the first 20 kg in a year or so would be much higher than this allocated cost.

Furthermore, the enrichment process uses UF_6, which is not a common article of commerce except for nuclear energy.

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[4] I.e., one MW(t)d. See "Management and Disposition of Excess Weapons Plutonium: Reactor-Related Options," Report of the National Academy of Sciences, Committee on International Security and Arms Control, Panel on Reactor-Related Options for Disposition of Excess Weapons Plutonium, (July 1995), p. 33. ("CISAC-2")

[5] Specifically, the industrialized nations use some 8 kW(t) of primary energy per person, so 17 MW(t) is the share of about 2000 persons.

[6] One "SWU" is a "separative work unit" suitable for measuring the capacity of isotope separation facilities such as centrifuge or gaseous diffusion plants. For general formula, see standard references or CISAC-2, p. 288.

The acquisition of kilograms of the artificial element Pu requires well known techniques for chemical separation of Pu from the irradiated fuel and, especially, from the highly radioactive fission products, together with the disposal of the waste material. It would be simpler for a sub-national group interested in proliferation to attempt to acquire (by purchase or theft-- or by purchased theft) the requisite material than to process spent fuel to obtain the plutonium. But the plutonium in "fresh" (not yet irradiated) Pu-bearing mixed-oxide ceramic ("MOX") fuel does not have significant penetrating radiation and is thus a much easier chemical task than is irradiated fuel.

The supply side. It is important to recognize that the available supply of bomb-usable material is so large that the details of the total amount are unimportant. Even ten tons of W-Pu would suffice for 2000 bombs. What is important is the number of sites at which such material exists, the ease of use of the fissile material (i.e., whether it is in metal form or oxide), the degree of protection by penetrating radiation as in spent fuel, and the protection afforded it to prevent and to detect the theft of the first few kg.

On the HEU side, the problem is slightly different. There is not a lot of surplus HEU outside the weapon (and naval fuel) industry. However there is a great deal inside: The United States has contracted to purchase from Russia 500 tons of surplus HEU, to be blended down to LEU and delivered as 4.4% U^{235}. Six tons of Russian HEU were delivered in this way in 1995, and 12 tons will be delivered in 1996. However, the Russian Minister of Atomic Energy has indicated that Russia has a good deal more HEU-- probably 750 tons in addition to this 500 tons. Even 100 tons of this HEU would suffice for 5000 implosion weapons.

Fortunately, the HEU problem is much more tractable than is the Pu problem, both because enriched uranium is a valued article of commerce and because it can be blended quickly and at low cost with natural uranium or depleted uranium to form an intermediate stock of 20% U^{235}, no longer usable in weapons, but retaining its value for use either as 2-5% U^{235} or as 10-20% U^{235} in fast-spectrum reactors.

The proliferation hazard of separated civil plutonium. Adding to the proliferation potential is the general recognition (rather long delayed) that civil plutonium can also be used to make nuclear weapons, pointing out[7] that with civil plutonium,

> "... the explosive yield of even a relatively simple device similar to the Nagasaki bomb would be of the order of one or a few kilotons ... 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. ... In short, it would be quite possible for a potential proliferator to make a nuclear explosive from reactor-grade plutonium using a simple design that would be assured of having a yield in the range of one to a few kilotons, and more using an advanced design. Theft of

[7] CISAC-1, pp. 32-33.

separated plutonium whether weapons-grade or reactor-grade, would pose a grave security risk."

This conclusion is fully endorsed in the Special Panel Report of the American Nuclear Society[8] which states explicitly (page 25),

> "We are aware that a number of well-qualified scientists in countries that have not developed nuclear weapons question the weapons-usability of reactor-grade plutonium. While recognizing that explosives have been produced from this material, many believe that this is a feat that can be accomplished only by an advanced nuclear-weapon state such as the United States. This is not the case. Any nation or group capable of making a nuclear explosive from weapons-grade plutonium must be considered capable of making one from reactor-grade plutonium.
>
> "It follows that both separated reactor-grade plutonium and weapons-grade plutonium are credible targets for sub-national theft or seizure, and that protective measures must be designed to take this into account."

There exists more than 1000 tons of R-Pu, most of it at the level of 1% concentration in spent fuel. However, more than 70 tons of R-Pu exist as pure oxide,[9] which for safety against dispersal of the material and against accidental criticality is stored in the form of welded steel canisters each holding about 2 kg of Pu.

The weapons usable materials-- HEU, W-Pu, and R-Pu-- in separated form share the characteristics that an individual can carry enough such fissile material to supply a nuclear weapon, without hazard from radiation in the process. From this point of view, and from that of time between acquisition of the material and the availability of a bomb core, these separated fissile materials are in a class by themselves. The next stage in hazard is posed by "fresh" MOX fuel-- somewhat mitigated by the 5% Pu content, the 500-cm length of the fuel elements, and the need for chemical separation.

CISAC-1 introduced a rationale for handling the proliferation threat of excess weapons plutonium (and uranium):

- Until the excess weapon material is permanently disposed of, it should be handled in a fashion that meets the "Stored Nuclear Weapons Standard".
- After final disposition, the excess weapon material should be in a form that meets the "Spent Fuel Standard".

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[8] Op. cit.

[9] For instance, October 24, 1995 White Paper on Atomic Energy published by the Atomic Energy Commission of Japan lists 126 kg of plutonium oxide at the PNC Reprocessing Plant, 2032 kg at the PNC Facility for Plutonium Fuel Fabrication, 1412 kg in Britain, and 7309 kg in France. Another 2000 kg (approximately) is listed in various other forms and facilities. (Table in Plutonium, No. 11, Autumn 1995, p. 15).

This was not the result of a conclusion that there is no proliferation hazard associated with spent fuel, but simply the recognition that to increase the amount of highly radioactive spent fuel from 1000 ton Pu content by 10% to a total of 1100 tons of Pu would not significantly increase the chances of proliferation. However, to have 100 tons of weapon Pu in metal or oxide form would pose a substantial additional hazard; in addition, it would indicate assurances to NNWS that the Pu might be rebuilt into weapons at some early time-- no matter how unlikely that seems.

In addition, both to minimize the threat of theft of intact nuclear weapons and to begin to meet the obligations of the US and Russia undertaken in the context of the NPT extension, weapons should be demilitarized as soon as possible, and the disposition process of excess weapon material should be handled expeditiously.

Ongoing activities.

Status of US program to dispose of excess weapon-usable fissile material. Two years after the first CISAC report, DOE has published its own document[10] accepting the "Stored Weapons Standard" and the "Spent Fuel Standard". But little progress has been made in implementing the strong recommendation[11] to begin programs both to consume W-Pu as MOX in reactors of existing type, and to dispose of W-Pu by vitrification with high-level fission product waste, for consignment to a mined geological repository (MGR).

