第10回原産年次大会英語論文

1977年3月

社団法人日本原子力産業会議

第１０回　原産年次大会プログラム

と　　き　昭和５２年３月９日（水）　１０日（木）　１１日（金）
ところ　イイノ・ホール〔内幸町・飯野ビル　７階〕　東京都千代田区内幸町２－１－１
基　　調　「原子力発電時代の新しい展開をめざして」

第１日　　３月９日（水）

開会セッション（９：３０～１２：００）

	議　　長	芦原義重氏	（関西電力㈱会長 日本原子力産業会議政策会議委員）
9：30	原産会長所信表明	有澤廣巳氏	（日本原子力産業会議会長）
10：00	原子力委員長所感	宇野宗佑氏	（国務大臣原子力委員長）

〔特別講演〕

	議　　長	駒井健一郎氏	（㈱日立製作所会長 日本原子力産業会議政策会議委員）
10：30	岐路に立つ原子力－米国の見解		
①		V. ギリンスキー　氏	（米国原子力規制委員会委員）
11：15	フランスの原子力政策		
②		J. テヤック　氏	（仏原子力庁最高委員）

午　餐　会（12：20～14：10）ホテルオークラ<別館２階・桃山の間>

挨拶　田中龍夫氏（通商産業大臣）
〔特別講演〕　「２１世紀の日本」
小松左京氏（作家）

原子力関係映画上映　（12：40～14：10）　<ホール>

自由参加

1. 「安全性を追求して ― 研究者たちの記録」
   ROSA，NSRRなどを紹介　（原研：１９７６年製作）
2. 「動燃１９.７６ ― 新しい原子炉と燃料の開発」
   （動燃：１９７６年製作）
3. 「世界の原子力発電」
   欧米・ソ連５ケ国の６発電所を紹介（NET朝日：１９７５年製作）

セッション1「エネルギー情勢と原子力開発」（14：30〜17：40）

〔講　演〕

議　長　松根宗一氏（経済団体連合会エネルギー対策委員会委員長
日本原子力産業会議政策会議委員）

14：30　世界のエネルギーと日本の進路

中　山　素　平　氏　（エネルギー総合推進委員会委員長
日本原子力産業会議副会長）

15：00　新エネルギー技術の評価とわが国の選択

大　島　恵　一　氏　（東京大学工学部教授）

議　長　原　谷　敬　吾　氏　（北陸電力㈱社長）

15：40　イタリアにおけるエネルギー情勢と原子力発電の役割

G. スペーリ氏　（イタリア電力公社建設本部長）

16：20　米国のエネルギー問題と原子力開発－産業界の見解

H. ラーソン氏　（米国原子力産業会議副理事長）

17：00　原子力開発のための国際協力への貢献

I. ウイリアムズ氏　（ＯＥＣＤ原子力機関事務局次長）

第2日　3月10日（木）

セッション2「核燃料サイクルの確立」（9：30〜11：30）

〔講　演〕

議　長　守　屋　学　治　氏　（三菱重工業㈱社長）

9：30　核燃料サイクルシステムの考え方

瀬　川　正　男　氏　（動力炉・核燃料開発事業団副理事長）

10：10　西ドイツの再処理センター計画

P. ツールケ氏　（西独ＫＥＷＡ社筆頭取締役）

10：50　放射性廃棄物対策の進め方

山　本　寛　氏　（東京大学名誉教授）

セッション3「核燃料サイクルと国際協力」(13:00〜16:45)

議　長　新関欽哉氏（原子力委員会委員）
副議長　村田　浩氏（日本原子力研究所副理事長）

13:00

〔国際パネル討論〕(13:00〜16:45)

⑦ パネリスト　P. タランジェ氏（仏原子力庁代表理事）
⑧ C. バック氏（英国核燃料公社再処理担当理事）
⑨ E. バンデンベムデン氏（ベルゴニュークリア社取締役核燃料生産部長）
⑩ 今井隆吉氏（日本原子力発電(株)技術部長 外務省参与）
J. ハイル氏（西独研究技術省核燃料サイクル担当官）
L. シャイマン氏（米国務省原子力担当補佐官）
⑪ D. フィッシャー氏（国際原子力機関事務総長補佐）
⑫ Dr. W. ブーランジェ氏

レセプション　(17:30 〜 19:00)

<日本工業クラブ　3階　大食堂>

第3日　3月11日(金)

セッション4「日本の原子力産業－開発戦略上の課題」(9:30〜12:30)

議　長　白澤富一郎氏（日本原子力発電㈱社長）
議長補佐　川上幸一氏（神奈川大学経済学部教授）

9:30　基本課題の提起（議長補佐）

10:00　〔パネル討論〕(10:00 〜 12:30)

パネリスト　堀　一郎氏（東京電力㈱常務取締役）
永野　治氏（石川島播磨重工業㈱副社長）
村田　浩氏（日本原子力研究所副理事長）
清成　迪氏（動力炉・核燃料開発事業団理事長）
田島敏弘氏（㈱日本興業銀行常務取締役）
並木　徹氏（通商産業省資源エネルギー庁原子力産業課）

セッション5「社会と原子力」（14：00〜17：30）

議　長　岸本　康氏（共同通信社論説副委員長）

〔基調報告〕（14：00 〜 14：30）

「エネルギーと原子力……最近の論争点」

山田　太三郎　氏（日本原子力産業会議常任相談役）

〔パネル討論〕（14：40 〜 17：30）

〔パネル討論〕

竹内　直一　氏（日本消費者連盟代表委員）

川上　正道　氏（東京経済大学教授）

生田　豊朗　氏（日本エネルギー経済研究所長）

小野　周　氏（東京大学教授）

豊田　正敏　氏（東京電力㈱原子力保安部長）

宮沢　洋夫　氏（日本弁護士連合会公害対策委員会第4部会長）

山田　太三郎　氏（日本原子力産業会議常任相談役）

閉会セッション 3/9 午前
ギリンスキー氏 本論文

Remarks of Victor Gilinsky
Commissioner, U.S. Nuclear Regulatory Commission
at the 10th Annual Conference of the
Japan Atomic Industrial Forum
Tokyo, Japan
March 9, 1977

A U.S. VIEW OF NUCLEAR ENERGY AT THE CROSSROADS

The title of this conference -- For a New Turn Toward the Nuclear Power Age -- is significant, for we are indeed meeting at a crossroads in the development of nuclear energy.

For little more than a generation, the industrial nations of the world have mined, milled, enriched and fabricated uranium -- a substance previously unknown as fuel -- for use in nuclear reactors, extracting from it increasingly large amounts of electricity. We have now arrived at a point where we are considering the advantages of exploiting the so-called "back end of the fuel cycle": in other words, whether we should proceed to mine the used fuel itself, thus obtaining additional fuel, or wait until satisfactory international arrangements for controlling the nuclear explosive plutonium contained in it have been devised.

As you are well aware, concern about our current ability to cope with the dangers that attend the widespread international commercial use of plutonium has caused the United States to question the wisdom of the course on which advanced nuclear programs have been proceeding up until now. This concern began to manifest itself in the United States in 1974, and by the end of 1976 it had become acute, culminating in the Statement on Nuclear Policy issued by President Ford on October 28.

That Statement, in which the decision to defer commercial separation of plutonium in the U.S. was announced, appears to have generated a high level of interest, particularly here in Japan. For this reason I shall depart somewhat from the custom of these annual talks by members of the Nuclear Regulatory Commission; instead of the usual detailed account of our commission's activities over the past year, I shall try to outline some of the events which led up to the October Statement and which continue to influence thinking in the U.S. about two matters intimately related to it -- reprocessing and waste management.

The overall reevaluation of U.S. nuclear energy policy begun last year has carried over into President Carter's Administration, where it is even now under intensive study. It would be premature to speculate on the outcome of this review and it would in any case be an exercise more appropriate for officials in the Executive departments. Nevertheless, I believe some idea of U.S. thinking and intentions might emerge if I were to tell you something about what has been going on recently and about the context in which these matters are being examined in the new Administration.

BACKGROUND

Over the past two years government mechanisms for dealing with nuclear energy have altered markedly. Not only that, but we have a new Administration headed by a President who is particularly interested in nuclear energy. The shift away from high specialization and separate treatment in nuclear matters which began in 1974 with the demise of the Atomic Energy Commission will be completed when a Department of Energy is added to the Cabinet. The plan is to include nuclear energy development, exclusive, of course, of NRC's regulatory activities, in this new Department's responsibilities. A reassertion of political control is also evident where international security problems posed by the widescale use of nuclear energy are concerned, a process which, incidentally, appears to be at work in some other countries as well. It is clear that in this Administration nuclear energy policy, both domestic and international, will no longer be left to a small group of technical experts, and that special treatment for these matters is at an end.

Though they are perhaps less noticed abroad, the changes that have taken place in the Congress are no less significant for the future of U.S. nuclear policy. Whereas once the very exclusive Joint Congressional Committee on Atomic Energy exercised sole jurisdiction over legislation and nuclear policy, these powers have now been parcelled out to various committees concerned with energy and foreign affairs.

Realignment of responsibilities for nuclear energy within the government coincided with, influenced, and was in turn influenced by, a very public review of nuclear energy issues. If any one issue dominated the debate since 1974, it was the future use of plutonium, with all its ramifications, domestic and international.

It is not too much of an exaggeration to say that until 1974 the American public as a whole paid little attention to the security aspects of nuclear energy. But the oil embargo sensitized the public to energy issues and the 1974 explosion of a nuclear device in India revived old fears about the spread of nuclear weapons. Concern was heightened by the realization that interest in plutonium had expanded worldwide and that even countries in the early stages of commercial nuclear development were planning to acquire reprocessing plants. When it became clear that widescale civilian use of plutonium was contemplated in the United States and abroad -- and in fact appeared imminent -- the reaction was unexpected in its swiftness and reach. The public and its political leaders insisted on a hard-boiled assessment of the problems of nuclear energy, an assessment unencumbered by the wishful thinking and exaggerated estimates of the past. The so-called "experts," in nuclear energy policy were viewed with skepticism, as were official reassurances that appeared to view the Indian explosion either as inevitable or as a one-time curiosity.

This change of public attitude was felt in the Congress, in the election campaign of 1976, and in the White House. Many of the assumptions of the past thirty years were subjected to close scrutiny: the adequacy of international arrangements to prevent weapons proliferation was questioned, as was the ease with which technical solutions for the safe disposition of nuclear wastes could be found. And -- perhaps most significantly -- the idea that the use of plutonium was a natural, legitimate, desirable, and even indispensable result of the exploitation of nuclear energy for the generation of electricity was reexamined; the idea that it was "inevitable" was rejected at the highest level. The pressures produced by this general loss of innocence culminated in the October 1976 Presidential Statement on Nuclear Policy, and marked the end of an era.

THE OCTOBER STATEMENT ON NUCLEAR POLICY

What President Ford said, in effect, was that in the rapid and essential development of nuclear energy we had been getting dangerously ahead of ourselves; that we had been carelessly and needlessly locking ourselves into a single track of nuclear development which threatened to culminate in ready access worldwide to nuclear explosive material; that without any penalty to the success of nuclear power generation and its continued growth we could afford to stop long enough to take stock, assess the alternatives to reprocessing, and make sure our single-minded pursuit of plutonium as the answer to all our energy problems was not precipitating us irretrievably into a world of multiplying nuclear weapons states. The President concluded that reprocessing "should not proceed unless there is sound reason to conclude that the world community can effectively overcome the associated risks of proliferation."

The statement reflected an awareness and a concern that in some parts of the world the feeling is growing that the United States is "crying wolf" about proliferation and the dangers of plutonium in order to maintain commercial advantage in the nuclear marketplace. To avoid such suspicions, President Ford insisted that U.S. domestic and international actions and policies on reprocessing be consistent: we could not now discourage reprocessing in the rest of the world and proceed with it ourselves, no matter how heavily we had already invested in it. "I believe," he said, "that avoidance of proliferation must take precedence over economic interests." He pleaded with all nations to recognize that we could not control the nuclear risk alone. Clearly, the example of the advanced countries to the rest of the world was crucial.

The statement pointed out that the time to decide on a commitment to widescale commercial use of the breeder is still many years away, sufficiently distant to allow for the introduction of some international discipline in the management of plutonium fuel.

To avoid the possibility that, by default, reprocessing might be seen as the only solution to waste management, the Energy Research and Development Agency was directed to proceed with plans for the disposal of radioactive wastes and storage of spent fuel in such a way as to allow for either contingency: reprocessing or no reprocessing.

The U.S. decision to keep its options open by a deferral of reprocessing does not reflect a momentary weakening in the face of public outcry; it reflects a carefully considered determination to restore the element of choice in our nuclear future and to obtain valuable time for the international community to cope with an uncertain technological future while at the same time protecting a large and expanding investment in power systems based on light water reactors. I am confident the decision to defer reprocessing will not be reversed by President Carter.

PLUTONIUM AND PROLIFERATION

We are very troubled by the possibility that if plutonium is equated with further civilian nuclear development the cost will be widespread international access to this nuclear explosive. Despite the fact that great progress has been made in developing international institutions -- both for development and dissemination of the benefits of nuclear energy in the IAEA, and for controls over the dangerous aspects of the fuel cycle in the Treaty on the Nonproliferation of Nuclear Weapons -- problems in controlling access to plutonium remain.

It is worth recalling that fundamental to the NPT are, first, that nations agree to foreswear nuclear explosives and, second, that they submit to a technical protective regime to back up these assurances. This latter requirement is a reflection of the practical reality that the widespread use of nuclear energy is compatible with world security only if these civilian developments are subject to a strict, commonly agreed-to discipline. It has been translated into what is, in effect, an international alarm system operated by the International Atomic Energy Agency, and based on international inspections. If such a system is to be effective in deterring possible wrong-doing it must provide warning in time for the international community to act -- that is, well before civilian materials can be transferred to military uses.

Where only reactors and their low-enrichment fuel are concerned this international inspection system works reasonably well; it takes months or years to make illicit use of diverted civilian fuel because the plutonium locked in spent fuel is still many complex and time-consuming steps from use as a nuclear explosive.

The situation is radically different where separated plutonium is involved. Once stockpiled, as the International Atomic Energy Agency has recently acknowledged, plutonium is vulnerable to seizure and translation into weapons within a matter of days. And, let me stress what we are concerned about here is not the exploitation of measurement inaccuracies to conceal theft but the possible wholesale appropriation by national governments so suddenly as to leave no opportunity for warning and international reaction. No amount of technical safeguards demonstration will alter this fact. Nevertheless, because it presents us with a dilemma, we struggle to escape this conclusion.

It has been argued, for example, that there are effective technological barriers because plutonium from civilian power reactors is unsuitable for military explosives. This is not true, unfortunately. There is no way around the fact that a country with a stock of separated plutonium is a country with a stock of nuclear explosive material, which differs only in form, geometry, and associated gadgetry from actual explosive devices.

The alarm expressed over this past year in the United States and the consequent desire to forestall national stockpiling of plutonium, may have come too late. But there should be no mistaking the national will to make still another attempt to impose some international discipline on a dangerously unstable situation.

The October decision to delay reprocessing in the U.S. was one important move in that direction. It was intended, without prejudice to the future of nuclear energy, to put a hold on a premature commitment to plutonium -- in other words, to keep our technical options open. Let us consider how this decision affects the operation of the present generation of reactors, particularly in relation to fuel resources, and how much it alters our approach to waste management problems.

LIGHT WATER REACTORS AND REPROCESSING IN THE UNITED STATES

It is often argued that reprocessing is essential to any genuinely economical use of light water reactor fuel, since it permits further extraction of energy from the plutonium and uranium in its spent fuel. For the first time we are reexamining this proposition, along with its constant companion -- the idea that the most efficient and safest way to dispose of spent fuel is to reprocess it as quickly as possible.

We are discovering that the economic usefulness of light water reactors is affected only marginally by the recycling of the spent fuel. And in any case, the plutonium and uranium locked inside it can be mined whenever it is wanted. As for reprocessing as the best means for disposing of spent fuel, we are finding the answer, in terms of safety, costs, comparative volumes of waste generated by plutonium utilization, is less obvious than we thought.

Much of our current thinking on this subject is being stimulated by a public proceeding before the NRC which was initiated in 1974 to decide whether reprocessing and wide-scale recycle of plutonium in light water reactors should be permitted, and if so under what rules. I should say parenthetically that this examination is still going forward despite the October 1976 decision to defer reprocessing. But while the question of whether to reprocess or not is thus still alive, it nevertheless no longer retains the character of a foregone conclusion; a decision has clearly moved further away in time.

The basic framework for the public hearings now taking place in Washington is provided by the Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Cooled Reactors (GESMO, August 1976). Some of the more interesting analytic findings of the report with regard to economics were that

-- widescale recycle had a slight economic advantage (using the reference unit costs chosen by the NRC staff) over no-recycle of the order of 1-2 percent of total power costs, a result which depends sensitively, however, on the choice of unit costs

-- delays of a few years in the initiation of reprocessing or plutonium recycle have negligible economic effects on the fuel cycle compared to the effect of not recycling.

The GESMO Report, which also examines health, safety, and environmental questions, indicates that differences between recycle and no-recycle in radiological effects and environmental considerations are not particularly significant.

Current hearings on these aspects will be followed, over the next eighteen months or so, by an exploration of the question of domestic security over plutonium; and by a separate statement on the international aspects.

I should add that no reprocessing can take place prior to an NRC decision on whether to permit widescale recycle because a court order has effectively stopped issuance of any kind of license for separation plants. Two reprocessing plants are involved at the moment: one (Barnwell) is partially complete, and the other (Exxon Nuclear) is still in the construction application stage.* Should reprocessing

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* Barnwell Nuclear Fuel Plant, a 1500 ton per year facility at Barnwell, South Carolina.

Exxon Nuclear Company, Oak Ridge, Tennessee, a somewhat larger proposed plant with spent fuel storage capacity of up to 7,000 tons.

There are two other reprocessing plants, but these will probably never be used for that purpose. The Nuclear Fuel Services plant at West Valley New York is now storing 170 tons of spent fuel; the GE Morris Facility in Illinois is licensed to store 750 tons.

eventually be found acceptable, these plants are most likely to perform the first commercial-scale separation in the U.S.