The US is currently dismantling some 1500-1800 nuclear warheads each year, with the metal "pits" containing the nominal 4 kg of Pu being put individually in a steel storage container and the "secondary" uranium parts returned to Oak Ridge, Tennessee. The pits are stored in concrete igloos at Pantex (Amarillo), Texas.

Disposition of excess Russian W-Pu and HEU. As discussed earlier in this paper, Russia has contracted to sell to the US over 20 years 500 tons of HEU, for a total of some $12 billion, blended to a U-235 content of 4.4%. Since the proliferation potential of this material is little diminished until it is all gone, it would be highly desirable to provide the funds to blend all excess HEU immediately to some 19.9% U^{235} (below the 20% HEU threshold), which would in no way preclude the energy use of the material following further blending to 4.4% for LWR or to 10% or 18% U^{235} concentration for fast-spectrum reactors.

The management and disposition of excess Russian W-Pu is making slow progress, with construction begun on a large storage site for such weapon pits and other materials.

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[10] "Storage and Disposition of Weapons-Usable Fissile Materials Draft Programmatic Environmental Impact Statement" (February 1996).

[11] "The current-reactor/spent-fuel and vitrification-with-wastes options are the two leading contenders for plutonium disposition to the spent fuel standard. Because it is crucial that at least one of these options succeed, because time is of the essence, and because the costs of pursuing both in parallel are modest in relation to the security stakes, the panel recommends that project-oriented activities be initiated on both options, in parallel, at once." (In CISAC-2, p. 14).

Russian technical analyses of the burning of W-Pu as MOX in LWRs show feasibility, but enthusiasm is directed more toward the building of several BN-800 sodium-cooled fast reactors (which would in any case probably be fed civil plutonium first). Some Russians claim that the fast reactors are no more expensive than the VVER-1000 LWRs when the latter are upgraded to modern safety standards, but primary data are not available to consider this claim.

While considering the "energy value" of Pu, it is easy to ignore the cost of releasing this energy-- particularly the cost of MOX fabrication, which at current costs with zero-cost Pu metal exceeds[12] the total cost to purchase equivalent LEU fuel elements. Although vast sums and human capital were invested in the acquisition of the military Pu, these additional costs over LEU reduce the economic value of Pu to zero; nevertheless, the energy from fission of a gram of Pu is just that available from U^{235}, so it should be possible to arrange an exchange of excess W-Pu for an equivalent amount of HEU blended to the 19.9% level. Indeed, such a swap would be highly advantageous to the initial holder of W-Pu, since the blended HEU would be much cheaper to use and hence more salable.

The option for earliest disposition of excess W-Pu still seems to be the conversion of VVER-1000 reactors to take full core MOX. Russia lacks an adequate MOX fabrication plant, but the Siemens-built plant at Hanau, which has not been allowed to begin operation, could be used as the source of equipment for a high quality plant within Russia for the fabriction of LWR MOX fuel elements-- the so-called Hanau East option.

CTBT negotiations. Some nations wish to transform the CTBT into the elimination of nuclear weapons themselves; if they persist, there will be no CTBT, and not only because the nuclear weapon establishments in the five nuclear states are not enthusiastic about the end of testing. A leading advocate of a nuclear-weapon-free world, Joseph Rotblat[13] argues that the elimination of nuclear weapons would make the world more secure, but that they would return in times of major crisis unless we could achieve a war-free world. And many non-nuclear weapon states apparently depend for their ultimate security on the existence of nuclear weapons in the hands of a small number of states.

One principal impediment to the completion of a CTBT is the ongoing Chinese nuclear test program. France conducted nuclear tests while negotiating, but stated that its series would terminate by May 1996 with 8 tests or fewer,[14] and China should give a date certain by which time their tests will be finished, preferably in 1996, and commit to obeying a CTBT after that time.

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[12] CISAC-2, pp. 292-298.

[13] Nobel Prize Acceptance Speech, "Remember your humanity" Oslo (December 10, 1995)

[14] In the event, it terminated February 1996, with 6 tests.

The most serious problem, perhaps is that represented by the statement of the Chinese disarmament ambassador Sha Zukang[15] formally to the 38-member UN negotiating Conference on Disarmament that a CTBT should permit peaceful nuclear explosions (PNEs). Even though peaceful nuclear explosives may differ considerably from military explosives (in needing to have a low fission fraction, or a low tritium content, or to be able to withstand high temperatures and pressures in a borehole), the point is that such charges would still be useful military explosives. A nuclear-weapon state (and perhaps many non-nuclear states) will not tolerate one nation going ahead unimpeded with its design efforts; and if all proceed with imaginative PNE designs such a program will prevent the achievement of a meaningful CTBT.

On the other hand, if the aim is simply to avoid impediments to inertial confinement fusion, induced by laser beams or particle beams, this can both be understood and accommodated. The heat required by a normal power plant corresponds to the energy of about one ton of HE per second, so an ICF pellet explosions every ten seconds would need to give ten tons of HE equivalent. The US would certainly not count this as a forbidden "nuclear explosion" even though it is 10,000 times as powerful as fission explosions that will clearly be banned under the CTBT. So an exemption is clearly in order in a CTBT for pure fusion energy release (without any fission component) taking place in a permanent, reusable containment above ground, and properly monitored.

As for the other uses to which peaceful nuclear explosions (as traditionally understood) were put in the 123-test Soviet program and the 27-test US program-- excavation, stimulation of oil and gas, creation of underground reservoirs, deep seismic sounding, and quelling runaway gas or oil wells, none of these has benefits that would repay its proliferation damage. Indeed, in a published interview a year ago, Victor Mihailov, head of the Russian MINATOM concluded about the Soviet and American PNE program, "So far, they have not proven to be economical." Still, Mikhailov is reluctant to ban any tool of scientific progress.

Humanity may need PNEs in the long term, and a CTBT now will not stand in the way. For instance, enormous nuclear explosions emplaced by high-performance rockets are one approach to diverting asteroids or comets from striking the Earth; such an impact was responsible for the extinction not only of the dinosaurs some 65 million years ago but of 70% of all species on Earth at the time. However, we should not start now to prepare for a disaster that will happen with good probability in tens of millions of years and with smaller magnitude of damage perhaps in 10,000 years. The reasonable solution would seem to be to sign a CTBT that bans any explosive energy release in tests from fission, and any unconfined pure fusion energy release, but includes a provision to call a well-prepared international conference on PNEs ten years after the CTBT enters into force, with a view to understanding not only the costs and problems of PNEs, but also

[15] "The Chinese delegation maintains that as an important principle, any disarmament or arms control treaty should not hinder the development and application of science and technology for peaceful purposes. Therefore it would be incorrect if CTBT should ban PNEs." (Reuters, March 28, 1996).

whether and how they might be carried out without compromising the security goals of a CTBT.

What is to be done?