In the meantime, the October statement argues that deferral of reprocessing removes at least one worry from the energy list in assuring "that the necessary increase in our use of nuclear energy will be carried on with safety and without aggravating the danger of proliferation."

Just as in most of the advanced nations, nuclear power in the U.S. encounters its share of rough weather with public concern about health and safety and the environment. But a decided element of acceptance is emerging. It may be based on the perception that the technology of light water reactors is proven and the plants are acceptably safe, and on the fact that they are in place and yielding electric energy in regions of the country where it is most needed. It is now generally acknowledged that the chief sources of energy for the rest of this century will have to be coal and uranium; the basic requirements for nuclear power are an assured supply of fuel and enough storage -- at least on an interim basis -- for that fuel when its energy is spent.

There are 62 reactors operating in the United States now, and 71 under construction. There is adequate fuel for all of these and many more. And while the problem of spent fuel storage is now being felt, it is not a difficult one to solve. I shall come to this in a moment.

I spoke earlier of a crossroads. As we contemplate the long term future of nuclear energy, it is clear that once reprocessing is deferred, there are two directions we may take. One is to find acceptable ways to use plutonium so that it is not available for nuclear weapons use; this might involve technical or political schemes, or both. The other is to find technical nuclear alternatives to the use of plutonium in generating electricity; we have been working on this latter possibility, but it is too early to gauge the chances of success.

In the interim there is uranium; so long as this is available, we can afford to defer plutonium. It is all there, locked in the spent fuel, safe and easy to store. It is not going to go away.

SPENT FUEL STORAGE

We are not worried about short-term or even interim storage of spent fuel, because we see ways to manage it. Let me tell you how we are dealing with our own problem in light of the fact that reprocessing has clearly moved further away in time. Spent fuel storage is technically quite simple: it is nonetheless a matter that demands immediate attention. We are determined not to get into a situation where the pileup of fuel assemblies at power stations will force unwanted policy decisions.

The fact is that even before it was decided to defer reprocessing we were beginning to experience the pressures of inadequate storage for the output of some of the older light water reactors in the U.S. In the past, as you know, storage of spent fuel assemblies was never viewed as more than a temporary expedient. But unanticipated delays -- technical, environmental, political -- in plutonium utilization programs have begun to cause space problems in storage pools. For the past two years NRC has been evaluating and licensing expanded spent fuel storage at reactor sites and elsewhere.

The need to do this has led to the realization that the technical problems are not particularly difficult. The reactors currently in service and under construction were originally designed with pools large enough to store the spent fuel output of about one or two years operation plus a so-called "full core reserve," or the equivalent of perhaps five years in total. What has happened among the older plants is predictable. First, as the years have passed, the full core reserve has been encroached upon in some reactors. While this makes for some potential inconvenience, it is not particularly disturbing from a safety point of view. Nevertheless good housekeeping dictates the development of better technical solutions to the crowding problem. Fortunately we have discovered it is possible, in Boiling Water Reactors, to double, and in Pressurized Water Reactors to triple spent fuel storage in pools at the plants without violating existing safety standards for nuclear criticality margins.

Applications are being filed by an increasing number of power companies for permission to expand capacity in storage pools, either by replacement of existing storage racks with new designs more economical of space, or by adding more racks to existing pools. These requests are being processed and granted as quickly as the safety of the proposed additions can be established.

About half of the 62 operating reactors have applied for permission to expand storage capacity, of which 14 applications have been approved. At least thirteen operating units have less than a full core reserve capacity.

It has been shown that the spacing between PWR assemblies in spent fuel pools can be safely reduced so as to double the number of assemblies that can be stored in a given area. A three-fold expansion can be achieved by using neutron poisoning materials for racking PWR assemblies; such materials as stainless steel, and stainless steel or aluminum with added boron are suitable. This last method is used for construction of replacement racks in BWRs, since here the original spacing was as close as can be safely accepted.

Interestingly, the addition of racks and more fuel assemblies does not significantly strain the ability of an existing facility to meet the seismic requirements; the major load which affects the seismic capability of a storage pool is the weight of the water.

Replacing racks which have fuel already stored in them must be carried out underwater, since the fuel must be shielded and cooled at all times. All stored fuel is moved to racks on one side of the pool. The vacated racks are removed, and replaced with the new racks. The fuel is moved back to the new racks. The underwater work is normally accomplished using remote tools for cutting and handling, although divers can be used if necessary.

The overall adequacy of spent fuel storage over the next ten years is currently under study by our staff. This spring we will issue a draft environmental impact statement on handling, shipping, and storing the spent fuel output expected between now and 1985. There is no reason to think that once current storage is expanded to maximum safe capacity, it will not be entirely adequate.

There are sufficient imponderables in the future of reprocessing to suggest that contingency plans for continued interim storage after 1985 are in order. Two things are necessary if we are to be prepared for the possibility. First we must have confidence that it is safe to let spent fuel assemblies remain in storage for periods beyond the ten years or so for which we have had satisfactory experience. Expert opinion seems to be in general agreement that storage would be safe for longer periods, but further study is needed. Second, it will be necessary that substantial increments to storage capacity be made available if interim storage is to continue after 1985, by which time expansion of capacity of existing pools at reactor sites may have been pushed to the limit.

CONCLUSION

What does all this mean to the U.S. and Japan, both among the largest producers of nuclear energy in the world? I am, of course, aware of Japan's own concern in this matter and its relationship to the transfer of U.S.-supplied spent fuel for reprocessing abroad. We recently received a visit from some of your utility colleagues pleading the urgency for a clarification of U.S. policy because of the spent fuel storage situation at Japanese power plants. And of course beyond that, I know you are concerned that programs entailing large investments over a period of years, particularly for reprocessing, may be placed in jeopardy.

There are many similarities in our situations. There are important differences as well, and these have to do with our relative dependence on this new energy source. But we are both dealing with the consolidation and improvement of established technologies, and our immediate problems have to do with how to make nuclear power safer, more reliable and more economical, as well as with the problem of how to manage its radioactive wastes.

Getting electricity out of light water reactors is in itself useful and important; increasing dependence on this resource offers many advantages. A headlong pursuit of technologies which may if successful realize the dream of energy independence should not lead us to discount the energy security we enjoy right now. Nuclear power has always suffered from this future orientation. Now, however, the stakes are getting too high and the commitment goes too deep to allow research and development enthusiasts, for whom the present has little value or interest, and for whom security questions are remote, to make the basic decisions about the future applications of nuclear energy. In the United States we see the decision to proceed with reprocessing as critical, and suspect we are collectively not yet quite ready to cope with the consequences. We have decided it is wiser to keep our options open. We have concluded there is no great penalty attached to deferring our own widescale reprocessing and use of plutonium; we believe this is true for other countries as well.

The American public sees the essential dilemma as one of the highest philosophical significance, poised as it is between fear of nuclear war on the one hand and the tantalizing prospect of an almost unlimited energy resource and self-sufficiency on the other. Whatever choice is made in the end will require an awesome weighing of advantages and disadvantages.

We are acutely aware of how much the Japanese economy has riding on its investment in nuclear power. It is this awareness, combined with the importance of Japan to world stability, that provides a powerful incentive to our two nations to take the lead in restraint. There is no reason why we should not consider joining together in some scheme aimed at developing a model for technological and political solutions to the problems of nuclear proliferation and safe utilization of nuclear power. Such a collaboration is possible if we keep our options open; once the commitment to widescale reprocessing is made any chance for serious investigation of new ideas or alternate technologies,will have been prejudiced, along with any realistic possibility of foreclosing the nuclear weapons option among many of our neighbors.

Conference by M. TEILLAC

テヤック博士 本論文

(J A I F, Tokyo, March 1977)

3/9 開会セッション

France's Nuclear Power Policy

1 - France's energy requirements and the need to use nuclear energy

The main motivations behind France's nuclear power policy are its energy requirements compared with its resources.

Our country, like Japan, is poor in fossil fuel resources. It has little coal and, unless off-shore resources are found, practically no petroleum. Its hydroelectric power has practically all been harnessed. Its remarkable development during the past 20 years was based on the use of imported petroleum. However, the 1973 crisis emphasized dramatically the political and economic limits of these imports.

On the other hand, France has substantial uranium reserves in its soil. From the outset, it was quite aware of the adequation of nuclear techniques to its general situation as a highly developed intermediate power : advanced technologies resulting from its high scientific and industrial level, existence of national uranium resources, small tonnages involved for storage as well as for wastes, and so forth. France thus initiated extensive research, development and industrialization efforts which are now beginning to bear fruit.

Figure 1 shows the trends in total French power consumption from 1956 to 1975, and the corresponding share between the primary energy sources. This shows an accelerated rise in petroleum imports until 1973, reaching over 60 percent in 1973, with total imports of approximately 70 percent. The slight improvement between 1973 and 1975 is due essentially to the reduction in consumption due partly to the economic crisis and partly to energy savings.

.../...

In 1976, consumption was 165M TOE and the French Plan authorities set the 1985 forecasts at 232M TOE plus an economic variation allowance of 30M TOE, representing a multiplication factor of the order of 1,5 from 1976 to 1985. The forecast growth is less rapid than during the preceding decades. It is nevertheless steady. Without resorting to nuclear power, it would lead to a correspon-ding increase in imports, with all their political and economic implications.

Thus, as regards France, and unlike neighbouring countries such as Germany and England which both have vast coal reserves (and off-shore petrolem reserves in the case of England), the use of nuclear power is an absolute necessity.

The projected breakdown between the various sources of energy is given in figure 2.

The main economic factors are the effect on the trade balance of imports paid in foreign currency, and the cost of the kWh. It was toward 1970 that the cost of the kWh of nuclear origin became competitive with that of the kWh of conventional origin and, at that time, short, medium and long-term prospects combined to support the present nuclear programme. Following events in the Middle East, the ratio of prices dropped until 1974, reaching practically 1/2. It then rose again to about 2/3 in 1976. Figure 3 shows this evo-lution. The reasons for this are the greater incidence of the eco-nomic crisis on advanced techniques, the strengthened safety re-quirements, and the taking into account of some marginal expendi-tures hitherto neglected. These prices may be expected from now on to follow roughly parallel tracks. The fact that uranium accounts for only 15 percent of the cost of the nuclear kWh, while fossil fuels account for 65 percent of the cost of the conventional kWh, makes the former much less sensitive to variations in the cost of raw matrials.

I think it is necessary to emphasize this point : it is not only because it is a solution for the future, nor because it allows a currency saving, but because it is less costly, that nuclear power is called for.And, incidentally, allowing for all local factors, I believe that this should be an important consideration when contemplating the use of nuclear power in developing countries.

II - French nuclear reactor programme

The present quantitative programme is based upon pressurized light-water reactors built by the company Framatome for the French Electricity Board. Since 1974, all new steam generation investments initiated by the Electricity Board have been for nuclear plants. This principle is not affected by the few downward revision which were made in 1975 and 1976 with respect to 1974 forecasts; these are only the result of downward trends (which may be reversed) in the evaluation of power requirements for 1985 and, in no case, involve the replacement of a nuclear power plant project by a conventional one.

Figure 4 shows the achievements already made and the present programme.

There was much discussion about the change-over, decided upon in 1970, from the natural-uranium, graphite-moderated, gas-cooled technique initiated in the 1950s, to the enriched-uranium, light-water technique. In fact, the discussion is a mute one. France was right to initiate the first technique. At that time, it could not do otherwise. It was the source of France's military power and of its capability in nuclear-power technology. Moreover, these plants were quite successful from the technical viewpoint. However, France was also right, even beyond technical and economic motivations, to switch to the second technique widely used today and with which it was fully familiar as a result of the experience acquired by the French Atomic Energy Commission in the field of naval propulsion reactors using the same principles.

In the longer term, France is very sensitive to pressures which will not fail to appear by the end of the century on the natural-uranium market because of the limited world reserves. In fact, while its national reserves place it in a position rather comfortable as compared to its petroleum dependency, they nevertheless do not give it self-sufficiency. It thus attaches great importance to the development of fast-neutron breeder reactors which make it possible to enhance by a factor of about 50 the energy potential of uranium, and so to delay beyond reasonable human forecasts the threat of uranium shortage. A very consistent policy has been conducted with respect to the development of this type of reactor :

- The Rapsodie 25 MW experimental reactor, subsequently upgraded to 40 MW, reached criticality in 1967. It made it possible to test the basic techniques. It is still in operation and constitutes a precious test bench for fuels and materials.

- The Phenix 250 MWe demonstration reactor, connected to the power network, reached criticality in 1973 and full power early in 1974. Its average load factor during two years of operation was 69 percent, which is remarkable for an installation of this type.

It was shut down in October 1976 following a failure in its primary heat exchangers. This failure does not in any way call into question the principles of the reactor. Quite the contrary, it allowed to test the possibility of maintenance operations on equipment immersed in the reactor vessel. These operations went off very smoothly. It is expected to go back to power soon.

- Finally, the SuperPhenix 1200 MWe industrial prototype was ordered at the end of 1976 by the company NERSA which will be operating it and which I shall speak of later on. Plant commissioning is scheduled for 1982.

SuperPhenix will usher in a serie of industrial reactors which should develop in the 1980's.

.../...

Toward the year 2000, breeder-based power could be of the order of 20 to 30 percent of the total installed electric power, itself essentially of nuclear origin. This will entail much less definite forecasts than those which guided our programmes until 1985. Figure 5 shows a likely rate of breeder reactor introduction in France. Figure 6 indicates, over a longer period, the annual and cumulated consumption of natural uranium in the extreme hypothesis, very academical indeed, where the breeders' introduction rate is limited only by plutonium production by thermal reactors and breeders themselves. Cumulated consumption begins to saturate around the year 2020. The operation of a slow-neutron plant involves the discharge from enrichment plants of a sufficient amount of depleted uranium every year to allow the operation of a breeder of the same power for over 50 years ; the reserves accumulated in this form will then be enormous. In fact, from the outset, breeder reactors are not affected by the problem of natural uranium.

We are also interested in the use of nuclear power for applications other than electricity, and also in other types of reactors.

The use of nuclear heat in industry or for residential heating can represent a very important source of fossil fuel economy. This heat can be produced by the electric power reactors themselves but also by smaller, specialized reactors adapted to market conditions.

We are developing two reactors of this type, one derived from naval propulsion reactors and capable of furnishing heat within the range from 200 to 300°C, the other derived from experimental reactors of the swimming-pool type capable of furnishing heat within the 100 to 120°C temperature range.

Naval propulsion is also one of our goals. We have developed a reactor suitable for ship propulsion in general : the CAP (chaudière avancée prototype), derived from the reactor developed for nuclear submarines. This reactor is the forerunner of the serie CAS (chaudière avancée de série). May I quote the licence agreement with IHI in that field.

This reactor moreover has a universal application within the medium power range from 300 to 1000 MWth and it is the one I mentioned earlier in speaking about heat generating reactors.

At last, France is also interested in high-temperature reactors which are the only ones capable of furnishing heat at the high temperatures necessary for certain industrial applications. A few years ago an agreement was signed for their design and development between the CEA and General Atomic in the United States. In spite of the problems encountered with this type of reactor , studies are being pursued.

All of this has called for the set-up of an industrial structure in which the main guidelines are :

- Concentration of industrial resources on a small number of companies capable to stand on the national as well as the international level.

- Coordination of the action of these companies within the national nuclear policy by the CEA holding shares in their capital.

Figure 7 outlines this organization.

For the large enriched-uranium, light-water reactors, the builder is the company Framatome which makes these reactors under Westinghouse (United States) license. It would have been incongruous that French experience, acquired with this type of power plant through the naval propulsion reactor, should not lead to national applications while a French industrial group built the same type of reactor under license. The question was solved by CEA taking a share in Framatome. Moreover, a quadripartite research and development agreement was signed by EDF, Framatome, Westinghouse and CEA. Upon its expiry in 1982, the license will be transformed into and association agreement, as both partners will have reached an equivalent level in knowledge and experience.

In the breeder field, in France we are quite familiar with the difficulty of the transition from technical successes such as Rapsodie and Phenix to industrial and commercial operations within the context of world competition. Thus, the development of Superphenix was extented to the European level and the company ordering it, NERSA, associates EDF with Italian and German electric power utility firms. Its construction was entrusted to the company Novatome, the counterpart of Framatome for advanced reactors, in which CEA holds a substantial share.

As for the following reactors, a close cooperation has been set up between France and Germany for research and development as well as for industrialisation. As a matter of fact, it is a joint system society which will deal with the other countries.

Research agreements on breeder reactors, in particular as concerns their safety, have also been signed with the United States.

Novatome is moreover in charge of high-temperature reactors.

Finally, it is the company Technicatome, in which CEA has a 90-percent interest and EDF a 10-percent interest, which is in charge of the design of small- and medium-power reactors. Those will be built and commercialised by the Alsthom-Atlantique industrial group.

III - Fuel cycle

Present French policy regarding the fuel cycle has, for its part, been dominated by three main criteria :

- Being present at all stages of the fuel cycle and, to achieve this, refusing anay de facto monopoly.

- Making the most of the efforts expended in the past both as regards graphite-gas fuels as well as the set-up of the Pierrelatte enrichment plant.

- Associate, within the fuel-cycle industry, some private interests, national or foreign, willing to cooperate to the CEA group placed under state control.

Considering the interactions between the different stages of the fuel cycle, it was found necessary for them to be grouped within one organization. To allow flexible adaptation to changes in the international market, this organization should have a private-law status. Accordingly, in 1976, the CEA created,with its own personnel resources and installations formerly assigned to the fuel cycle, a private-law subsidiary, the Compagnie Générale des Matières Nucléaires (COGEMA) in which it holds all the capital.

As regards natural uranium, our position is good. We are pursuing our prospecting in France and in French-speaking Africa but also in Indonesia, Australia, Canada and even in the United States. In the field of production, the goal is to increase the output from existing mines and to open new ones. Private industry is taking part in this effort, to the extent of about 10 percent, and I would like to mention here the Japanese holding in the company Cominak which operates the Akouta mines in Nigeria, and the joint venture in prospecting the Afasto West area.

In a fairly tight future world market, COGEMA has set the goal of being able to cover by 1985 at least the strict requirements of the national programme. The contribution of private producers should thus keep us in an exporting position.

Uranium enrichment will be carried out in Europe by the Tricastin plant whose production will begin in 1979. This plant is built by Eurodif whose capital is shared between France, Italy, Belgium and Spain, as well as Iran through the French-Iranian company Sofidif.