Beyond the CTBT and START II. My own belief is that the US and Russia should rapidly negotiate START III, which would leave them in the year 2005 with 2000 nuclear warheads each instead of the "3500" under START II. The difference is larger than it appears, since the "3500" is no limitation on warheads, but rather on the number of warheads mounted on strategic delivery vehicles; the US plans to maintain some 8000 total warheads in working condition, and nothing prevents Russia from having even more. In contrast, the "2000" represent the total warheads-- active and reserve, strategic plus tactical-- with the warhead as the controlled and verified unit of account.

The further reduction of 6000 warheads need not depend on an expansion in the capacity for dismantlement; the fissile material in the warheads themselves could be designated irrevocably for civil use, declared and monitored under the agreement; the weapons could be demilitarized, even before being disassembled.

Enhanced Russian-US cooperation.

Material protection, control and accountancy (MPC&A). It is critically important to account for all the weapon usable material in every country, particularly in Russia, and to bring it under physical protection and control.

One example of the scope of the problem is given by project SAPPHIRE, in which the US agreed with Kazakhstan to buy and transport to the United States some 600 kg of HEU. At the $12 B agreed with Russia for the transfer of 500 tons of HEU, this would be worth about $14 M. The purpose of the transfer, of course, was the inadequate protection offered this material, which could have provided the fissile core for some 20-30 nuclear weapons.

The US Department of Energy has requested $95 M from the US Congress to fund an MPC&A plan on which agreement has been reached with Russia to upgrade security and accounting systems that cover more than 70% of all the locations in the former Soviet Union where weapons-usable plutonium and HEU are located, but these security and accounting upgrades would not be completed until the year 2002. Funding at a level of $150 M per year would permit more rapid reduction in these highest priority proliferation risks.

But it would be good to have other nations looking at themselves and their neighbors (and helping with the states of the former Soviet Union) to increase the international standards for security and accounting of weapons-usable materials worldwide, in view of the serious proliferation risks that these pose. To the extent that these standards are not equivalent to those for restricting access to nuclear weapons, they should be brought to that level.

A comprehensive approach to nuclear smuggling. This could involve not only Russia, but especially states through which fissile material might travel, including information sharing, the identification and standardizing of analysis centers, the training of law enforcement units and the provision of equipment and the establishing of communication links, as well as improved detection and other equipment at borders.

Increased emphasis on nuclear transparency It has been proposed that the MPC&A be supplemented by initial bilateral and later international exchange of information, visits to storage and production sites, and similar means for establishing secure control over fissile material. Additional legislation and funding is needed in the US, and similar measures in Russia.

Halting production of weapon Pu. The US Congress has imposed on the Administration the requirement to pursue and agreement with Russia to end the production of weapon plutonium, which continues at reactors that also provide community heat. The reactors will need to be provided with an alternative, durable fuel, at the cost of some $100 million.

Pu/HEU disposal. Neither in the US nor in Russia are these activities proceeding at the pace that would be warranted by the "clear and present danger" posed by these excess weapon-usable materials. In both nations it would be useful to have a multi-year high priority program to implement the program to burn W-Pu in reactors of existing type, and to vitrify Pu (perhaps only scrap Pu in Russia) with high-level fission product wastes.

Recommendations.

For catching up with the threat posed by excess weapon material and separated plutonium:

1. Japan should consider very seriously both as an energy resource and as a financial investment the acquisition of 700 tons of Russian HEU, to be blended down immediately to 20% U^{235} and either to be shipped as such or to be delivered on a contractual basis as 2-5% U^{235}.
2. Increased effort and investment in improved MPC&A where these excess weapon materials are becoming available (Russia and US).
3. Responsible firms and nations such as Canada and Japan could follow up their analyses of the feasibility and cost of burning excess weapon Pu as MOX in their reactors (CANDU and LWR) by proposals to the United States and/or to Russia to obtain either Pu under strict protection and safeguards, or fabricated MOX fuel, for commercial energy production. Some subsidy from the G-7 or other source is likely to be required, since there would be no incentive to burn this W-Pu unless the perceived cost of fuel was less than that of LEU fuel elements.

Managing the proliferation threat from near-term civil nuclear power activities:

1. Prescribe and use appropriate measures in the nuclear energy system to protect

against proliferation, and internalize their cost (as is done with taxes or rebates for emissions control).

2. Create and use international Pu banks with both IAEA safeguards and international security measures.
3. Build and use commercial, competitive Mined Geologic Repositories (MGRs). The one most important step in advancing the fortunes of civil nuclear energy, and a good next step in minimizing proliferation hazard of spent fuel, would be the opening of a few large competitive MGRs by the US, Russia, China, Japan, and perhaps other nations. These would accept (for a fee) qualified spent fuel or vitrified waste from any nation, so long as it met IAEA standards to be worked out or refined in the future.
4. Communicate more openly, as in this meeting-- i.e., via an updated PNC "home page" on the WorldWide Web.

Opening the long-term future for nuclear power:

1. Uranium from seawater. Japan seems almost alone in this field, but since uranium dissolved in seawater amounts to some 4000 million tons (about 1000 times that available from known and likely mineral deposits at current prices) it is essential for planning purposes to do enough development work to understand the ultimate cost of winning uranium from seawater. Current Japanese work[16] indicate a cost of some $300/kg U, which would add about $0.009/kWh to the cost of nuclear electricity in a once-through cycle.
2. Comparative analyses[17] and experimental work on breeder or break-even reactor systems, especially lead-cooled Pu/U^{238} breeders and accelerator-driven lead-cooled thorium/U^{233} reactors.
3. More candor, and more recognition that there are blind alleys in this field as in all others.

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[16] "Nuclear Electricity Generation Using Seawater Uranium," by Toru Hiraoka in Atoms in Japan, pp. 14-16, Dec. 1994.

[17] But note the caution, "Studies that offer estimates of costs without providing sufficient detail about the derivation of these to permit such a procedure (that is, providing the estimates of direct construction costs, or of labor or materials requirements) are not useful for the purpose of making systematic comparisons." (In CISAC-2, p. 75). CISAC-2 itself goes to great efforts to present primary data and assumptions, as well as the procedure for deriving cost totals from time-spaced expenditures.

ABSTRACT

"Nuclear Weapon Free Zones - the Management of the Nuclear World"

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A new nuclear compact, for the post Cold War/globalised world, would lead to the development of the architecture of a nuclear weapon free world (NWFW).

Nuclear Weapon Free Zones (NWFZ), already developed, are parts of that emerging architecture and are helping in the safe management of a world of nuclear weapons.

NWFZ rest on two central propositions:

-a world in which nuclear weapons exist cannot be managed by nuclear weapon states alone

-there is a range of nuclear/atomic issues which affect the lives of people, the management of which can be made secure by co-operative action on a geographic basis.

NWFZ can mitigate the harmful effects upon people of: the proliferation of nuclear weapons, nuclear testing, disposal of radioactive waste, transit of nuclear/atomic goods.

NWFZ have various characteristics depending upon what can be negotiated, politically, in each geographic area forming a zone.

They can be and have been done with full respect for relevant international laws, such as the Law of the Sea Convention.

The possession of nuclear weapons with ranges spanning multiple geographic zones does not confer upon nuclear weapon states the right to use or threaten to use those weapons wherever they choose.

Nuclear weapon states are invited to accede to and respect NWFZ Treaties.

NWFZ Treaties can be linked to spread their security benefits across an increasing portion of the world, for example, a southern hemisphere link is possible between the Treaties of Tlateloco, Rarotonga and Pelindaba.

TWENTY-NINTH ANNUAL CONFERENCE OF THE JAPAN ATOMIC INDUSTRIAL FORUM.

Joaquín Mercado
Ministry of Foreign Affairs, Mexico

APRIL 1996

For me it is a great honour to have been invited to the Twenty-Ninth Annual Conference of the Japan Atomic Industrial Convention to refer to the position of Mexico regarding the regime established by the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) and its perspectives. During the Review and Extension Conference held in New York from 17 April to 11 May 1995, 174 of the 179 States parties to the NPT agreed to extend the Treaty indefinitely.

Unlike other multilateral treaties, the NPT was conceived as a treaty of limited duration. The nuclear-weapon States wanted to make its duration indefinite from the very outset, but the States at which the Treaty was aimed insisted on a period of 25 years, as a means of testing it, together with periodic review conferences to ensure that the nuclear-weapon States would disarm, before they would accept a permanent status as non-nuclear-weapon States. To attract non-nuclear-weapon States to the Treaty, they were offered increased cooperation to develop nuclear energy and progress in nuclear disarmament, as long as they renounced nuclear weapons.

A review conference to meet every five years was incorporated into the Treaty, as well as a conference to decide on its continuation 25 years after its entry into force (article X, paragraph 2).

The results obtained at the 1995 Review and Extension Conference, however, seem inconsistent with the reasons for establishing it. A year after the Conference, some conclusions concerning its importance to the Treaty can be drawn. So far, two nuclear-weapon States (China and the Russian Federation)

have noted that achieving an indefinite duration for the NPT does not mean that they can possess nuclear weapons forever. This is reassuring to a significant group of non-aligned countries that believe the NPT could permanently maintain the nuclear-weapon-State status of a small group of countries and thereby make it impossible to exert pressure to achieve the elimination of nuclear weapons once and for all.

Loyal to its disarmament-related political tradition, Mexico supported the extension of the Treaty, but not before ensuring that an agenda to negotiate concrete progress in nuclear disarmament would be approved. From the outset of the Conference, Mexico insisted on the need for a periodic and strengthened review mechanism to examine fulfilment of the Treaty obligations. It clearly noted that, if the periodic reviews detected any failure of the nuclear powers to fulfil the obligations they had accepted, it would consider the possibility of taking drastic measures and even exercising the provisions established in article X of the Treaty.

An understanding must be reached among the States parties to the Treaty on the best way to correct its failures and strengthen the provisions that have not been fulfilled. Several contradictions and weaknesses of the NPT have become evident and, although, in general, it is considered an important instrument for international security, it has neither prevented the proliferation of nuclear weapons nor stopped the qualitative and quantitative development of nuclear-weapon arsenals.

Because the Treaty legitimizes the distinction between nuclear-weapon and non-nuclear-weapon States, it is viewed as a discriminatory treaty in which the obligations are not equal for all States. The development of nuclear weapons is forbidden for some States, while it is allowed for others.

The Government of Mexico has noted that "when deciding to continue the Treaty indefinitely, we have not perpetuated the dichotomy between the nuclear-weapon States and the non-nuclear-weapon States because, in this context, the Review and Extension Conference has reaffirmed the complete elimination of nuclear weapons as the ultimate objective of the Treaty...".

What occurred at the April 1995 review of progress in fulfilling the most important Treaty provisions? As at the four previous review conferences, the nuclear-weapon States avoided any thorough discussion, particularly on the subject of nuclear disarmament. Once again, questions of procedure and, in this case, decisions regarding the extension of the Treaty, precluded the study of causes and problems that prevent the establishment of an authentic, universal and non-discriminatory regime.

The decision to extent the NPT indefinitely was agreed to as part of a package of three resolutions, which included reinforcement of the Treaty review process, a document of principles and objectives for non-proliferation and disarmament, and extension of the Treaty. Major differences in interpretation concerning the subject of nuclear disarmament prevented agreement being reached on the final declaration. The nuclear-weapon States sought acknowledgement of the progress made over the past five years in reducing nuclear weapons and the non-nuclear-weapon States, Members of the Movement of Non-Aligned Countries, sought commitments to a programme of concrete nuclear disarmament.

The document of non-proliferation principles and objectives contains the same issues identified 25 years ago during the NPT negotiations; that is, the conclusion of a comprehensive nuclear-test-ban treaty, prohibition of the production of

fissionable materials for military use, guarantees of security for non-nuclear-weapon States, safeguards for preventing the deviation of nuclear energy for non-peaceful uses and confirmation of the right of all Member States to develop nuclear energy research, production and use for peaceful purposes, including the transfer of technology.

In accordance with the provision adopted, the preparatory process for considering the principles agreed to and the recommendations for their fulfilment will begin in 1997. Discussion on fulfilment of the Treaty provisions will also have to begin, so as to prepare the field for the Review Conference to be held in the year 2000.

Review of the document of principles and objectives for non-proliferation should not preclude an in-depth examination of the NPT. The topics that require priority attention are as follows:

Article I of the Treaty forbids the nuclear-weapon States to help any non-nuclear-weapon State to acquire nuclear weapons. Article II forbids non-nuclear-weapon States to build or acquire nuclear weapons or seek assistance in developing them in any other way.

In spite of the provisions of these articles, the known cases of proliferation have been the result of activities conducted by States parties to the Treaty, and to a great extent, because of the deficiencies imposed by these articles. The prohibitions of article I regarding the transfer of nuclear weapons, other nuclear explosive devices and the control of such weapons and devices are comprehensive for the nuclear-weapon States. In contrast, the prohibition to help, appraise or encourage the manufacture or acquisition of nuclear weapons or other nuclear devices is aimed exclusively at the non-

nuclear weapon States, leaving the nuclear-weapon States free to cooperate among themselves in this field. In article VI, the nuclear-weapon States are obliged to negotiate in good will effective measures related to ending the nuclear arms race at an early date and to nuclear disarmament, which means that the prohibition should be extended to all parties on an equal basis.

In the case of article II, several prohibitions are imposed on the non-nuclear weapon States, but a prohibition against helping another State to make or acquire nuclear weapons or explosive devices through other means is nowhere to be found. If such a State were to take an action of this nature, it would, of course, be working against the principles of non-proliferation embodied in the Treaty, but it would not be violating it in a literal sense.

There has been a tendency to distinguish between direct and indirect assistance, thereby allowing nuclear-weapon States and other States with civil nuclear industry to trade double-use nuclear technology and materials under the guise of mere commercial transactions, which has resulted in the development of military programmes among countries such as Iraq, Israel and South Africa.