Its capacity of 10,7 millions SWU per year will allow it to supply about 80 power plants of 1 000 MWe. Its production will be distributed mainly among the Eurodif share-holders, but a sizeable part will be commercialized in other countries. In particular, Japanese utilities have signed contracts amounting to about 1 million of SWU per year.

.../...

Eurodif capacity is now fully booked up to 1990. Long before will Electricité de France requirements have outgrown the French share of Eurodif separative work, as shown on Figure 8.

We have then decided, together with the same partners grouped inside a new company named Coredif, to launch a second plant which should begin production around 1983.

The capacities of this new plant are not yet fully covered by contracts, but the rythm of orders makes one think that they will be so rather soon.

Finally, reprocessing is the third essential element of the fuel cycle. Although there is some discussion at the present time as to this matter, we think it is necessary to reprocess, for economic an safety reasons. It is obviously a necessity for breeder reactors but, even outside of this indisputable case, we do not feel that it is reasonable to consider storing wastes from the plants under such a complex form as are irradiated fuel elements.

We are converting the La Hague plant, initially designed to process fuels from graphite-gaz reactors, for the processing of water- reactor fuels.

The first run on light water fuel elements began on mid-1976. It was normally carried out. Taking into account our lengthy previous experience in reprocessing metallic fuels, while keeping very careful during this first stage, we are confident for the future.

The plant capacity will be raised to 800 tonnes/year around 1980 and then increased as shown on figure 9. The expected growth in capacity remains higher than national requirements, so that the margin allows us to reprocess to order for foreign clients, among which Japan would be in a good position.

We have also processed in an experimental form fast-neutron reactor fuels irradiated to a level of 100,000 Mwj/t. The industrial processing installations are under study.

I think I should stress the controversial question of effluents wastes.

In fact, effluents are presently quite limited and this is becoming increasingly recognized even by the opponents to nuclear energy. This situation should not be allowed to deteriorate as a result of the multiplication of nuclear power plants. Essentially, what will be involved is stopping the gaseous products of average life, which are presently discharged without danger to the environment. Solutions are being developped and will be ready fully in time.

Similarly, for the storage of radioactive waste, present means are satisfactory in the short and medium term and may be scaled up as required by new needs.

The long lived products storage has for long years been the subject of extensive studies, which take place within a very active international collaboration. Actually we already master long term conditioning techniques which we think good, for instance the vitrification process. It allows for the first time to implement on industrial level the I A E A recommandation to solidify wastes.

We think necessary to let emerge, during the coming years, the very long term solutions which will meet a general consensus.

The french policy is then, on a general ground :

- to store with present techniques but always in a reversible manner so as to be able to reclaim the products when a final technique is adopted ;
- to pursue, in liaison with international organizations, the studies for defining these techniques.

IV - Research and development

All this industrial activity has to be backed by a research and development policy ranging from the technical support of installations to the preparation of future evolutions.

These studies are part of the mission of the CEA. It carries them out with its own means but also, to the extent possible, in association with industry or with foreign partners.

Figure 10 reckons the research/development activities of CEA in 1977 in the fields of reactors, fuel cycle and safety.

I shall mention but a few of these activities.

For light water reactors, I already indicated earlier the four-party agreement we have signed. The studies are aimed at further improving the reliability of components and, finally, the availability and profitabily of installations. They are carried out in the area of fuel performance, stresses, vibrations, double-phase liquid flow, checking of vessels and primary circuits, etc...

For fast-neutron reactors, similar studies are conducted on fuels, materials and structures but also on the main characteristics of these reactors, doubling time, plutonium cycle, which, in time, will be decisive elements for the introduction of this type of reactor.

Considerable attention is given to safety and to environment studies. Let me mention the work relative to the loss of coolant accident in light water reactors, and that on core melting accident in breeders. A high standard of safety is indispensable for the development of nuclear power. Any human activity calls for a certain level of risk and there is no totally harmless source of energy. But precisely, the development of nuclear techniques has been accompanied by unprecedented efforts in the field of their safety. It is necessary to continue these efforts which are already contributing spinoffs in other technical areas.

As regards the future, I should not like to overlook the efforts we are making in the field of controlled fusion. This is being done within the framework of Euratom. The Fontenay-aux-Roses Centre has a Tokomak of international class and France is participating in the European project JET (Joint European Torus) which is presently under discussion.

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Based upon a high-quality technique, which is the outgrowth of persevering work carried out for 30 years, French policy is thus aimed at making full use of the exceptional opportunities offered by nuclear power, from the energy standpoint as well as the industrial standpoint, by ensuring the development of this new form of energy under the best conditions of safety and efficiency.

An objective mind cannot help but be astronished by the harsh criticism under which this technique with indisputsable qualities has fallen, precisely at a moment when needs appear that it is capable of satisfying. In fact, an analysis of this opposition appears to show that it exploits the diffuse concern of modern man in the face of industrial development itself, which he feels cannot be indefinitely pursued. We should bear this concern in mind but must state clearly that the opposition is confusing its target when it aims at a technique having one of the lowest detrimental levels. In fact, if one takes a look at the difference between the regulatory limits of doses and the first medical effects, or at the probability of accidents with respect to their seriousness, nuclear energy is one or two orders of magnitude safer than most other techniques.

On the other hand, on the world level, this development raises the problem of non-proliferation.

I should simply like to point out, in this area, the principles of French policy as defined by the High Counsel on Foreign Nuclear Policy (Conseil Supérieur de Politique Nucléaire Extérieure).

1 - For certain countries, nuclear energy represents a competitive source of energy necessary for their development. France is thus ready to countribute to the implementation of its peaceful applications.

2 - France intends to retain control of its nuclear export policy, in compliance with its international commitments in this respect.

3 - France will not favour the proliferation of nuclear weapons. In its nuclear export policy, it will strengthen the arrangements and appropriate guarantees with regard to equipment, materials and technologies.

4 - France will ensure the dependability of nuclear fuel supplies

for power stations it furnishes and will comply with the legitimate needs for the acquisition of technology. It will also provide the fuel-cycle services requested of it. It is ready to examine, with interested parties, any bilateral or multilateral agreements capable of guaranteeing these results.

5 -The French goverment considers it indispensable that all suppliers of nuclear equipment, materials or technologies should avoid promoting the proliferation of nuclear weapons by commercial competition

6 -It is ready to discuss these problems, with supplying countries as well as with non-supplying countries engaged in substantial nuclear power programmes.

3/9 開会セッション ②'
テヤック氏論文 図表

PRIMARY ENERGY CONSUMPTION IN FRANCE

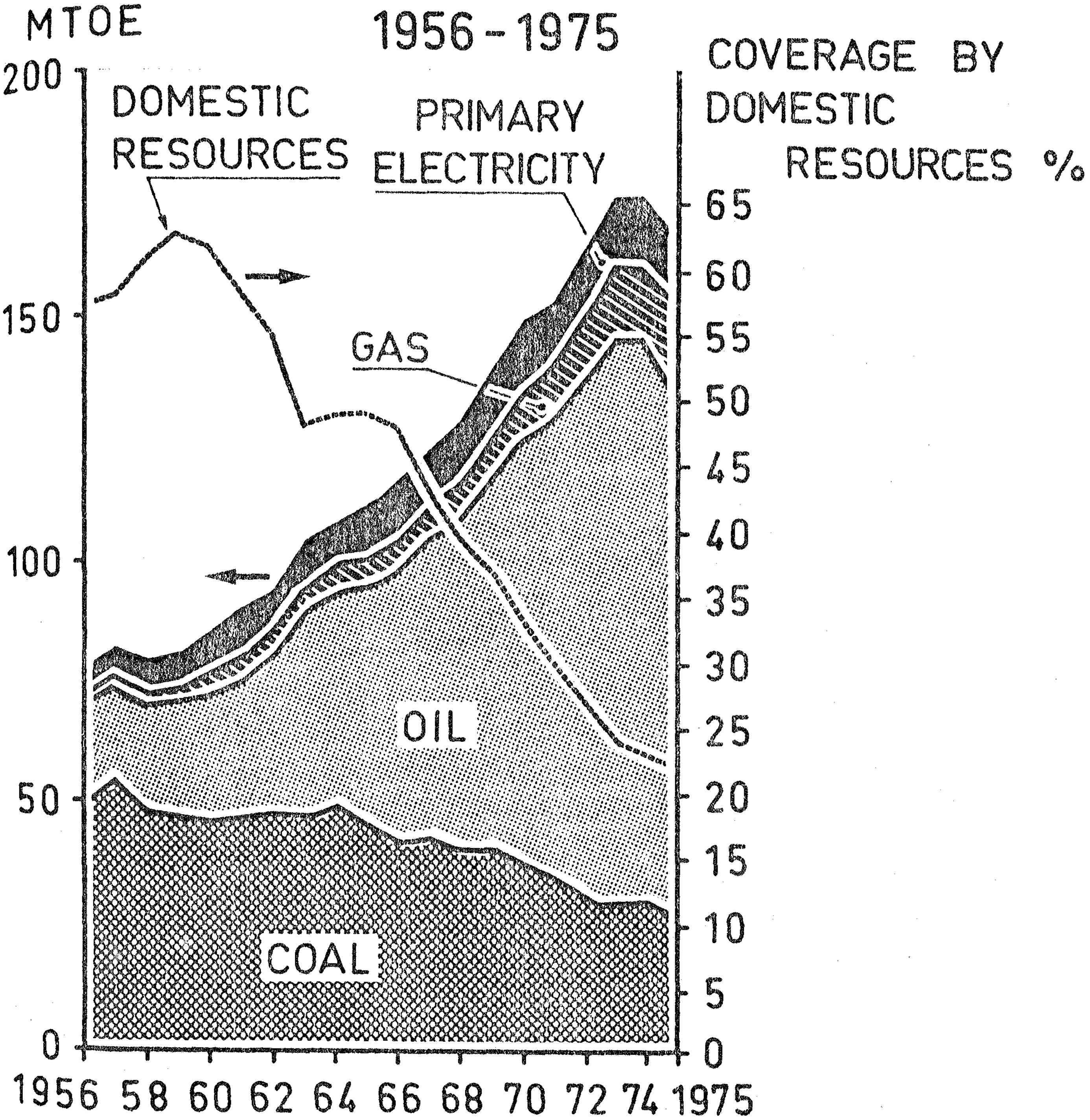


FIG. 1

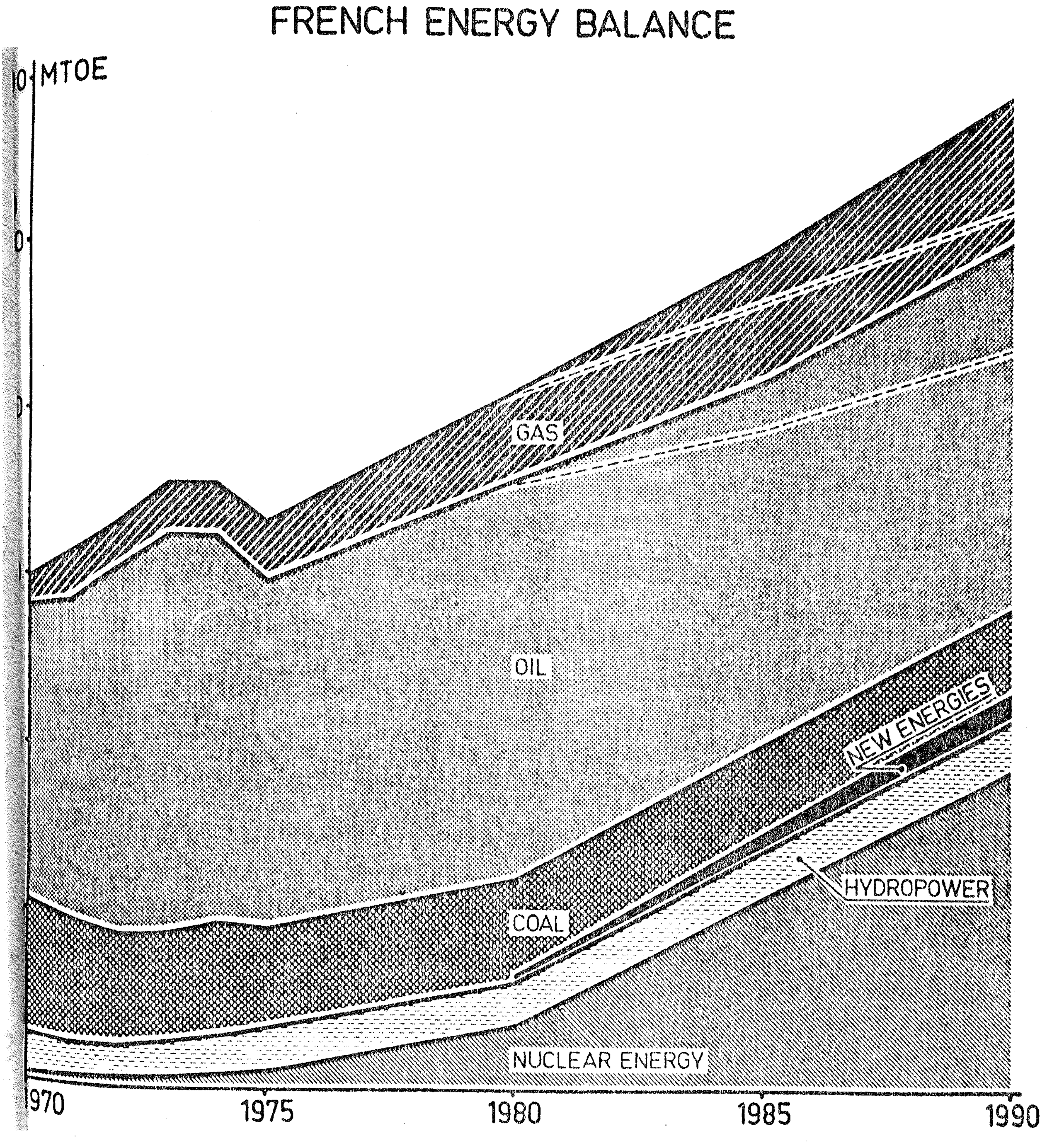

FRENCH ENERGY BALANCE
MTOE
GAS
OIL
NEW ENERGIES
HYDROPOWER
COAL
NUCLEAR ENERGY
1970
1975
1980
1985
1990

FIG. 2

EVOLUTION OF COST PER kWh

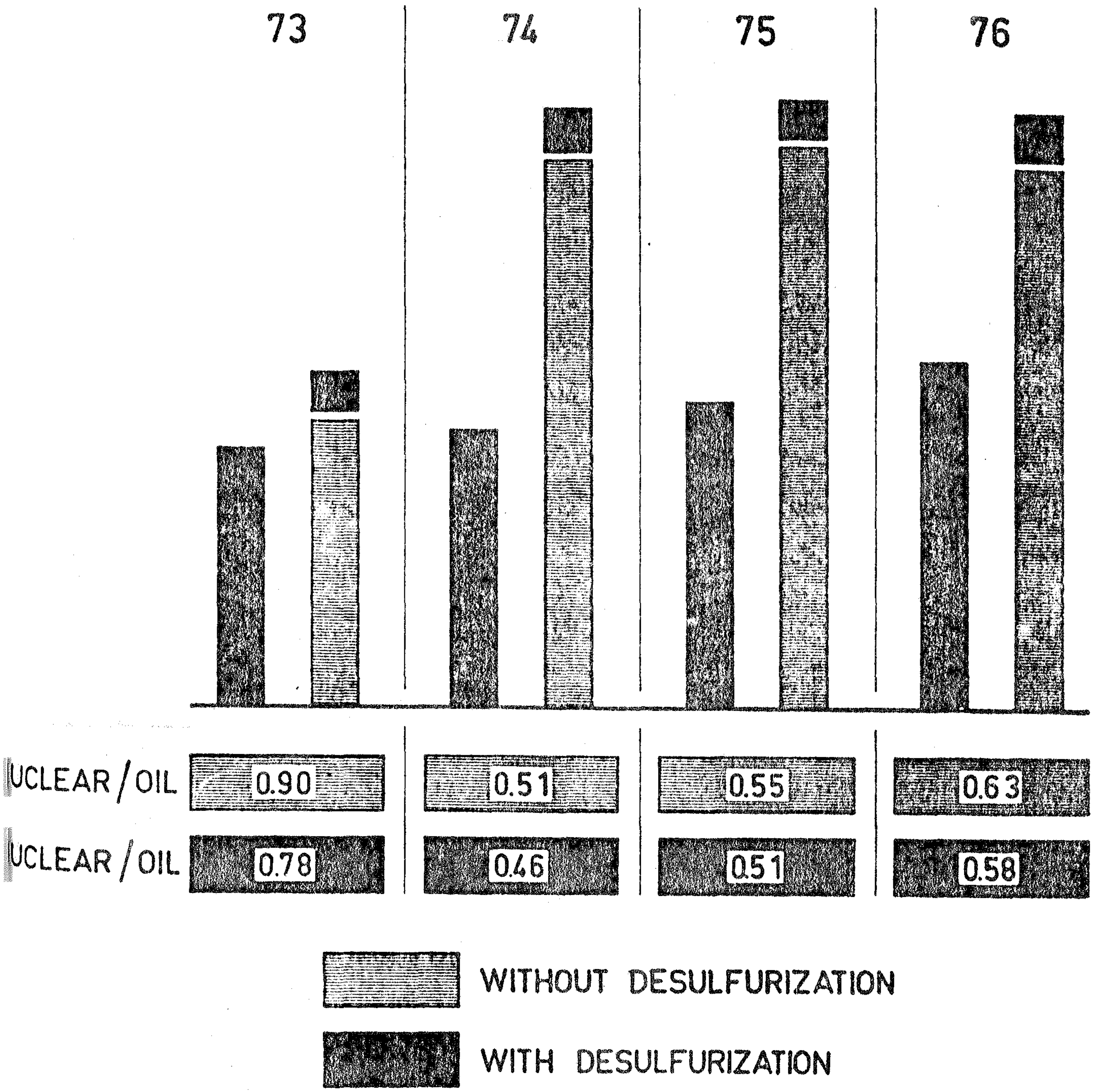


FIG. 3

FRENCH NUCLEAR POWER PLANTS (MWe)