A thorough examination of these articles would allow pronounced deficiencies to be corrected. It would not necessarily call for amendments to the Treaty, since it could be accomplished through concerted agreements among the parties to help to interpret the actual spirit of the NPT.

In accordance with article VI, the parties commit themselves to hold negotiations in good will on efficient measures related to ending the arms race at an early date, to nuclear disarmament and to a general and complete disarmament treaty.

his has been the topic most extensively discussed in the istory of the NPT. The obligations assumed by the nuclear-eapon States through this article are viewed by the non-nuclear-weapon States as compensation for their renouncing possession of nuclear weapons. Since the first Review Conference was held, the non-nuclear-weapon States have accused the nuclear-weapon States of failing to fulfil these obligations, which is the reason the 1980, 1990 and 1995 Conferences were unable to reach agreement on a final declaration.

The minimum measures required have been a complete ban on nuclear tests, prohibition of the production of fissionable material for military purposes and prohibition of the use of nuclear weapons. Although the Treaty has been in force for 25 years, none of these measures has yet been achieved.

Following the failure of several attempts to conclude a comprehensive nuclear-test-ban treaty (CTBT), it is being negotiated in the Conference on Disarmament. However, the political will to conclude the treaty varies among the nuclear-weapon States, and the pace at which the negotiations are progressing makes it unlikely that agreement on the fundamental provisions of the treaty will be reached by the date established. After two years of negotiations, obstacles to achieving the ban have not yet been overcome.

In 1993, the Conference on Disarmament decided to establish an ad hoc committee to initiate negotiations on a treaty to prohibit the production of fissionable material. But when the core of the problem is reached; that is, a prohibition that would include all material that could be used for the manufacture of nuclear weapons and control over stored supplies, the negotiations become stagnant.

As far as the prohibition of the use of nuclear weapons is concerned, we have seen the fate of the General Assembly resolutions requesting the International Court of Justice to render its advisory opinion on the legality of using nuclear weapons. Although they were adopted by the General Assembly, the nuclear-weapon States and their allies voted against them. Mexico has actively participated in efforts to settle the problem in the International Court of Justice.

Nevertheless, assessments have recognised the positive developments of nuclear disarmament over the past decade. The INF, START I and START II agreements will contribute significantly to nuclear disarmament when they are fully put into practice. However, the lack of transparency in this sector hinders any precise examination of the situation and only two of the nuclear Powers are committed to the arms reduction. France, the United Kingdom and China continue increasing and improving their arsenals significantly.

The end of the cold war and, above all, the end of the confrontation between the major nuclear Powers have resulted in the international community recognizing that nuclear weapons are not politically and militarily useful (if indeed they were in the past). The five nuclear Powers do not, however, seem to willing to abandon their modernization plans in the near future. New arguments have arisen to justify the existence and maintenance of their arsenals, such as the emergence of new nuclear threats from the South, possible resurgence of former nuclear powers or even their use to discourage a possible attack with other arms of mass destruction.

The establishment of an international mechanism to verify fulfilment of treaties concluded to reduce and destroy armaments would be important to ensuring irreversible

compliance. Another confidence-building measure would be the establishment of a system of unilateral declarations for purposes of nuclear arsenal control.

From a technical standpoint, the impossibility of doing away with the immense existing arsenals in the near future is understandable. But, what is unacceptable is that we continue to allow the uncontrolled manufacture of nuclear weapons, taking into account that our treaty seeks non-proliferation. In military fields, it is a recognized fact that extremely powerful conventional weapons can be used with such precision that the use of nuclear weapons cannot be justified and is obsolete in military planning. It is illogical for the nuclear-weapon States to claim that nuclear weapons are essential to their national security and global security, while, at the same time, they argue that other countries such as India, Pakistan and Israel should not have them to use in discouraging conflicts in their regions.

Since the time the NPT was negotiated, security guarantees have been a very controversial issue. When the non-nuclear-weapon States renounced nuclear weapons, they became vulnerable to an attack or threat of an attack with nuclear weapons. The lack of agreement among the depository States prevented the Treaty from including related provisions. Instead, commitments were made through resolution 255 (1968) of the Security Council to defend the States parties to the NPT in case of an attack or the threat of an attack with nuclear weapons (positive guarantees). However, in addition to not being legally binding, such guarantees do not provide any security that nuclear weapons would not be used against them (negative guarantees).

The nuclear-weapon States subsequently attempted to solve the problem through unilateral declarations which offered negative

guarantees of security, but they were conditional and continued to be non-binding. Immediately prior to the beginning of the 1995 Review and Extension Conference, the United Nations Security Council adopted a new resolution, 984(1995), to update the guarantees agreed to in 1988. Four of the nuclear Powers updated their individual declarations and this time they harmonized them, although they still remained conditional. China, for its part, extended its guarantees unconditionally to all the non-nuclear-weapon States and nuclear-weapon-free zones, including a commitment not to strike first. For most of the non-nuclear-weapon States, the updating is of little importance, as long as an unconditional and legally binding commitment is not reached.

Article III of the NPT establishes application of the safeguards of the International Atomic Energy Agency (IAEA) for all nuclear activities for peaceful purposes in order to verify compliance with the obligations assumed in the Treaty. It also obligates all exporters of nuclear products to apply safeguards to nuclear materials, equipment and technology.

Article IV commits the parties to achieve the greatest possible cooperation in the field of using nuclear energy for peaceful purposes, including the transfer of technology, and to take into particular account the needs of the developing countries.

The current system of IAEA safeguards has been subject to several criticisms. The lack of confidence in the system's ability to identify clandestine nuclear programmes following the discoveries in Iraq make it essential to strengthen its fundamental bases. The IAEA document that establishes the safeguards (INFCIRC/153) refers basically to verification of quantities of nuclear materials.

The IAEA does not, in fact, verify obligations other than those to which a non-nuclear-weapon State is committed under the Treaty and the specifications in article II, paragraph 2; that is, materials and equipment which would not make a new nuclear facility subject to safeguards. The wording of this article lends itself to ambiguous interpretations, since it is limited to the export of nuclear materials for peaceful uses, and does not refer to the allowable military use, as in the case of nuclear propelled submarines.

Actually strengthening the safeguards will require increased funding. One third of the IAEA's budget is allocated to this item. Without an increase in the current budget, it will be impossible to put into practice new ideas needed to improve its effectiveness. For instance, in a true non-proliferation spirit, the use of safeguards in the activities of the nuclear-weapon States would reconsidered. The safeguards could verify non-production and use of plutonium and highly-enriched uranium, as well as the size and qualitative characteristics of their nuclear arsenals.

Some of the gaps in this article have given rise to export control systems. Such systems have proved to be ineffective, since exporters are the only ones who participate in the preparation of guidelines. An efficient control system should take into account the interests of importers as well. A thoughtful discussion on this problem among the parties to the Treaty would indicate the form e content of a new control system, whose enforcement should entrusted to an authority recognized by all parties. Opposition to a truly multilateral system has prevented the topic from being included in the deliberations of the United Nations Disarmament Commission.