in Operation	Graphite Gas	2 305
	HWR	70
	PWR°	585
	FBR	250
	subTotal 1.1.77	3 210
in Construction	PWR	25 925
	FBR+	580
Additional Plants in operation in 1985	PWR	17 015
	FBR	1 800
TOTAL 1985		~48 000

o FRENCH SHARE IN CHOOZ & TIHANGE
+ FRENCH SHARE IN SUPERPHENIX

FIG. 4

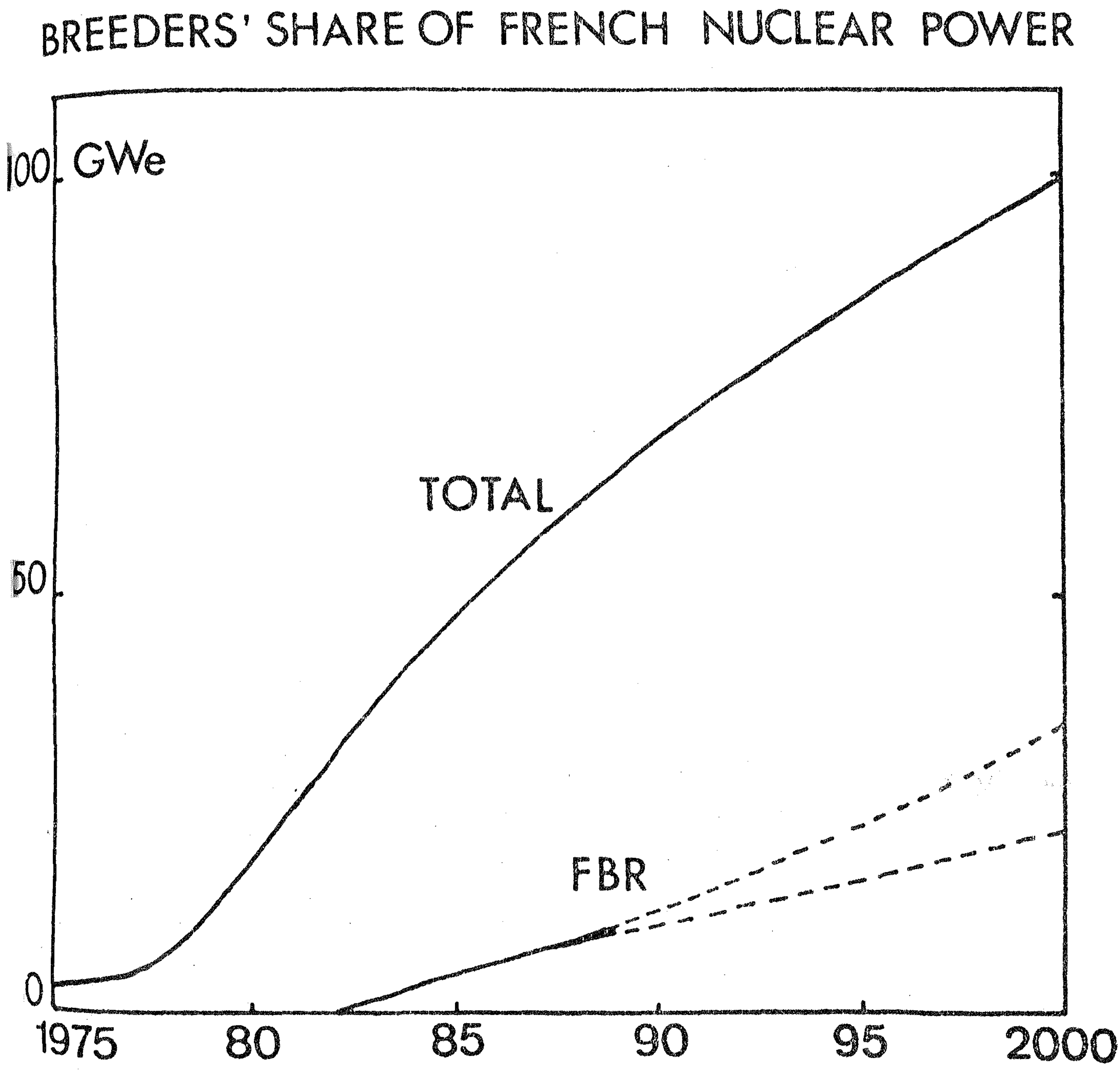

BREEDERS' SHARE OF FRENCH NUCLEAR POWER
100
GWe
50
0
TOTAL
FBR
1975
80
85
90
95
2000

FIG. 5

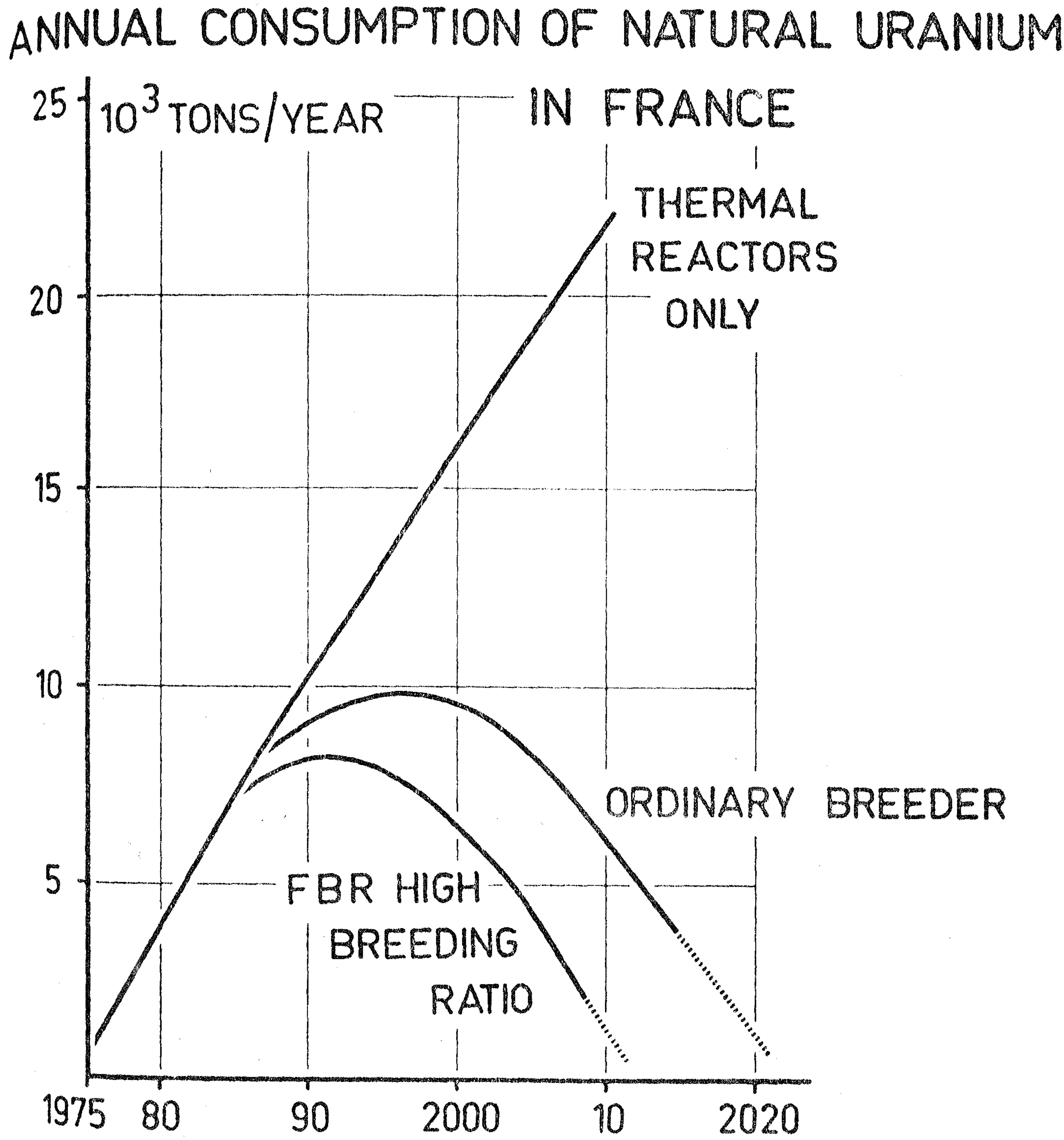

ANNUAL CONSUMPTION OF NATURAL URANIUM
IN FRANCE
10³ TONS/YEAR
25
20
15
10
5
THERMAL
REACTORS
ONLY
ORDINARY BREEDER
FBR HIGH
BREEDING
RATIO
1975
80
90
2000
10
2020

FIG. 6

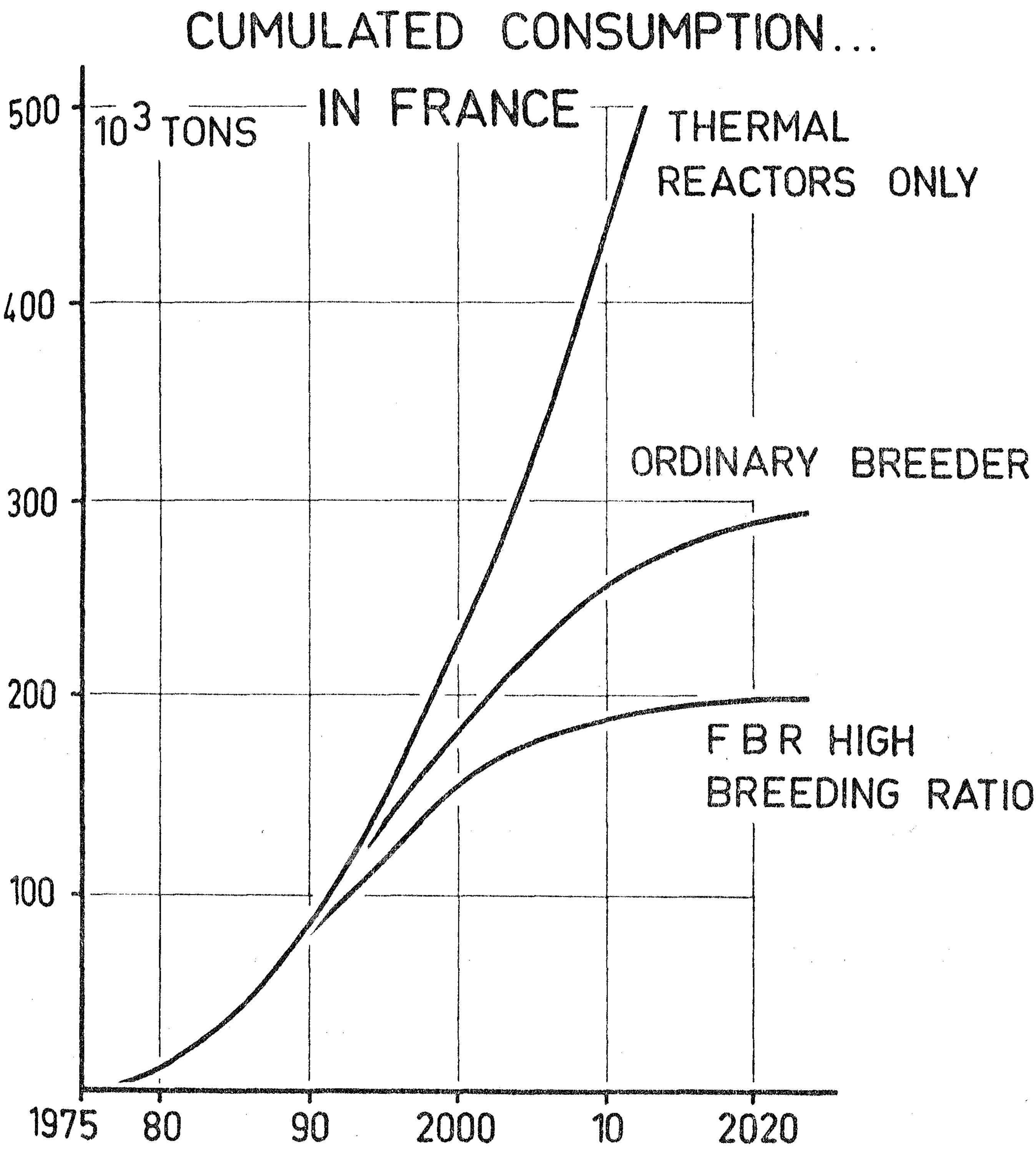
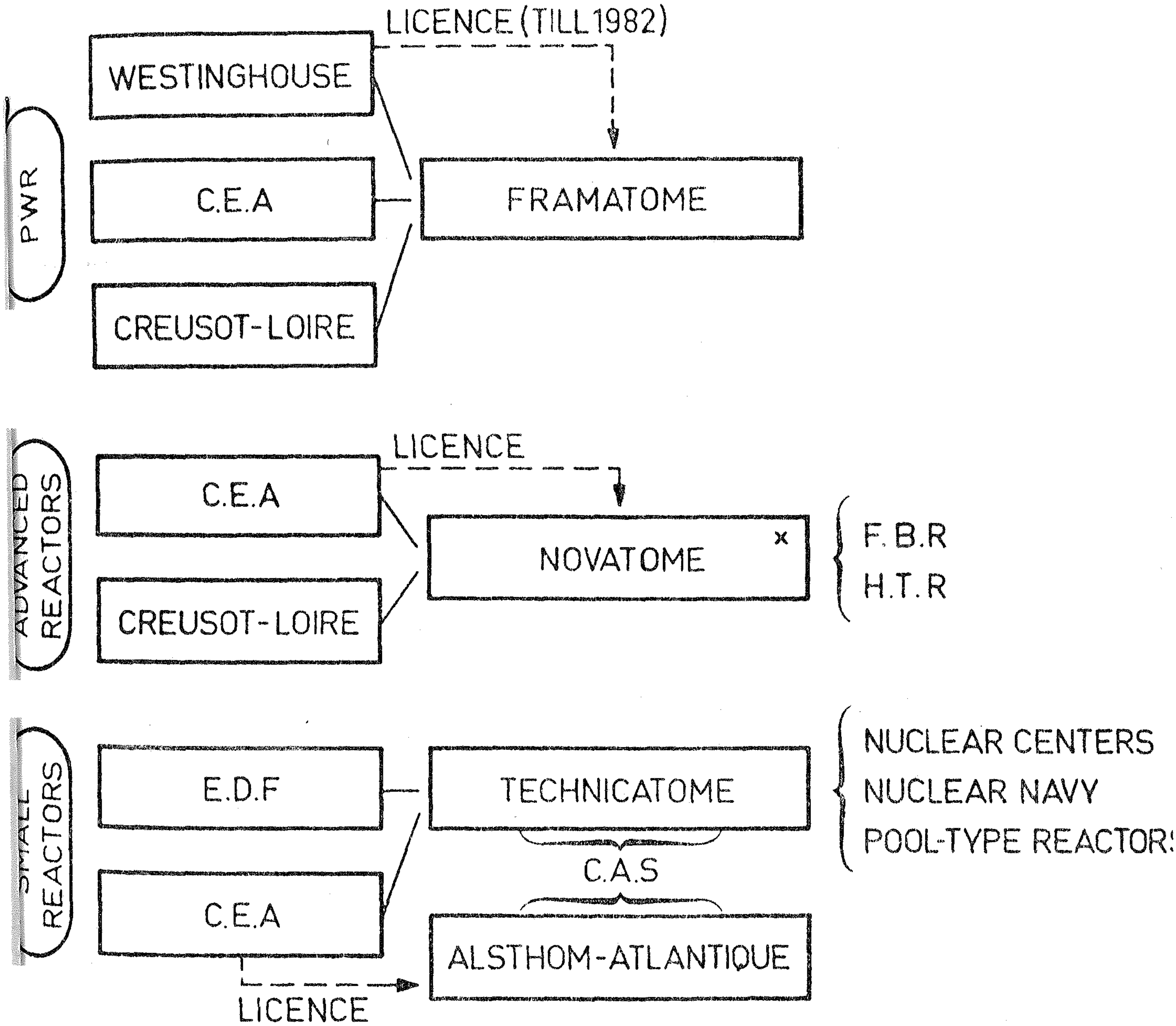

CUMULATED CONSUMPTION...
IN FRANCE
10^3 TONS
500
400
300
200
100
1975
80
90
2000
10
2020
THERMAL
REACTORS ONLY
ORDINARY BREEDER
F B R HIGH
BREEDING RATIO

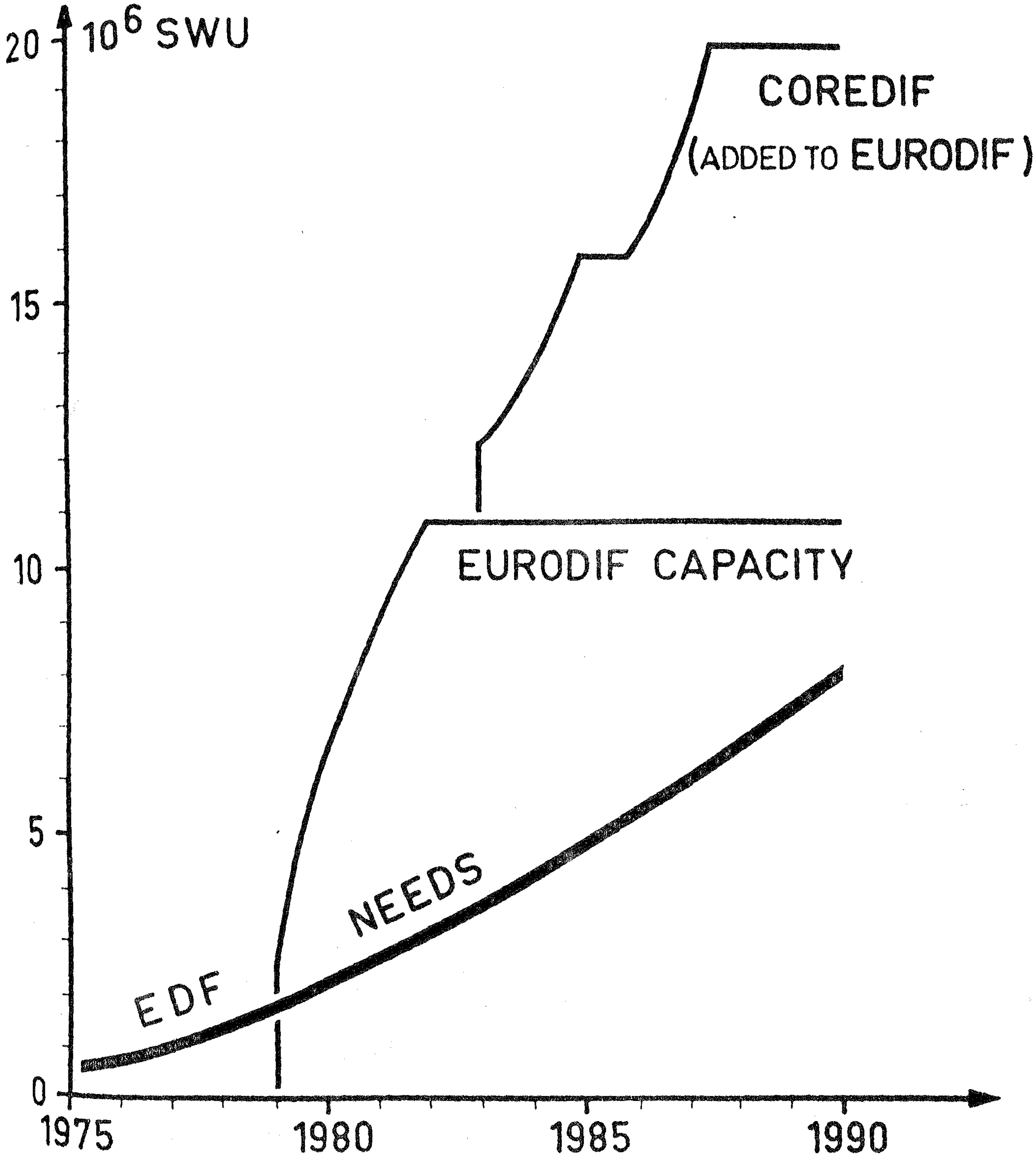
FIG. 6 bis

NUCLEAR REACTORS ENGINEERING IN FRANCE (NSSS ONLY)



× ALSTHOM ATLANTIQUE IS SLATED TO ENTER NOVATOME LATER ON.