Article VII of the Treaty confirms the right of the parties to establish nuclear-weapon-free zones in the regions as a means

of reinforcing their commitment to non-proliferation. The proliferation of nuclear weapons continues to be the most severe danger confronting humanity. In performing the urgent task to eliminate nuclear weapons, every possible measure should be taken to prevent the nuclear problem from becoming more complex and widespread.

The Government of Mexico, convinced of the danger that an increase in the number of nuclear-weapon States would pose, directed its efforts toward disarmament to prevent the risk of their proliferation in the Latin American region. Conditions in the region made possible the preparation of a multilateral instrument which, from the standpoint of disarmament and international law, is unquestionably far superior and more complex than the Non-Proliferation Treaty, as is evident in merely referring to the goals that both treaties pursue.

The fundamental purpose of the Treaty of Tlatelolco is to ensure the total absence of nuclear weapons in Latin America and the Caribbean, regardless of the State under which nuclear weapons might be possessed or controlled. The NPT only seeks to guarantee that the number of States that possess or control nuclear weapons does not increase, but without limiting in any way the capacity of current powers to instal nuclear weapons in the territories of other States.

In regard to the control system, the Treaty of Tlatelolco establishes a complete systems that includes not only the implementation of the IAEA safeguards, but also the submission of reports to the Agency for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (OPANAL) and the power of its Council to make special inspections. All the States parties to the Treaty are equal under the control system. In the NPT, the control system only consists in implementing the IAEA safeguards in non-nuclear-weapon States.

The nuclear Powers are not subject to any control. The Treaty of Tlatelolco unquestionably demonstrates what is possible when the necessary political will exists.

Mexico's priority interest in strengthening and assuring the efficiency of the system established by the Treaty of Tlatelolco prompted it to propose, during the last meeting of the OPANAL Council on 21 March 1996, the establishment of cooperation agreements with the nuclear-weapon-free zones of the South Pacific, South-eastern Asia and Africa, with a view to unifying positions related to the consideration of disarmament topics in the United Nations forums.

The system established by the Treaty of Tlatelolco has truly become a model for the establishment of other nuclear-weapon-free zones, and has significantly contributed to strengthening international peace and security through the reduction of areas in conflict.

The great expectations concerning the benefits of nuclear energy were fading as a result of the failure of many projects and the dangers stemming from a nuclear accident. Nevertheless, nuclear energy continues to be one of the most important sources of electric energy in the western world. The concerns of those possessing this technology that it may be deviated to non-peaceful uses and the high risk to environmental security have discouraged the promotion of nuclear energy in the developing countries.

The number of countries that have reactors in operation or under construction is very limited, owing to the lack of capacity and funds to acquire them, as well as the incipient technical preparation of their people. The small percentage of the IAEA budget allocated to technical and scientific cooperation does not contributes to solving the problem.

The cost of implementing a nuclear programme has made it prohibitive for the developing countries, and the IAEA seems to offer no solutions. Consideration should finally be given to offering truly beneficial incentives to the developing countries parties to the Treaty, which will require increasing the IAEA budgets and voluntary contributions to expand the training, research and technical cooperation programmes.

The risk of radioactive pollution, high costs, unsatisfactory results, the risk of nuclear-weapon proliferation and the so-called peaceful nuclear explosions have made the content of article V nothing more than words. Its provisions should be frankly analysed and its content formally declared inapplicable.

Finally, I would like to refer to the commitments assumed at the NPT Review and Extension Conference on the subject of disarmament, and particularly to the most important aspect, the total elimination of nuclear weapons. Among the nuclear Powers, the political will needed to make progress in nuclear disarmament is not yet evident. At the Conference on Disarmament, the only multilateral forum for negotiation on disarmament, it has not yet been possible to establish an ad hoc committee to initiate negotiations, even thought the topic is included as an item on our agenda. The arguments of the nuclear Powers to prevent its being dealt with are unconvincing and counter to what has been agreed to, not only in the final document unanimously approved at the first special session of the General Assembly devoted to disarmament, but also in the document of principles and objectives for non-proliferation of nuclear weapons and nuclear disarmament.

The efficiency of the non-proliferation system depends on systematic and progressive efforts to reduce the nuclear

arsenals at the world level, with a view to eliminating them. It is absurd to deal with nuclear disarmament in the abstract, when it is obvious that measure to address it cannot be postponed.

The conclusion of a CTBT this year must be considered not only a measure important to non-proliferation, but, above all, an essential action to end the nuclear arms race and a first step towards the total elimination of these terrible weapons.

At the past United National General Assembly, Mexico co-sponsored a resolution in which the Conference on Disarmament was asked to establish, on a priority basis, an ad hoc committee on nuclear disarmament to implement negotiations on a step-by-step programme for the total elimination of nuclear weapons within a definite time period. The conclusion of a CTBT should ease and promote the task of promoting a global programme that could, among other measures, contain steps to reduce the nuclear threat, stop the manufacture and upgrading of nuclear weapons and their delivery vehicles and reduce nuclear arsenals to minimum levels, so as finally to consolidate nuclear disarmament through the conclusion of an agreement to prohibit the use, production and possession of nuclear weapons.

Non-Proliferation and CTBT

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Chinese View of Nuclear Non-Proliferation

China's principled position has been consistent on the issue of prevention of the proliferation of nuclear weapons, namely, its solution should be part of the process of eliminating such weapons, contributing to their complete prohibition through destruction and promoting international peace and security. Therefore, China has always considered the issue in a broad context of arms control and disarmament and made its policy correspondingly. Specifically, China's policy was made up of three parts: first, to be against nuclear monopolization, nuclear blackmail and nuclear threats of any states; second, not to advocate, encourage and help other states to develop nuclear weapons; thirdly, to emphasize the necessity of preventing the proliferation of nuclear weapons on a fair and reasonable basis. At the same time, with changing of the international security environment, this policy of China has experienced a process of gradual development and improvement on its some aspects.

According to China, "arms control is means", and only " achieving just and persistent peace is the goal". [i] Therefore, on the issue of prevention of the nuclear proliferation, China has fought against hegemonism and power politics of major powers, especially against their policies of nuclear monopolization, nuclear blackmail and nuclear threats. It is these policies which have seriously endangered peace, security and stability of the world.

When China was developing its nuclear force under arduous conditions for self-defense, the Soviet government informed China of its mutual understanding reached with the United States in August of 1962: (1) nuclear-weapon-states would assume the obligation not to transfer nuclear weapons and technical information needed for their production to non-nuclear-weapon states; (2) non-nuclear-weapon states would assume the obligation not to produce nuclear weapons and ask for them from nuclear-weapon states and not to accept technical information needed for their production. Chinese government responded in three memos, that the Soviet Union could assume any obligation to the United States but should not do this on behalf of China, which would be regarded as violation of China's sovereignty and would not be tolerated by China. In the last memo of them, Chinese government declared unequivocally : "China don't admit absolutely that a certain country or certain countries have privileges to monopoly nuclear force in the world and issue orders arbitrarily to other countries."[ii]

The United States, the Soviet Union and the United Kingdom signed the PTBT on July 25, 1963. Chinese government pointed out sharply: "The key purpose of this treaty is to make all of the peace-loving countries with China included unable to increase their defense-force by the partial nuclear test ban, so that the United States can make unbridled threats and blackmail against them ."[iii] On August 15, in another statement it said: "It is dependent on whose hands they have been put into whether nuclear weapons are

beneficial to the peace, not while in the control of imperialist countries and yes while in the control of socialist countries."[iv] From these documents we can find that China's policy at that time was to maintain the rights of those peace-loving countries to develop their own nuclear weapons. It believed that nuclear weapons in their grasp could contribute to the breakup of nuclear monopolization, nuclear threats and nuclear blackmail by major powers.

If so when China did not posses nuclear weapons, it has still adhered to this policy and opposed the hegemonist approach of the superpowers over the issue of arms control after it developed its nuclear weapons. China refused to sign NPT in the 1970s and 1980s mainly out of the discriminatory nature of the treaty. In June of 1982, Huang Hua, China's Foreign Minister, proposed six fundamental principles that disarmament should follow at the Second Special Session on Disarmament of United Nations, among which is that any state has rights to keep the national defense capability needed for maintenance of its "independence, seventy and security".[v]

While visiting Latin America in the autumn of 1985 the premier of China said repeatedly: "It is totally for self-defense and for opposition against nuclear monopolization and nuclear blackmail that China owns nuclear weapons in very limited numbers".[vi] In September of 1986, Wu Xueqian, China's Foreign Minister said in the 41st UN Session of General Assembly: "Any talks and agreements of disarmament between the major nuclear powers should not harm interests of other countries."[vii] Though these statements were not so acute as those made by Chinese leaders in the 1960s, still they reflected the same position: nuclear monopolization, nuclear threats and nuclear blackmail pursued by few nuclear major powers in the name of the prevention of nuclear proliferation should be resisted resolutely, and every country has rights to develop its force of national defense needed for opposing aggression and maintaining independence.

But, nuclear weapons are not weapons in common sense, having capability of mass destruction and being able to cause very serious catastrophe if used. Moreover, the proliferation of nuclear weapons itself can often impair both global and regional peace and stability in varying degrees. Therefore, while claiming that each country has its rights to develop military force for its national defense, Chinese government has put forward its policy definitely not to encourage and help other countries in their efforts to develop nuclear weapons.

This policy can be traced back to the time when China did not possessed its nuclear weapons. On July 31, 1963, in the statement issued over sign of PTBT by the US, the Soviets Union and the UK, Chinese government disclosed its hypocrisy on the one hand, and suggested that both nuclear-weapon states and non-nuclear-weapon states in the world declare solemnly "the complete, through, utter and resolute prohibition and destruction of nuclear weapons" on the other hand. Furthermore, it proposed five measures which should be taken by them first for attaining the goal, including not to export and import nuclear weapons and technical materials needed for their production in any means. [viii] On October 16,

1964, namely on the day China made its first nuclear test successfully , Chinese government reiterated this policy.

After the discriminatory NPT was signed, China adopted a critical attitude against it and refused to adhere to it for a long time. Nevertheless, Chinese leaders declared publicly not to stand for the nuclear proliferation and help other states in their efforts to develop nuclear weapons. In January of 1984, Chinese Premier told some persons-in-charge of *New York Times* in New York City: "We don't support and encourage the nuclear proliferation, and don't help other states to develop nuclear weapons. We have done this before and will surely do our duty which should be done in the international institutions in the future." Especially in the late 1980s, in opposition to those people who had deliberately distorted China's position on the issue of nuclear proliferation, and also for maintenance of stability of various regions in the world, Chinese government readjusted its attitude over NPT. In February of 1990, Foreign Minister Qian Qishen restated China's policy not to stand for, encourage and be engaged in the nuclear proliferation at the Geneva Conference on Disarmament. He declared that China would send its observers to attend the 4th Review Conference of NPT scheduled in coming August. [ix] In September of 1991, at the 46th Session of the UN General Assembly he announced that China had decided in principle to adhere to NPT. In March of 1992, Foreign Minister Qian submitted the instrument of accession when he visited the UK. He reaffirmed China's persistent policy not to stand for , encourage, and be engaged in the nuclear proliferation.[x] In May 1995, at the 5th Conference on the Review and Extension of NPT, China supported the decision to extend the treaty indefinitely.

Chinese View of Nuclear Testing and CTBT

It is in a special historic and international background that China has developed and owned a few of nuclear weapons. China has been enforced to do this only after it was put under nuclear threats repeatedly by the nuclear powers and had no other alternative but to do it for self-defense. Therefore, China has adopted a very restrained attitude in terms both of numbers and size of nuclear tests. It has made the fewest tests among the five nuclear-weapon states. China has always opposed nuclear arms race and had no intention to join in it.

Furthermore, China has always objected to the policy of nuclear threats and never based its security on the nuclear threats against other countries. Its nuclear weapons have not threatened international peace and security. Above all, this can be seen very clearly from its policy of "negative security assurance" and "positive security assurance" .

From the first day it gained nuclear weapons, China has solemnly undertaken not to be the first to use nuclear weapons at any time and in any circumstances and unconditionally not to use or threaten to use nuclear weapons against non-nuclear-weapon states or nuclear-weapon-free zones. This unconditional

provision of "negative security assurance" to all non-nuclear-weapon states has been reiterated again and again afterwards.[xi]

At the same time, in the official statements, Chinese government undertook to provide non-nuclear-weapon states with "positive security assurance". Namely, when any non-nuclear-weapon state is attacked with nuclear weapons, China will take actions in the Security Council of UN so that it can take adequate measures to assist the victimized country and apply sanctions against the aggressor country. [xii]

In addition to these negative and positive security assurances made to non-nuclear-weapon states, China has taken CTB in the context of effective nuclear disarmament as a goal and has striven for its achievement , especially since 1992.[xiii] On October 5, 1993, after China made another underground nuclear test, Chinese government declared formally in a statement: "China can understand the sincere wishes of various non-nuclear-weapon states to negotiate and conclude CTBT at an early date and regards it positively sensible. Therefore, China supports its negotiations and conclusion and will participate in the process actively, by common efforts with other countries, making its efforts for its conclusion in 1996 at latest." "When CTBT is reached and put into force, China will abide by the treaty and don't make nuclear tests any more."[xiv] On November 19, 1993, with attendance of Hou Zhitong, China's ambassador and senior export on disarmament, the UN First Committee approved unilaterally a decision made by Geneva Conference on Disarmament that it will negotiate a CTBT which is "complete, global and verifiable".[xv]

Since the negotiation began in early 1994, China has actively and seriously participated in it so that CTBT can been reached in 1996 at latest. It has expressed its pleasure for the quick progress the negotiation made and promised again and again to stop its tests of nuclear weapons as soon as CTBT is put into force.