FIG. 7



10^6 SWU
20
15
10
5
0
COREDIF
(ADDED TO EURODIF)
EURODIF CAPACITY
EDF
NEEDS
1975
1980
1985
1990

FIG. 8

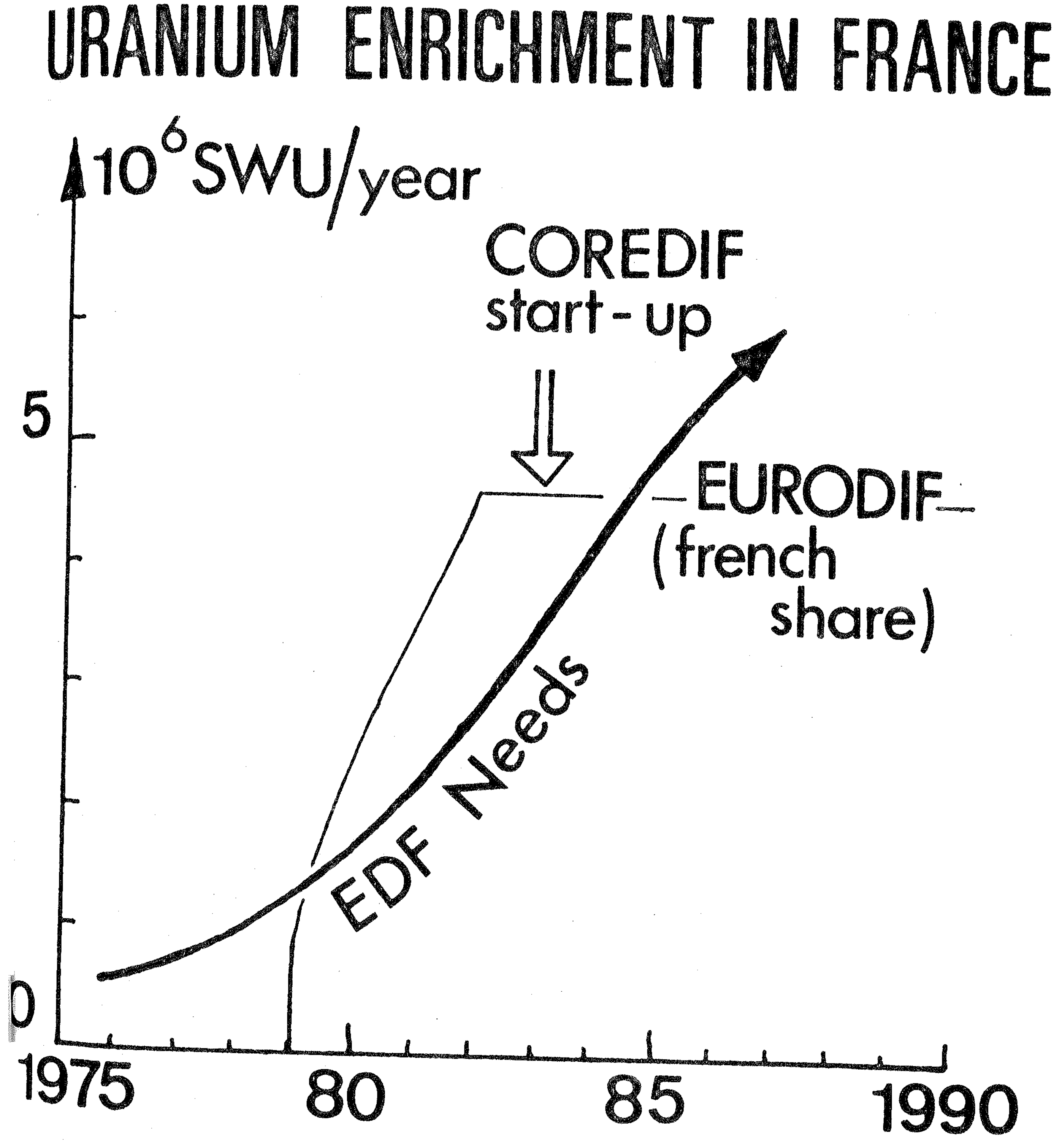
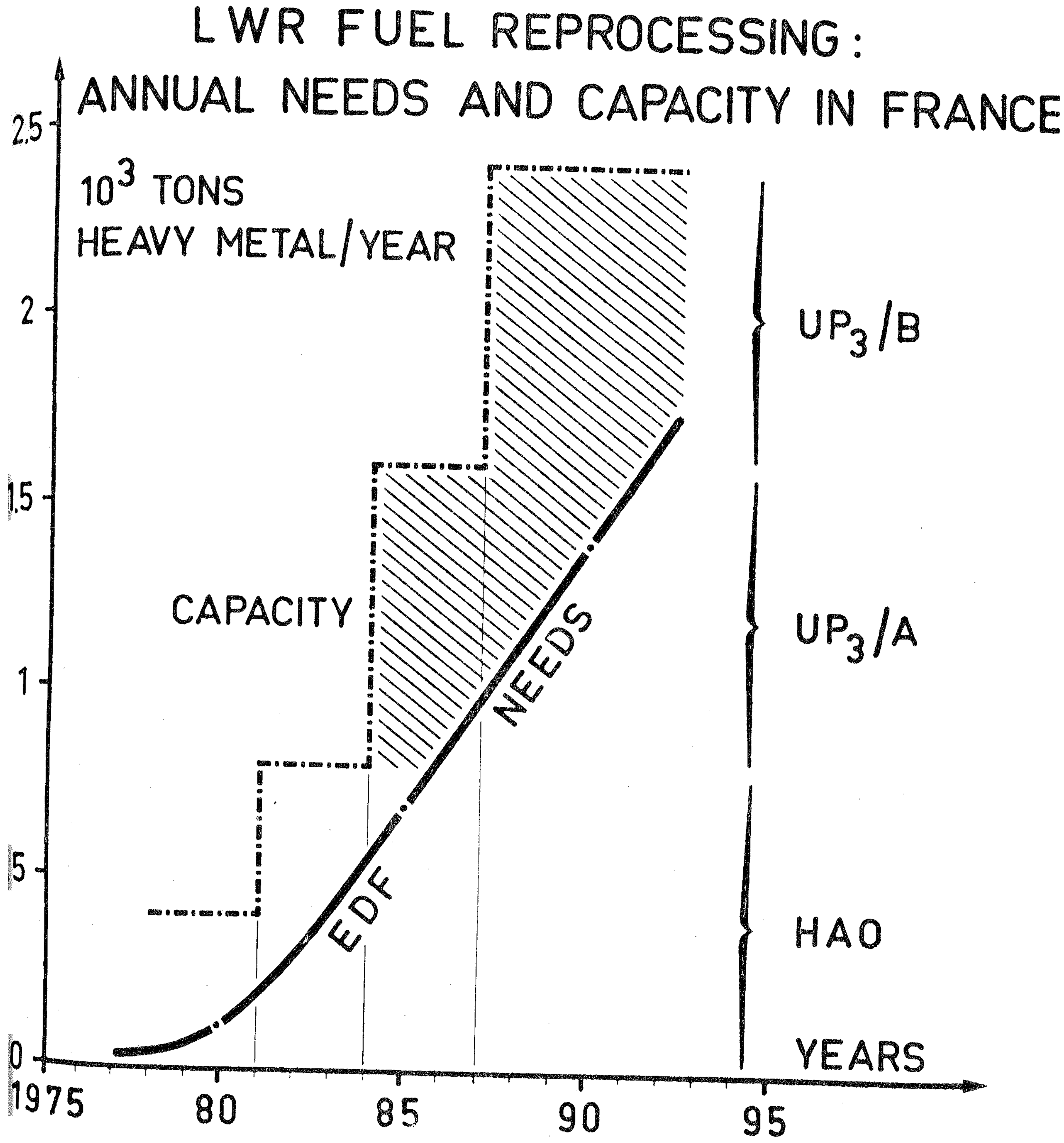

URANIUM ENRICHMENT IN FRANCE
10⁶SWU/year
COREDIF
start-up
EURODIF
(french
share)
EDF Needs
5
0
1975
80
85
1990

FIG. 8



LWR FUEL REPROCESSING:
ANNUAL NEEDS AND CAPACITY IN FRANCE
10^3 TONS
HEAVY METAL/YEAR
2,5
2
1,5
1
,5
0
CAPACITY
NEEDS
EDF
UP_3/B
UP_3/A
HAO
YEARS
1975
80
85
90
95

FIG. 9

CEA'S R&D BUDGET FOR 1977

in millions french francs (MF)

TOTAL	2 710
Reactors	890
Fuel Cycle	380
Safety	340

(5 MF ≈ $\$ 10^6$)

FIG. 10

③-1

E N E L

ENTE NAZIONALE PER L'ENERGIA ELETTRICA

第1セッション 3/10 午後
スペーリ本論文

JAPAN ATOMIC INDUSTRIAL FORUM

1977 Annual Conference

THE ITALIAN ENERGY SITUATION AND THE ROLE OF NUCLEAR POWER

by Dr. G. Speri

Manager, Plant Construction Division, ENEL

Tokyo, 9 March 1977

③

THE ITALIAN ENERGY SITUATION AND THE ROLE OF NUCLEAR POWER

Giorgio Speri

Mr. Chairman Ladies & Gentleman

1. Electric Power Generation in Italy.

1.1 Present state and prospective developments

Even though the rate of the electricity demand growth in Italy has slackened a little in these past years, the peak power demand, that is, the "maximum load" has continued to go up, as can be seen in Fig. 1 This slide. This trend is very important from the standpoint of planning new plants, because the power demand determines the size of the generating plant --and of the transmission, transformation and distribution facilities-- and thus the investment required. However, in the very long term, the increase in electricity consumption will tend to an asymptote, as it is inconceivable that the exponential trend with a growth rate of about a doubling every ten years will continue indefinitely.

In this connection, a distinction should be made among the various countries on the basis of the per-capita electricity consumption; for instance, the consumption in Italy is low as compared to other European countries. In fact, in 1974 the per-capita consumption was 4,500 kWh in Germany, 4,205 kWh in England, 3,854 kWh in Belgium, 3,199 kWh in France, and only 2,375 kWh in Italy broken down as follows: 3,036 in Northern Italy, 1,930 in Central Italy and 1,509 in Southern Italy. The difference would be even greater when compared to countries outside the European Community.

From the standpoints of predicting the electricity requirements and of planning new stations, since ENEL applies the "annualy sliding plan" principle, any excess in generating capacity would be temporary and its cost would be contained within reasonable limits. It is much more difficult to assess the cost of an inadequate supply of electricity. Furthermore, the power generation development programs for the coming years are based essentially on nuclear plants, and by meeting the demand with the largest possible recourse to nuclear generation it would be possible to alleviate the balance of payments. At present, the cost per kWh of fuel oil is over 20 mills (18 lire) versus 5 mills (4.50 lire) of nuclear fuel, which means that for every 1000-MWe unit in the network today the disbursement of foreign currency would be reduced by some 100 million dollars ~~(nearly 80 billion lire)~~ a year. Even if the cost of nuclear fuel should increase, there is ample margin for nuclear power to be at an advantage over thermal power.

I shall now illustrate the sources currently used in Italy for power generation and the related prospects of development based on the trends of these past years (Fig. 2).

slide

1.

The most abundant energy source in Italy in the past was the water resource. Up to twenty-five years ago nearly all the country's energy requirements were covered by this source. Today, it hardly meets 30% of the demand, and new sites that are acceptable from the technical, economic and environmental standpoints are practically nil. Regardless of economic considerations, the residual "natural" production potential is on the order of 10 billion kWh a year. This is but a small percentage of the energy requirement, which reached 160 billion kWh in 1976, but it corresponds to over 2.3 million tons of fuel oil or about 200 million US dollars a year at the present prices (1), and this is not a negligible amount from the standpoint of the balance of payments.

The activities in our country in the area of hydro plant construction are directed mainly towards pumped-storage stations. Because of its size and characteristics, this type of station has played and will continue to play an increasingly important role for the so-called "modulation of the load diagram".

To cover the peaks in the load diagram, recourse is also had to gas turbine units, which I shall speak of later on.

The purpose of pumped-storage stations is to transfer surplus supplies of thermal, and especially nuclear, energy from low-load periods (nights and holidays) to peak-load periods. This function is clearly illustrated in the diagram in Fig. 3, which relates to the winter peak in 1975.

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next slide (4)

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It is worth while pointing out the pre-eminence of the existing or scheduled Italian pumped-storage stations in the European Community and in the world. Of these, I shall mention the Roncovalgrande station with a capacity of nearly one million kilowatts ~~(Fig. 4)~~, the Upper Gesso station ~~(Fig. 5)~~ for which use was made of a tunnelling machine with a 3-m-dia. cutter ~~(Fig. 6)~~, and the Brasimone station ~~(Fig. 7)~~ which uses 150-MW monostage reversible units.

~~1.3 Geothermal energy~~

Another national source of primary energy, to which ENEL has always given special attention, is the geothermal resource. Our Country is in the vanguard as regards prospection and utilization of hot steam wells; it will suffice to say that ENEL's geothermal output, though only 2.5% of the total output, is over one third of the world's geothermal output.

Following the development of more advanced exploration techniques, ENEL extended their research to areas that had no surface manifestation and an additional producibility of about 250 million kWh a year has been developed. In the Larderello area, thanks to the new exploratory campaigns, to the increased depth of the drilling (down to 2900 meters), to the technological improvement and enlargement of the stations, it has been possible to make up for the natural decline in productivity. ~~Figs 8 and 9~~ show the Larderello - 3 geothermal power station.

When the oil crisis broke out and urged several countries to undertake geothermal prospections, Italy was already heavily engaged in this sector. The research for new resources is concentrated in the belt along the foot of the Apennines from Tuscany to Campania. This belt, where preferential sites totalling about 600 sq km have been located, include the Travale-Radicondoli area in which it is very recent news that a new well has been found at a depth of 950 m. To exploit the flowrate of this well, which is 150 tons/h, two 15-MW units are being manufactured by the Italian industry and will be ready in a relatively short time. The total capacity installed in this area will thus rise to 50 MW with a yearly output of some 400 million kWh.

Because of ENEL's experience and expertise in the prospection and utilization of geothermal energy, their services have been sought by other countries (Iran, Venezuela and Greece) with whom ENEL renders assistance and consulting services. A cooperation agreement has also been entered into with the Energy Research and Development Administration of the United States.

No less challenging will be the efforts in the future. The nature of the geothermal source, which originates from the heat emanated by the magmatic basins deep in the earth, does not, however, allow reliable predictions to be made on the possible contributions from this source, even though some areas appear to be particularly promising.

As to the possibility of extracting heat from dry rocks, experiments are under way in Italy to fracture rock at a depth of about 3000 meters. The tests are going to be extended to 5000 meters in the near future.

Before going on to discuss fossil-fired and nuclear power stations, I shall only briefly mention the so-called "new" energy sources, because the output of electric energy from these sources is practically negligible.

Tides are practically non-existent in Italy. The activities under way in Italy--particularly by ENEL-- are devoted to the more interesting prospects offered by solar energy as an alternate source to fossil fuel. Enel is participating in a European Community study for a 1000-MWe solar station to be built in Italy. In the area of direct exploitation of the sun for heating purposes, ENEL is working on a heating system for the dwellings of the ENEL personnel that work at the Rossano Calabro steam power station in Southern Italy.

~~1.1 Thermal energy from fossil fuels~~
next ~~presentation~~ slide

As shown in (Fig. 2) thermal power generation from fossil fuels has been the prevailing source of electricity in Italy since 1963, year in which it overtook hydroelectric generation. Therefore, since the sixties ENEL has been devoting its utmost attention to this type of energy, in all its aspects related to planning, design, construction and operation, with the object of obtaining more economical, more reliable and more efficient power generating stations.

One particular feature of the Italian steam power generation system is the standardization of the stations. In fact, ENEL has pursued the advantages resulting from the definition of standard characteristics ever since most of the generating capability was taken over after nationalization.

The standardization concerns the unit rating, the thermal-dynamic characteristics (steam conditions, regenerative cycle, etc.), the general layout of the plant, the distribution of components and systems in the main buildings, the flow diagrams, wiring diagrams, automation logic diagrams, and the component characteristics.

The standardization was accomplished by steps at three capacity levels: first, the 160-MW unit (steam conditions: 140 atm gage, 538°C, 538°C); then the 320-MW unit (steam conditions: 170 atm gage, 538°C, 538°C); and finally the 660-MW unit (steam conditions: 245 atm gage, 538°C, 538°C). Our plurennial experience with the first two ratings has been quite positive, and quite satisfactory results have been obtained so far from the third rating as well.

These slides
~~Figs. 10, 11, 12~~ show some of the latest 320-MW thermal stations.
Table 2 gives the total capacity of ENEL's fossil-fired thermal stations in operation or planned. As one can see, this type of plant is bound to contribute substantially to the coverage of the demand still for several years, but percentagewise its contribution will gradually decrease as the nuclear program is implemented.

TABLE 2 (slide 15)

ENEL Fossil-Fuelled Thermal Power Stations

Stations	Gross continuous capability (kW x 10^3)	
	Steam power stations	Turbine-gas stations
In operation	19,200	430
Under construction or planned as of 31.12.1976 with commissioning within 1983	11,040	1790
Additional planned stations	6,440	-

As concerns the fuels employed, it should be borne in mind that Italy has practically no resources of this kind, except for a small supply of lignite and natural gas; the latter, however, is far too little to cover the national requirements for domestic and industrial uses. As a result, most of the fuel used in the steam power stations is imported.

The stations are designed to fire the widest range of fossil fuels foreseeable for each site, so as to allow the maximum differentiation of the sources of supply. All the stations are equipped to run on petroleum products, which are still the most abundant primary energy source in the Mediterranean basin. Some of the latest plants have been designed to run on crude oil, as well as on fuel oil, to achieve freedom from the oil refining cycle. Provisions have also been made in all the latest stations for the use of natural gas in order to have a different source of supply.

With regard to coal, even in the years preceding the 1973 oil crisis, ENEL had considered going to coal firing at all the stations where there were reasonable prospects that the necessary infrastructures to receive this fuel and transfer it to the station would be built. Wherever these infrastructures were already available, the stations were designed to fire both coal and fuel oil.

Unfortunately, the scarcity of adequately equipped harbours and the impracticality of transporting coal inland owing to the characteristics of the Italian railroads made it impossible to consider coal firing in more than about one fourth of the total thermal stations. Consequently, the percentage of coal versus fuel oil burnt is still small (about 6% in calories, including lignite), but a vast program is under way to increase the coal consumption for power generation in Italy.

In this survey, it is worth while to spend a few words on gas turbine units. The installation of this type of plant in Italy was justified to meet a few particular network conditions, for instance in the islands, but especially to tide us over the delayed issuance of construction permits for the steam power stations.

ext slide (16)

After a first series of stations with 16-MW and 25-MW units (e.g. the Camerata Picena plant with four 25-MW units shown in Fig. 13), we have now gone on to a unit rating of 90 MW with a standardized design. The first units of this rating are in construction.

When the emergency mentioned above is over, the gas turbines will be used for peak duty and as a reserve. To this purpose, these stations have been located at strategic points in the national network.

2. Development of Nuclear Energy in Italy

~~2.1 General considerations~~

As one can see from the diagram in ~~Fig. 2,~~ nuclear energy made its first appearance in Italy as a primary source for power production in 1963-64 with the stations of Latina (gas-graphite), Garigliano (boiling water) and Trino Vercellese (pressurized water) totalling about 600 MW. The output of these stations to date is over 42 billion kWh.

After that, the 850-MW Caorso boiling water reactor station was built, and at the time of this writing the pre-operational tests were under way. Figures 14 through 17 show some of the more significant phases and aspects of this station.

In 1973-74, orders were placed for four units rating about 1000 MW each (ENEL-V, -VI, -VII, and -VIII). A decision on the site for two of these units was finally reached at the end of last year (Upper Latium). As to the future, we are awaiting our Parliament's deliberation on the National Energy Plan which provides for the commissioning of a fairly large number (--originally the PEN proveded for twenty units; today, it seems that may be twelve.--) .

Apart from the programs, it may be appropriate to recall the major difficulties that have conditioned the growth of nuclear energy in our country, ~~just as in other countries~~. They can be summarized as follows:

(a) ungrounded, and at times exasperated, concern about the safety of nuclear stations;

(b) financial problems due to the fact that a nuclear station costs about twice as much as a conventional thermal station, even though the generated electricity costs less. In US dollars and at the 1976 prices, excluding interest during construction and price escalation, the cost of a 1000-MWe nuclear station is estimated to be on the order of ~~500 ÷~~ 550 dollars/kW.

With regard to the first point, that is, nuclear plant safety, our experience with the first-generation stations (which were not of the same degree of perfection as those of the current generation) has been absolutely positive. No injury has been suffered nor any trouble worth speaking of to the environment. Nevertheless, there is some opposition by a few sectors of the population to the construction of new nuclear stations which they link with the atom bomb. The interesting thing to note in this respect is that no such opposition is encountered in the communes where the nuclear stations in operation are located.

ENEL conducted a sample investigation around the Latina station to assess the impact of coastal power stations on the touristic and recreational activities. It appears that it has neither created any negative psychological effects nor hampered the development of touristic and recreational facilities in the area. Interviews with 600 ~~bathers~~ chosen at random on the Latina beach, indicated that the attitude of the local residents was even more positive in respect of the nuclear station than that of the vacationers from other areas. This is quite a meaningful result, because the opinion of the local residents is certainly based on a good knowledge of the facts of a nuclear plant.

Information Centers were born to make nuclear plants known to the public without breaking the safety rules, and especially to those who can in any way influence the decision on the siting of future stations. At the ENEL stations an apposite two-storey building will be provided for this purpose ~~(Fig. 18)~~ and located so as to allow a panoramic view of the station during construction and operation. Appropriate audio-visual aids will complete the view of the station.

Apart from the unjustified concern, there is another factor of importance to nuclear plant acceptance that cannot be ignored, and that is the solution of the social-economic problems that the construction of a nuclear station entails. Nuclear stations are generally built in rural areas whose balance could be upset by the thousands of workers settling in for the implementation of the project unless proper action is taken. To contribute towards the expenditures incurred by the communes involved to upgrade their infrastructures s, ENEL provides for a subsidy that is proportional to the plant rating; for instance for a nuclear station with two 1000-MW units, the subsidy amounts to about five million US dollars.

However, the location of sites for new stations is a problem in Italy, regardless of the above-mentioned actions. In fact, in view of the land configuration in our country, when we take out the Alpine and Apennine areas, there remains the Po valley and a few coastal areas, but these are already dense with inhabited areas, factories, roads, railroads, etc. As a result, where the amount of water available is enough for cooling purposes, we find that nuclear plant siting is obstructed by the land configuration or by the utilization of the land. Fig. 19 illustrates this problem for one of the flat stretches of coast available in Italy, namely, the coast of Emilia-Romagna.

As a consequence of the situation, notwithstanding the commitments taken with the manufacturers in 1973-74 for four units, ENEL has been able to get a site authorization for only one station (Upper Latium).

In the other Regions, investigations and meetings with the local Authorities have been going on and on, but we have not even been able to start writing the preliminary site reports yet.

The other factor that conditions the implementation of nuclear programs is the high investment required to build those plants. This in anything but a matter of small consequence, especially in view of the economic crisis in our country today. The solution to this problem is beyond ENEL's decisional powers, but the answer here should lie in an improved tariff system and an allocation of funds.

I shall now revert to other basic problems of major import, which, however, may be overcome by suitable engineering efforts.

2.2 Standardization and Code Changes

For the implementation of a program comprising several nuclear stations it is of primary importance to develop a reference standard design. Of course, the validity of such an effort is greater as greater is the number of stations to be built and as shorter is the time interval in which they are to be built. Like other utilities and engineering companies in other countries, ENEL is developing a reference standard design for its future nuclear stations. The standardization was initially based on 1000-MW units, but it can be extended up to the highest ratings offered today. Figs. 20-21 show the general layout and a model of the ENEL standard twin-unit station.

The advantages of a standard design are well known, so I shall merely mention the main ones: a reduction in plant construction times, less encumbered procedure for permit issuance, higher plant reliability, easier operation and maintenance, and, last but not least, greater safety.

An obstacle to--or rather a restrictrion on--standardization, at least with regard to the civil works (foundations, intakes and tailraces), lies in the dependence of the final design on the site characteristics, mainly the availability of water for cooling purposes and the seismic characteristics. The seismic characteristics, in particular, which vary considerably from one area to another, are a special problems to nuclear plant siting in our country.

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Another restriction on nuclear plant standardization arises from the fact that the reference design must allow for incorporation both of the experience accrued with nuclear plant operation and of the technological improvements achieved during plant construction. It is thus necessary to plan for development based on the foreseeable evolution of Standards and Code which, in turn, follow the broadening of knowledge in the various areas, and the results of the operating experience.

A considerable effort has been made in the matter of odes in countries where the various reactor concepts were developed. For instance, in the United States, the guidelines issued for light water reactor are quite broad and deep in scope, and thus represent a useful and precise point of reference also for other countries. In Italy, several groups of experts of all the Organizations concerned (ANCC, CNEN, ENEL, industries) have been working on these Codes and Guides to adapt them to, or to develop specific rules for the systems and components more closely related to our particular situation.

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~~2.3 Modifications during Plant Construction~~

Some flexibility should be allowed to modify the original design in order to accommodate new intervening requirements, especially when the new requirements are a further improvement in safety. On the other hand, it is not always easy to modify or improve a plant, once construction is under way. Without going into the details of our experience with the Caorso station in this regard, I will merely mention the pressure suppress system which had to be modified almost at the end of the construction stage.

The problem of design changes has even been encountered with the stations recently ordered by ENEL. The modifications to the original designs as tendered, requested for ENEL -V, -VI and -VIII, come roughly under two categories :

(1) modifications to further improve safety;

(2) modifications to incorporate technical developments.

2.3.1 Modifications to further improve safety

One of the first areas in which modifications were requested was the radioactivity release to the environment. To minimize this release, provisions have been made for a secondary containment, an intermediate closed-cycle cooling system for the nuclear-section components, and special conditioning and ventilating systems in the buildings where there is a potential hazard of equipment contamination. The purpose of these provisions is also to reduce the exclusion area around the nuclear station, as this is of paramount importance in a densely populated country like Italy.

Another area was the exposure of the station personnel to radiation. To minimize personnel exposure, we revised the layout of the equipment and we segregated any areas that are contaminated or likely to become so. For instance all the waste treatment systems (fig. 20) are in one building away from the main station buildings, and all the power centers are installed in a single building where also the control room is located. Combined with independent ventilation systems for each building and the subdivision of the station into areas with different contamination levels, this should considerably reduce the average contamination level of the station and personnel exposure.

Of course, these criteria have had a considerable import on the general layout and on the volume of the station. For instance, the total volume of each BWR unit for the Upper Latium station increased from about 368,000 cubic meters to about 435,000 cubic meters.

2.3.2 Modifications to incorporate technical developments

Of the main modifications originated from the standardization process and from new technological improvements I shall recall the control room layout, the station electrical system the station accesses and routes.

next slide (26) control room

As to the control room (Fig. 22), we have tried to standardize, as far as possible, a control room layout for both the BWR and the PWR, and we have adopted solid-state systems for control and signalling, just as we do at our thermal stations. The use of solid-state controles and an appropriate distribution of the instruments between the consoles and panels in the control room avoid the situation where an operator would have to supervise more than four or five meters of console during normal operation,a value which experience indicates as a practical limit.

coupler

An important innovation in the electric system is the adoption of a coupleur on the generator busbars which confers considerable flexibility to station operation. For fire-protection, all cables are of the flame-choking type, and fire barriers are installed both on horizontal and vertical cable routes.

accesses

Operation and maintenance require ease of passage from one area to another in full observance of the maximum separation of clean areas from contaminated areas. This is the basic criterion underlying the location of the accesses to, and the routes inside, the station. Other requirements ar[e] protection against intrusion from outside and a check on the movements of persons inside the station; to meet the former requirement we are consider[-]ing only one access to the buildings of the two units, and to meet the latter we are considering compulsory routes.

2.4 Project Implementation Time

site authorization time

A factor that has a determining influence on the inclusion of nuclear stations in the energy development program is the project implementation time. This includes the times required for site selection, permit issuanc[e] and construction proper.

Site selection takes several months to establish the actual characteristics of the site and environment, but even a longer time is required to obtain the authorization to use that site. In Italy, a law (No. 393) was emanated in 1975 to specify the procedures to be followed for plant siting.

by adding the times required for the various procedural steps, it takes twenty-seven months from the decision to build the station and the authorization to use the site selected for it.

Then, we must bear in mind the time between the authorization of a site and the breaking of the ground. Expropriation of an area for public utility, as contemplated in Law 393, may give rise to local reactions and further delays. The preparation of a map of possible plant sites in Italy by CNEN is under way, and it should be ready in 1978. This map will certainly help contain the length of the initial stage.

struction

As to construction proper, today it takes ~~six or~~ about seven years from the preparation of the construction area to the commissioning of a nuclear power station.

xt slide (27)

When we add all the times mentioned above, we see looking at Fig. 23 that it takes from the decision to build a twin-unit station up to the time when the first unit can be placed on line, a long period and it still takes a lot of of effort to meet the schedule. This brings us back to the need for legislation on plant siting (such as, the plant site map), engineering means (such as, plant standardization), and means to facilitate the public's acceptance of nuclear stations (such as the information centers).

2.5 Problems associated with the use of nuclear energy

Apart the aspects more closely linked with nuclear stations proper, before concluding this report I would like to recall the most common questions of the use of nuclear energy for the production of electricity in general. I refer particularly to the back-end of the fuel cycle, waste disposal and nuclear station decommissioning.

2.5.1 Irradiated fuel storage and reprocessing

Irradiated fuel became a problem when the industrialized countries started encountering difficulties for the construction of reprocessing facilities. The provisions studied in Italy and elsewhere will give us some respite, but it is foreseeable that around the middle eighties the situation will become critical and untenable, and it will not be possible to defer the construction of reprocessing plants any longer.

3. CONCLUSIONS

It is to be hoped that before the end of the seventies the main difficulties mentioned above can be overcome and that the recourse to nuclear energy to meet the growing power requirements can be resumed. In this connection, we should not overlook the advent of commercial breeder reactors, anticipated for the eighties. These reactors will increase the utilization of the energy potential of natural uranium over fifty times more than the proved type reactors. The gradual penetration of breeder reactors will render the uranium resources practically inexhaustible and, at the same time, they will decrease the need for enrichment services. Besides, it will also be possible to recycle the depleted uranium discharged from the present reactors in the breeder reactors.

In the field of breeder reactors, Europe holds a first-rank position. An enterprise has been set up by France, Germany and Italy for the development of these reactors in the very near future. ENEL participates by one third, and also our manufacturing industry is included in this share. The viability of this program is ascertained by the fact that a few stations rated up to 250 MW that are already beyond the experimental stage have been in operation for some time. But these prospects will be discussed by other speakers, so I shall just conclude by thanking the audience for their kind attention.

but Before leaving the floor to them, I would like to show you an alternate source of energy I recently heard [illegible] an American [illegible].

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ENTE NAZIONALE PER L'ENERGIA ELETTRICA

第1セッション 3/10 午後
スペーリ本論文

JAPAN ATOMIC INDUSTRIAL FORUM

1977 Annual Conference

THE ITALIAN ENERGY SITUATION AND THE ROLE OF NUCLEAR POWER

by Dr. G. Speri
Manager, Plant Construction Division, ENEL

Tokyo, 9 March 1977

THE ITALIAN ENERGY SITUATION AND THE ROLE OF NUCLEAR POWER

Giorgio Speri

Mr. Chairman Ladies & Gentleman

1. Electric Power Generation in Italy.

1.1. Present state and prospective developments

Even though the rate of the electricity demand growth in Italy has slackened a little in these past years, the peak power demand, that is, the "maximum load" has continued to go up, as can be seen in Fig. 1 This slide. This trend is very important from the standpoint of planning new plants, because the power demand determines the size of the generating plant --and of the transmission, transformation and distribution facilities-- and thus the investment required. However, in the very long term, the increase in electricity consumption will tend to an asymptote, as it is inconceivable that the exponential trend with a growth rate of about a doubling every ten years will continue indefinitely.

In this connection, a distinction should be made among the various countries on the basis of the per-capita electricity consumption; for instance, the consumption in Italy is low as compared to other European countries. In fact, in 1974 the per-capita consumption was 4,500 kWh in Germany, 4,205 kWh in England, 3,850 kWh in Belgium, 3,199 kWh in France, and only 2,375 kWh in Italy broken down as follows: 3,036 in Northern Italy, 1,850 in Central Italy and 1,500 in Southern Italy. The difference would be even greater when compared to countries outside the European Community.

From the standpoints of predicting the electricity requirements and of planning new stations, since ENEL applies the "annually sliding plan" principle, any excess in generating capacity would be temporary and its cost would be contained within reasonable limits. It is much more difficult to assess the cost of an inadequate supply of electricity. Furthermore, the power generation development programs for the coming years are based essentially on nuclear plants, and by meeting the demand with the largest possible recourse to nuclear generation it would be possible to alleviate the balance of payments. At present, the cost per kWh of fuel oil is over 20 mills (18 lire) versus 5 mills (4.50 lire) of nuclear fuel, which means that for every 1000-MWe unit in the network today the disbursement of foreign currency would be reduced by some 100 million dollars (nearly 80 billion lire) a year. Even if the cost of nuclear fuel should increase, there is ample margin for nuclear power to be at an advantage over thermal power.

next slide (2) I shall now illustrate the sources currently used in Italy for power generation and the related prospects of development based on the trends of these past years (Fig. 2).

1.2 Hydroelectric energy

The most abundant energy source in Italy in the past was the water resource. Up to twenty-five years ago nearly all the country's energy requirements were covered by this source. Today, it hardly meets 30% of the demand, and new sites that are acceptable from the technical, economic and environmental standpoints are practically nil. Regardless of economic considerations, the residual "natural" production potential is on the order of 10 billion kWh a year. This is but a small percentage of the energy requirement, which reached 160 billion kWh in 1976, but it corresponds to over 2.3 million tons of fuel oil or about 200 million US dollars a year at the present prices (1), and this is not a negligible amount from the standpoint of the balance of payments.