It is understandable that China has paid much attention to the quality of CTBT. According to what was said by Ambassador Sha Zukang at the 50th Session of the UN General Assembly and the UN First Committee respectively on October 17 and October 26, 1995, it should:

* "be effective indefinitely";

* "guarantee the equal footing for every signatory to the Treaty and be beneficial to universal participation of each country";

* "have clear-cut extent of prohibition, completely banning any tests of nuclear weapons, but not banning peaceful nuclear explosion and limiting peaceful use of nuclear energy";

* "have effective, just and reasonable verification mechanism", and "not stuff national technical means into international verification regime, even less replace international verification regime with national technical means";

* "be reached as soon as possible and in 1996 at latest".

As for the effective, just and reasonable verification mechanism, China regards it as "an issue of important principle related to equal interests and rights among all the signatories to the Treaty, especially between developing countries and developed countries technically". [xvi]

Now the Geneva Conference on Disarmament has made important progress in the negotiation of CTBT in spite of continuous existence of some differences. We have reasons to be optimistic to the prospect of its final conclusion before the end of 1996. After this treaty is put into force, surely China will stop its tests of nuclear weapons.

Therefore, any non-nuclear-weapon state which understands China's policy very well has no cause to worry over China's nuclear tests which are very limited in numbers. In fact, China's position as showed above can greatly promote their security.

Measures for Strengthening Nuclear Non-Proliferation Regime

As said above, in China's view, non-proliferation is not the goal itself. Only signing and extending the NPT is not enough. In order to make the mankind ultimately to get rid of threats of the nuclear war and bring about a world free from nuclear weapons, it should be used cooperatively with other measures. They should make up an integrated and inter-related nuclear disarmament process. Both nuclear-weapon states and non-nuclear-weapon states have their rights to participate in the process. Other measures include:

Sign a No-First-Use Treaty by Nuclear-Weapon States. All nuclear-weapon states should declare unconditionally not to use nuclear weapons against each other and immediately begin negotiations to this effect. They should also pledge not to use or threaten to use nuclear weapons against non-nuclear-weapon states and nuclear-weapon-free zones. According to Qian Qishen, to promise not to use nuclear weapons is especially important, "because it will not only make tests, development, production and deployment of nuclear weapons senseless and contribute to the process of nuclear disarmament, but will promote international peace and security. If the goal of complete prohibition and thorough destruction of nuclear weapons is not yet attainable temporarily, it is absolutely practicable and should be done as soon as possible for nuclear-weapon states to reach an agreement not to use nuclear weapons first against each other and not to use nuclear weapons against non-nuclear-weapon states and nuclear-weapon-free zones ."[xvii]

Conclude a treaty on CTB no later than 1996. In order to guarantee the feasibility of this treaty, it is necessary to set up a strict, effective and just international verification mechanism.

Promote nuclear disarmament.

First, the major nuclear powers should implement existing nuclear disarmament treaties as scheduled and further substantially reduce their nuclear weapon stockpiles;

Second, an international convention banning production of fissile materials for nuclear weapons should be negotiated and concluded;

Third, an international convention prohibiting all nuclear weapons should be signed, whereby all nuclear-weapon states undertake to completely destroy existing stocks of nuclear weapons under effective international supervision.[xviii]

Promote international cooperation in peaceful uses of nuclear energy while preventing the proliferation of nuclear weapons and pushing forward nuclear disarmament. Non-nuclear-weapon sates, especially those developing countries, has rights to get the technology and assistance on peaceful uses of nuclear energy to render service to their economic development.[xix] On September 19, 1994, Jiang Xinquan, the head of Chinese delegation, said to the 38th session of IAEA that prevention of the proliferation of nuclear weapons and promotion of peaceful uses of nuclear energy supplements and complements each other. Both of them promote each other as well as influence each other. But, they can not replace each other. The lawful rights and claims of IAEA member states, especially those developing countries for peaceful uses of nuclear energy can not been ignored in preventing the proliferation of nuclear weapons .[xx]

It is not difficult to understand why China emphasize such an integrated and interrelated nuclear disarmament process.

On the one hand, it is in conformity with China's fundamental position on nuclear arms control and disarmament. It always claims that only complete prohibition and thorough destruction of nuclear weapons can rid the mankind of shadow of nuclear wars. As the first step in the direction, no-first-use policy should be adopted by all nuclear-weapon states.

On the other hand, it is in conformity with China's attitudes toward other developing countries. These countries always complain that nuclear-weapon states have not cut down their nuclear weapon stockpiles and provided non-nuclear-weapon states with assistance in peaceful uses of nuclear energy as promised by NPT.

If all of these measures can be used cooperatively and integratedly, not only can the existing nuclear non-proliferation regime be strengthened, but the true goal of nuclear arms control, namely, achieving the just and persistent peace for the world, will be promoted very effectively.

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[i] See the speech by Chinese Foreign Minister Ian Qishen in the 46th Session of the UN General Assembly, in People's Daily (人民日报), September 26, 1991, p. 7.
[ii] Xie Yixian: A Diplomatic History of China (中国外交史), Henan People's Publishing House, 1988, p. 300.
[iii] idem, pp. 301-302.
[iv] idem, p. 302.

[v] Shanghai Institute of International Studies: Survey of International Affairs • 1983 (国际形势年鉴), Shanghai Branch of Chinese Encyclopedia Publishing House, p. 358.
[vi] Shanghai Institute of International Studies: Survey of International Affairs • 1986 (国际形势年鉴), Shanghai Branch of Chinese Encyclopedia Publishing House, 1986, p. 298.
[vii] Shanghai Institute of International Studies: Survey of International Affairs • 1987 (国际形势年鉴), Shanghai Branch of Chinese Encyclopedia Publishing House, 1987, p. 296.
[viii] Xie Yixian: A Diplomatic History of China (中国外交史), Henan People's Publishing House, 1988, p. 303.
[ix] People's Daily, March 1, 1990, p. 4.
[x] People's Daily, March 11, 1992, p. 6.
[xi] People's Daily, February 25, 1995, p. 6.
[xii] People's Daily, April 9, 1995, p. 6.
[xiii] People's Daily, May 23, 1992, p. 1; July 6, 1993, p. 1.
[xiv] People's Daily, October 6, 1993, p. 1.
[xv] People's Daily, November 21, 1993, p. 6.
[xvi] People's Daily, October 19 , 1995, p. 6; October 28, 1995, p. 3.
[xvii] People's Daily, September 30, 1993, p. 6.
[xviii] People's Daily, April 8, 1995, p. 6.
[xix] People's Daily, September 29, 1994, p. 6.
[xx] People's Daily, September 21, 1994, p .7.

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