The activities in our country in the area of hydro plant construction are directed mainly towards pumped-storage stations. Because of its size and characteristics, this type of station has played and will continue to play an increasingly important role for the so-called "modulation of the load diagram".

To cover the peaks in the load diagram, recourse is also had to gas turbine units, which I shall speak of later on.

The purpose of pumped-storage stations is to transfer surplus supplies of thermal, and especially nuclear, energy from low-load periods (nights and holidays) to peak-load periods. This function is clearly illustrated in the diagram in Fig. 3, which relates to the winter peak in 1975.

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When the oil crisis broke out and urged several countries to undertake geothermal prospections, Italy was already heavily engaged in this sector. ~~The research for new resources is concentrated in the belt along the foot of the Apennines from Tuscany to Campania. This belt, where preferential sites totalling about 600 sq km have been located, include the Travale-Radicondoli area in which it is very recent news that a new well~~

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~~V.1 Thermal energy from fossil fuels~~
next ... 2

next slide (11)

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~~The standardization was accomplished by steps at three capacity levels: first, the 160-MW unit (steam conditions: 140 atm gage, 538°C, 538°C); then the 320-MW unit (steam conditions: 170 atm gage, 538°C, 538°C); and finally the 660-MW unit (steam conditions: 245 atm gage, 538°C, 538°C). Our plurennial experience with the first two ratings has been quite positive, and quite satisfactory results have been obtained so far from the third rating as well.~~

I have next slides (12, 13, 14)

These slides ~~Figs. 10, 11, 12~~ show some of the latest 320-MW thermal stations.

next slide (15)

Table 2 gives the total capacity of ENEL's fossil-fired thermal stations in operation or planned. As one can see, this type of plant is bound to contribute substantially to the coverage of the demand still for several years, but percentagewise its contribution will gradually decrease as the nuclear program is implemented.

TABLE 2 (slide 15)

ENEL Fossil-Fuelled Thermal Power Stations

Stations	Gross continuous capability (kW x 10^3)	
	Steam power stations	Turbine-gas stations
In operation	19, 200	430
Under construction or planned as of 31. 12. 1976 with commissioning within 1983	11, 040	1790
Additional planned stations	6, 440	-

As concerns the fuels employed, it should be borne in mind that Italy has practically no resources of this kind, except for a small supply of lignite and natural gas; the latter, however, is far too little to cover the national requirements for domestic and industrial uses. As a result, most of the fuel used in the steam power stations is imported.

The stations are designed to fire the widest range of fossil fuels foreseeable for each site, so as to allow the maximum differentiation of the sources of supply. All the stations are equipped to run on petroleum products, which are still the most abundant primary energy source in the Mediterranean basin. Some of the latest plants have been designed to run on crude oil, as well as on fuel oil, to achieve freedom from the oil refining cycle. Provisions have also been made in all the latest stations for the use of natural gas in order to have a different source of supply.

With regard to coal, even in the years preceding the 1973 oil crisis, ENEL had considered going to coal firing at all the stations where there were reasonable prospects that the necessary infrastructures to receive this fuel and transfer it to the station would be built. Wherever these infrastructures were already available, the stations were designed to fire both coal and fuel oil.

Unfortunately, the scarcity of adequately equipped harbours and the impracticality of transporting coal inland owing to the characteristics of the Italian railroads made it impossible to consider coal firing in more than about one fourth of the total thermal stations. Consequently, the percentage of coal versus fuel oil burnt is still small (about 6% in calories, including lignite), but a vast program is under way to increase the coal consumption for power generation in Italy.

In this survey, it is worth while to spend a few words on gas turbine units. The installation of this type of plant in Italy was justified to meet a few particular network conditions, for instance in the islands, but especially to tide us over the delayed issuance of construction permits for the steam power stations.

After a first series of stations with 16-MW and 25-MW units (e.g. the Camerata Picena plant with four 25-MW units shown in ~~Fig. 13)~~, we have now gone on to a unit rating of 90 MW with a standardized design. The first units of this rating are in construction.

ext slide (16)

When the emergency mentioned above is over, the gas turbines will be used for peak duty and as a reserve. To this purpose, these stations have been located at strategic points in the national network.

2. Development of Nuclear Energy in Italy

~~2.1 General considerations~~

As one can see from the diagram in ~~Fig. 2,~~ nuclear energy made its first appearance in Italy as a primary source for power production in 1963-64 with the stations of Latina (gas-graphite), Garigliano (boiling water) and Trino Vercellese (pressurized water) totalling about 600 MW. The output of these stations to date is over 42 billion kWh.

After that, the 850-MW Caorso boiling water reactor station was built, and at the time of this writing the pre-operational tests were under way. Figures 14 through 17 show some of the more significant phases and aspects of this station.

In 1973-74, orders were placed for four units rating about 1000 MW each (ENEL-V, -VI, -VII, and -VIII). A decision on the site for two of these units was finally reached at the end of last year (Upper Latium). As to the future, we are awaiting our Parliament's deliberation on the National Energy Plan which provides for the commissioning of a fairly large number (--originally the PEN proveded for twenty units; today, it seems that may be twelve.--) .

Apart from the programs, it may be appropriate to recall the major difficulties that have conditioned the growth of nuclear energy in our country, ~~just as in other countries~~. They can be summarized as follows:

(a) ungrounded, and at times exasperated, concern about the safety of nuclear stations;

(b) financial problems due to the fact that a nuclear station costs about twice as much as a conventional thermal station, even though the generated electricity costs less. In US dollars and at the 1976 prices, excluding interest during construction and price escalation, the cost of a 1000-MWe nuclear station is estimated to be on the order of ~~500~~ ÷ 550 dollars/kW.

With regard to the first point, that is, nuclear plant safety, our experience with the first-generation stations (which were not of the same degree of perfection as those of the current generation) has been absolutely positive. No injury has been suffered nor any trouble worth speaking of to the environment. Nevertheless, there is some opposition by a few sectors of the population to the construction of new nuclear stations which they link with the atom bomb. The interesting thing to note in this respect is that no such opposition is encountered in the communes where the nuclear stations in operation are located.

ENEL conducted a sample investigation around the Latina station to assess the impact of coastal power stations on the touristic and recreational activities. It appears that it has neither created any negative psychological effects nor hampered the development of touristic and recreational facilities in the area. Interviews with 600 bathers chosen at random on the Latina beach, indicated that the attitude of the local residents was even more positive in respect of the nuclear station than that of the vacationers from other areas. This is quite a meaningful result, because the opinion of the local residents is certainly based on a good knowledge of the facts of a nuclear plant.

Information Centers were born to make nuclear plants known to the public without breaking the safety rules, and especially to those who can in any way influence the decision on the siting of future stations. At the ENEL stations an apposite two-storey building will be provided for this purpose ~~(Fig. 18)~~ and located so as to allow a panoramic view of the station during construction and operation. Appropriate audio-visual aids will complete the view of the station.

Apart from the unjustified concern, there is another factor of importance to nuclear plant acceptance that cannot be ignored, and that is the solution of the social-economic problems that the construction of a nuclear station entails. Nuclear stations are generally built in rural areas whose balance could be upset by the thousands of workers settling in for the implementation of the project unless proper action is taken. To contribute towards the expenditures incurred by the communes involved to upgrade their infrastructures

s, ENEL provides for a subsidy that is proportional to the plant rating; for instance for a nuclear station with two 1000-MW units, the subsidy amounts to about five million US dollars.

However, the location of sites for new stations is a problem in Italy, regardless of the above-mentioned actions. In fact, in view of the land configuration in our country, when we take out the Alpine and Apennine areas, there remains the Po valley and a few coastal areas, but these are already dense with inhabited areas, factories, roads, railroads, etc. As a result, where the amount of water available is enough for cooling purposes, we find that nuclear plant siting is obstructed by the land configuration or by the utilization of the land. ~~Fig. 19~~ illustrates this problem for one of the flat stretches of coast available in Italy, namely, the coast of Emilia-Romagna.

As a consequence of the situation, notwithstanding the commitments taken with the manufacturers in 1973-74 for four units, ENEL has been able to get a site authorization for only one station (Upper Latium).

In the other Regions, investigations and meetings with the local Authorities have been going on and on, but we have not even been able to start writing the preliminary site reports yet.

The other factor that conditions the implementation of nuclear programs is the high investment required to build those plants. This in anything but a matter of small consequence, especially in view of the economic crisis in our country today. The solution to this problem is beyond ENEL's decisional powers, but the answer here should lie in an improved tariff system and an allocation of funds.

I shall now revert to other basic problems of major import, which, however, may be overcome by suitable engineering efforts.

2. ~~2 Standardization and Code Changes~~

For the implementation of a program comprising several nuclear stations it is of primary importance to develop a reference standard design. Of course, the validity of such an effort is greater as greater is the number of stations to be built and as shorter is the time interval in which they are to be built. Like other utilities and engineering companies in other countries, ENEL is developing a reference standard design for its future nuclear stations. The standardization was initially based on 1000-MW units, but it can be extended up to the highest ratings offered today. Figs. 20-21 show the general layout and a model of the ENEL standard twin-unit station.

The advantages of a standard design are well known, so I shall merely mention the main ones: a reduction in plant construction times, less encumbered procedure for permit issuance, higher plant reliability, easier operation and maintenance, and, last but not least, greater safety.

An obstacle to--or rather a restrictrion on--standardization, at least with regard to the civil works (foundations, intakes and tailraces), lies in the dependence of the final design on the site characteristics, mainly the availability of water for cooling purposes and the seismic characteristics. The seismic characteristics, in particular, which vary considerably from one area to another, are a special problems to nuclear plant siting in our country.

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Another restriction on nuclear plant standardization arises from the fact that the reference design must allow for incorporation both of the experience accrued with nuclear plant operation and of the technological improvements achieved during plant construction. It is thus necessary to plan for development based on the foreseeable evolution of Standards and Cod which, in turn, follow the broadening of knowledge in the various areas, and the results of the operating experience.

A considerable effort has been made in the matter of odes in countries where the various reactor concepts were developed. For instance, in the United States, the guidelines issued for light water reactor are quite broad and deep in scope, and thus represent a useful and precise point of reference also for other countries. In Italy, several groups of experts of all the Organizations concerned (ANCC, CNEN, ENEL, industries) have been working on these Codes and Guides to adapt them to, or to develop specific rules for the systems and components more closely related to our particular situation.

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2.3 Modifications during Plant Construction

Some flexibility should be allowed to modify the original design in order to accommodate new intervening requirements, especially when the new requirements are a further improvement in safety. On the other hand, it is not always easy to modify or improve a plant, once construction is under way. Without going into the details of our experience with the Caorso station in this regard, I will merely mention the pressure suppress system which had to bé modified almost at the end of the construction stage.

The problem of design changes has even been encountered with the stations recently ordered by ENEL. The modifications to the original designs as tendered, requested for ENEL -V, -VI and -VIII, come roughly under two categories :

(1) modifications to further improve safety;

(2) modifications to incorporate technical developments.

2.3.1 Modifications to further improve safety

One of the first areas in which modifications were requested was the radioactivity release to the environment. To minimize this release, provisions have been made for a secondary containment, an intermediate closed-cycle cooling system for the nuclear-section components, and special conditioning and ventilating systems in the buildings where there is a potential hazard of equipment contamination. The purpose of these provisions is also to reduce the exclusion area around the nuclear station, as this is of paramount importance in a densely populated country like Italy.

Another area was the exposure of the station personnel to radiation. To minimize personnel exposure, we revised the layout of the equipment and we segregated any areas that are contaminated or likely to become so. For instance all the waste treatment systems (fig. 20) are in one building away from the main station buildings, and all the power centers are installed in a single building where also the control room is located. Combined with independent ventilation systems for each building and the subdivision of the station into areas with different contamination levels, this should considerably reduce the average contamination level of the station and personnel exposure.

Of course, these criteria have had a considerable import on the general layout and on the volume of the station. For instance, the total volume of each BWR unit for the Upper Latium station increased from about 368,000 cubic meters to about 435,000 cubic meters.

2.3.2 Modifications to incorporate technical developments

Of the main modifications originated from the standardization process and from new technological improvements I shall recall the control room layout, the ext slide (26) Control room

station electrical system the station accesses and routes.

As to the control room (Fig. 22), we have tried to standardize, as far as possible, a control room layout for both the BWR and the PWR, and we have adopted solid-state systems for control and signalling, just as we do at our thermal stations. The use of solid-state controles and an appropriate distribution of the instruments between the consoles and panels in the control room avoid the situation where an operator would have to supervise more than four or five meters of console during normal operation, a value which experience indicates as a practical limit.

Coupler

An important innovation in the electric system is the adoption of a coupleur on the generator busbars which confers considerable flexibility to station operation. For fire-protection, all cables are of the flame-choking type, and fire barriers are installed both on horizontal and vertical cable routes.

Accesses

Operation and maintenance require ease of passage from one area to another in full observance of the maximum separation of clean areas from contaminated areas. This is the basic criterion underlying the location of the accesses to, and the routes inside, the station. Other requirements ar protection against intrusion from outside and a check on the movements of persons inside the station; to meet the former requirement we are consider ing only one access to the buildings of the two units, and to meet the latter we are considering compulsory routes.

2.4 Project Implementation Time

Site authorization time

A factor that has a determining influence on the inclusion of nuclear stations in the energy development program is the project implementation time. This includes the times required for site selection, permit issuanc and construction proper.

Site selection takes several months to establish the actual characteristics of the site and environment, but even a longer time is required to obtain the authorization to use that site. In Italy, a law (No. 393) was emanated in 1975 to specify the procedures to be followed for plant siting by adding the times required for the various procedural steps, it takes twenty-seven months from the decision to build the station and the authorization to use the site selected for it.

Then, we must bear in mind the time between the authorization of a site and the breaking of the ground. Expropriation of an area for public utility, as contemplated in Law 393, may give rise to local reactions and further delays. The preparation of a map of possible plant sites in Italy by CNEN is under way, and it should be ready in 1978. This map will certainly help contain the length of the initial stage.

[Construction time:] As to construction proper, today it takes about six or seven years from the preparation of the construction area to the commissioning of a nuclear power station.

[next slide (27)] When we add all the times mentioned above, we see looking at Fig. 23 that it takes, from the decision to build a twin-unit station up to the time when the first unit can be placed on line, a long period and it still takes a lot of of effort to meet the schedule. This brings us back to the need for legislation on plant siting (such as, the plant site map), engineering means (such as, plant standardization), and means to facilitate the public's acceptance of nuclear stations (such as the information centers).

2.5 Problems associated with the use of nuclear energy

Apart the aspects more closely linked with nuclear stations proper, before concluding this report I would like to recall the most common questions of the use of nuclear energy for the production of electricity in general. I refer particularly to the back-end of the fuel cycle, waste disposal and nuclear station decommissioning.

2.5.1 Irradiated fuel storage and reprocessing

Irradiated fuel became a problem when the industrialized countries started encountering difficulties for the construction of reprocessing facilities. The provisions studied in Italy and elsewhere will give us some respite, but it is foreseeable that around the middle eighties the situation will become critical and untenable, and it will not be possible to defer the construction of reprocessing plants any longer.

3. CONCLUSIONS

It is to be hoped that before the end of the seventies the main difficulties mentioned above can be overcome and that the recourse to nuclear energy to meet the growing power requirements can be resumed. In this connection, we should not overlook the advent of commercial breeder reactors, anticipated for the eighties. These reactors will increase the utilization of the energy potential of natural uranium over fifty times more than the proved type reactors. The gradual penetration of breeder reactors will render the uranium resources practically inexhaustible and, at the same time, they will decrease the need for enrichment services. Besides, it will also be possible to recycle the depleted uranium discharged from the present reactors in the breeder reactors.

In the field of breeder reactors, Europe holds a first-rank position. An enterprise has been set up by France, Germany and Italy for the development of these reactors in the very near future. ENEL participates by one third, and also our manufacturing industry is included in this share. The viability of this program is ascertained by the fact that a few stations rated up to 250 MW that are already beyond the experimental stage have been in operation for some time. But these prospects will be discussed by other speakers, ~~so I shall just conclude by thanking the audience for their kind attention.~~

but before giving the floor to them, I would like to show you an alternate source of energy I recently saw in an American countryside.

…nal slide (25)

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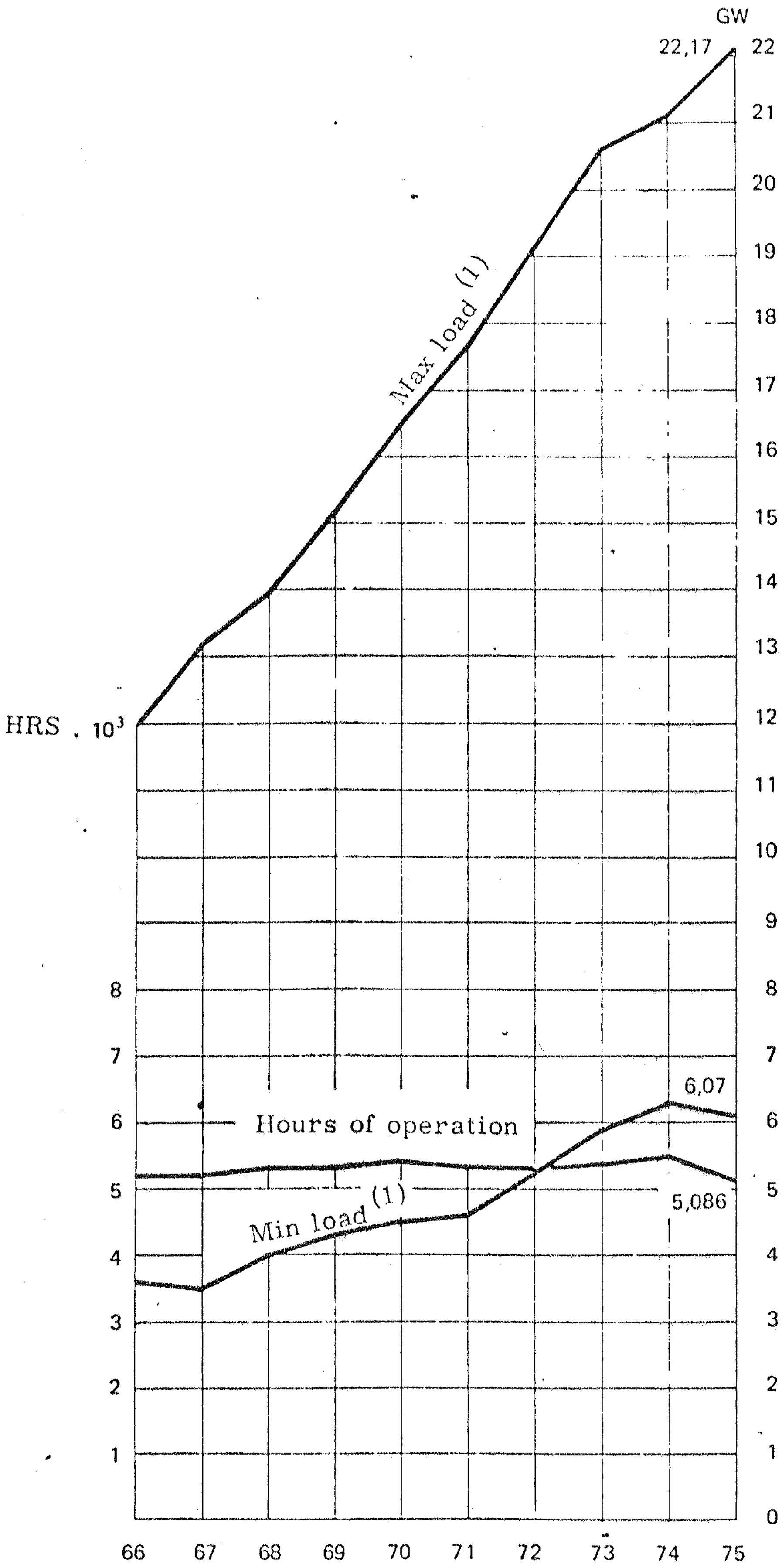
③-3

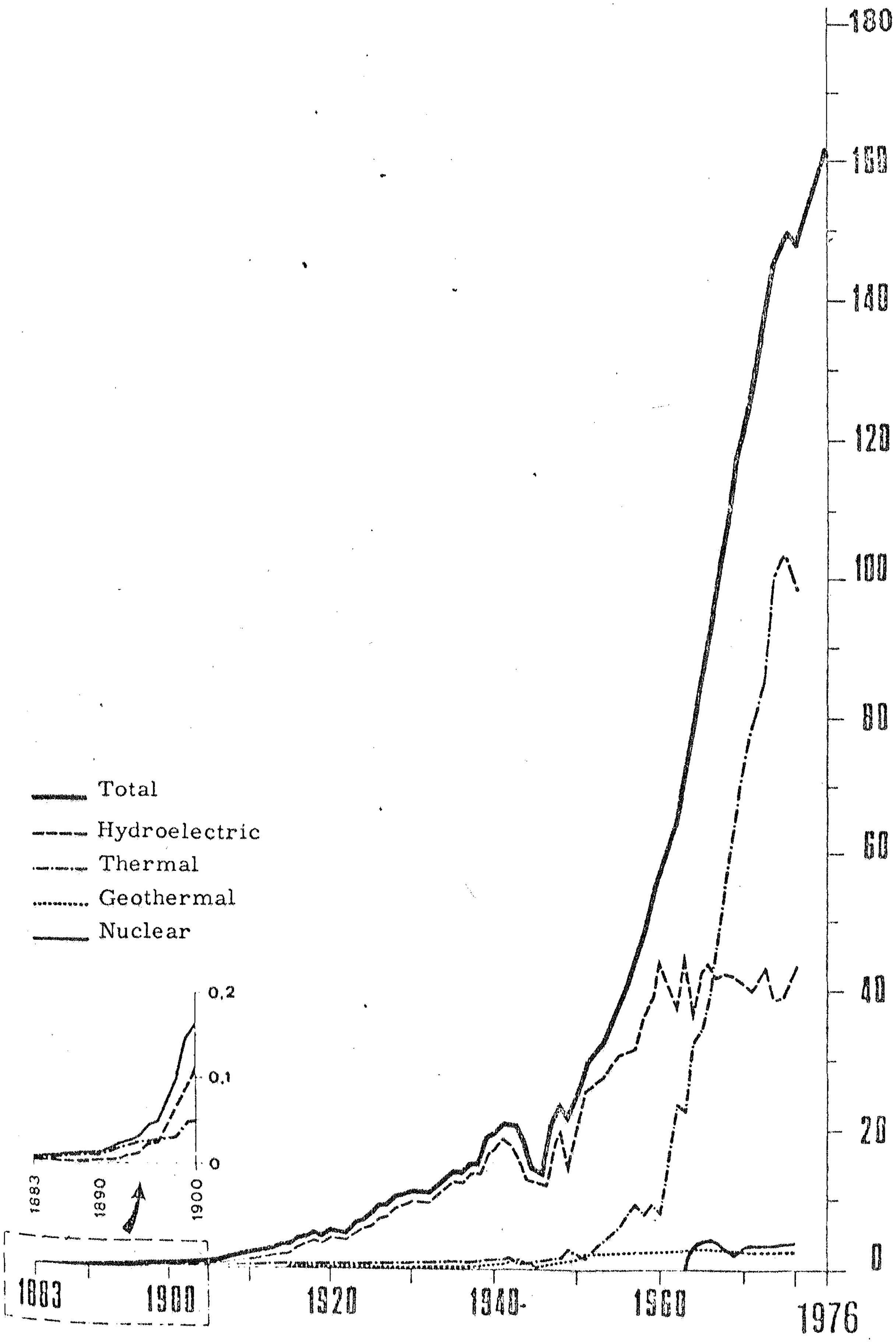


(1) Including auxiliaries and pumping

SLIDE 1

FIG. 1 - Minimum and maximum load curves and hours of operation at peak load in ENEL's network

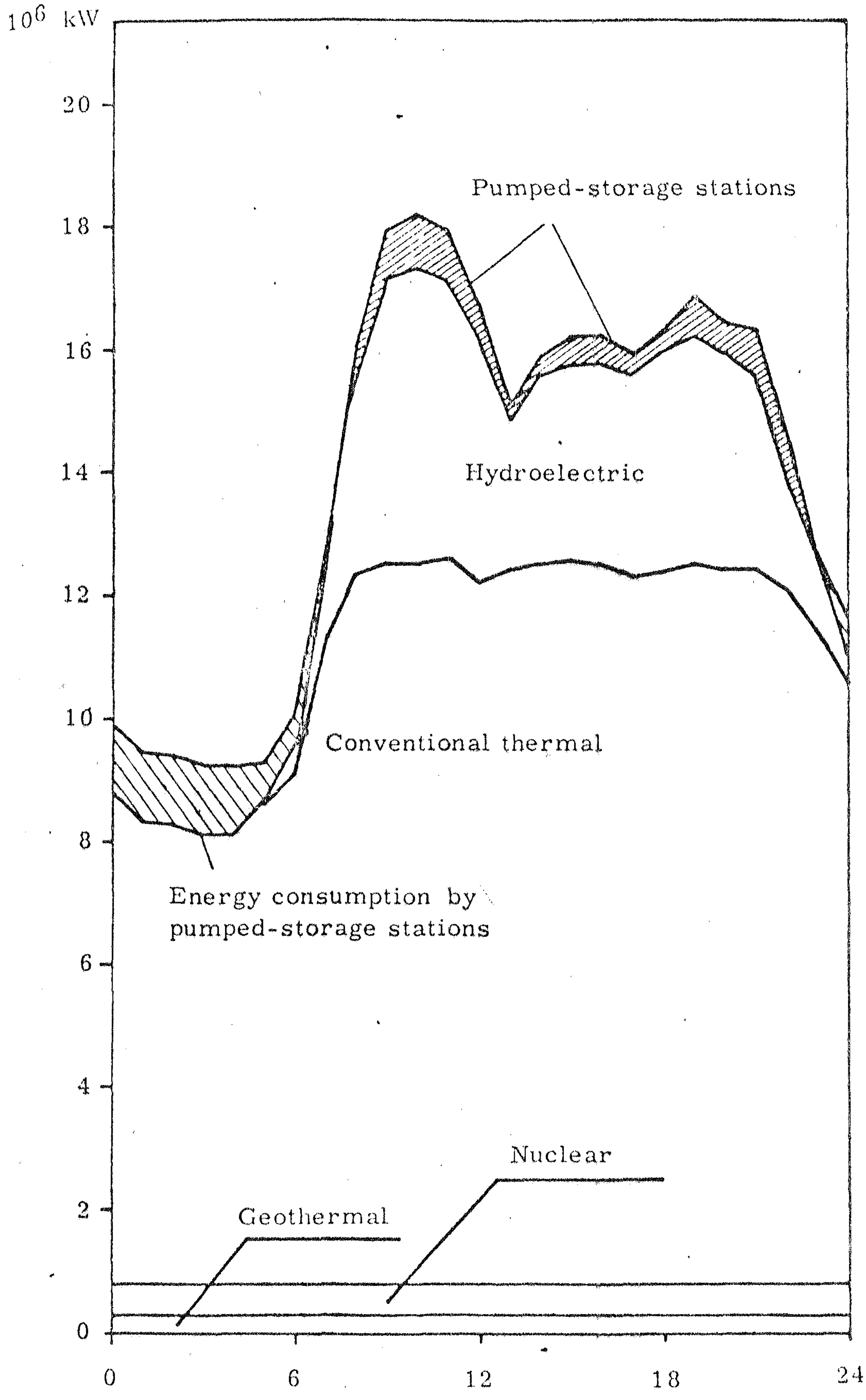
③



SLIDE 2

FIG. 2 - Electricity production in Italy (Billions of kWh)

SLIDE 11
SLIDE 17



SLIDE 3

FIG. 3 - ENEL's production (Monday, 24 february 1975)

TABLE 1

ENEL's Hydroelectric Power Stations

STATIONS	Capability (kW x 10^3)	Average yearly producibility (kWh x 10^6)
In operation in 1975	11,803	34,684
(pumped-storage)	(3,000)	
Under construction or planned at end-1975	5,537	1,467
(pumped-storage)	(5,200)	
Not built because of difficulties in permit issuance	932	1,148
With promising economic prospects	15,157	3,200
(pumped-storage)	(13,400)	
Mainly for potable water and land irrigation uses	559	1,144

SLIDE 4

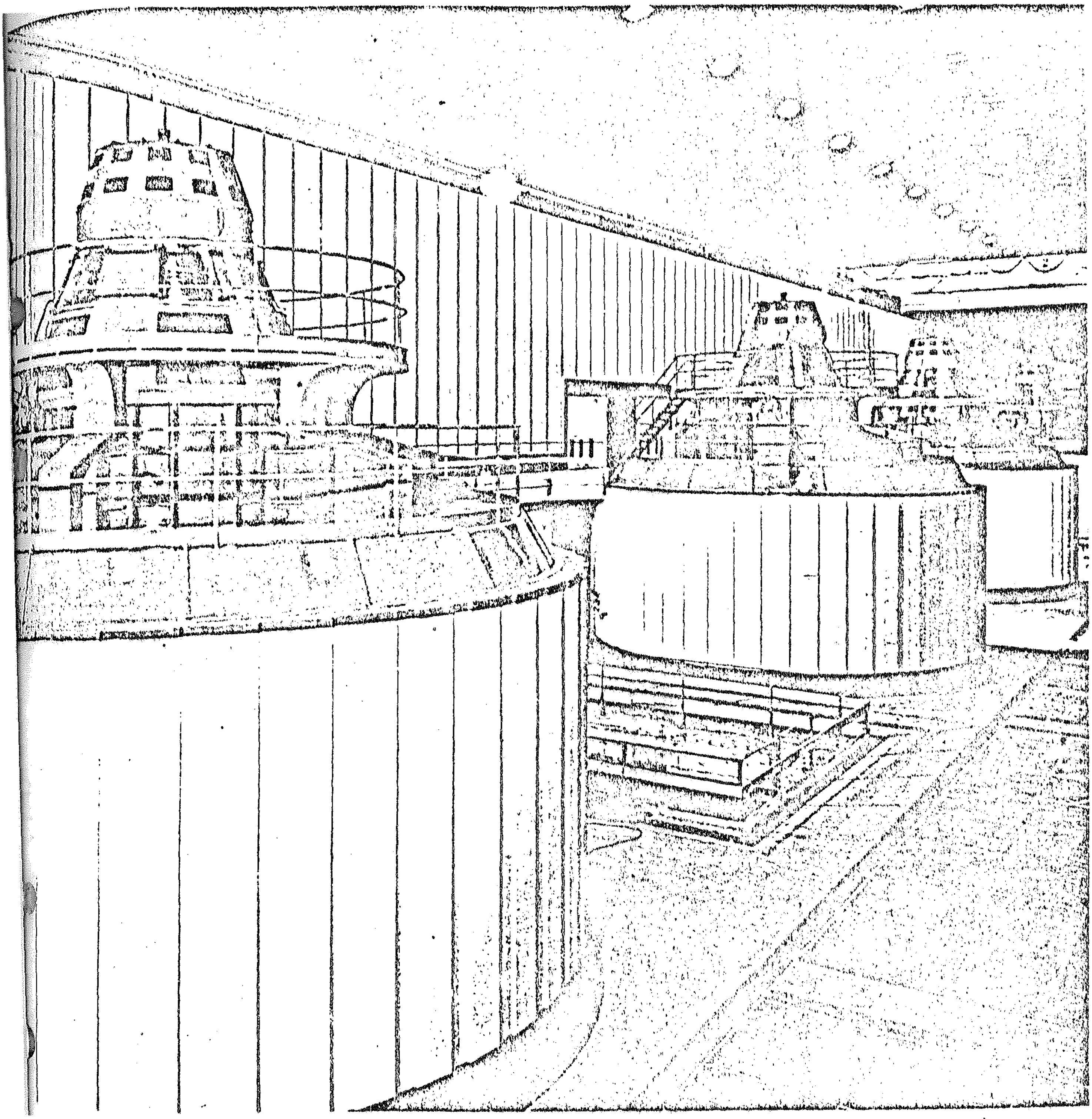


FIG. 4 - "Roncovalgrande" pumped-storage plant: underground machine hall

SLIDE 5

FIG. 5 - "Alto Gesso" Chiotas dam building site : pours of the lower part of the dam

quota attacco diga 1850 m

SLIDE 6

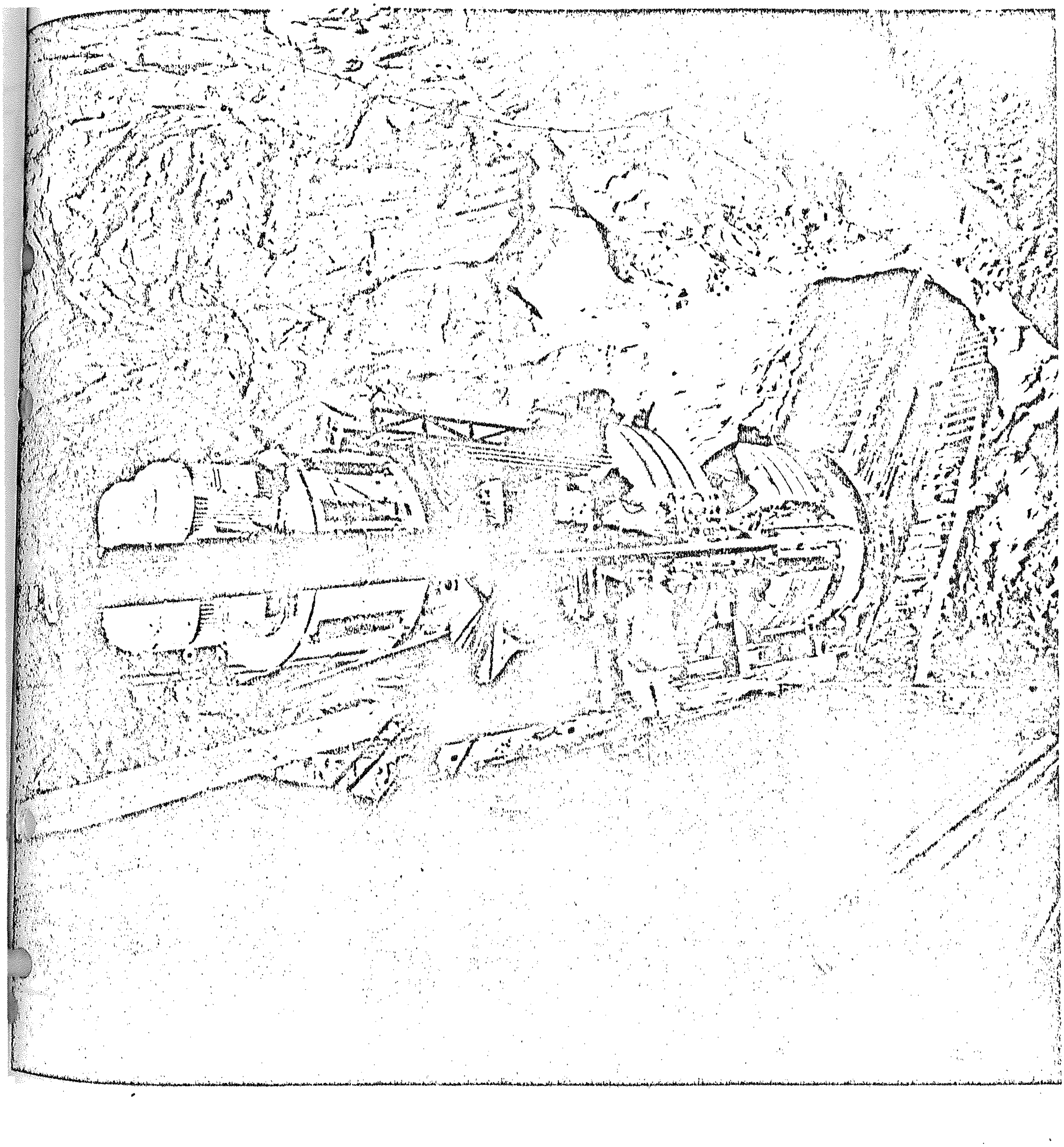


FIG. 6 - "Alto Gesso" Tunnelling machine

SLIDE 7

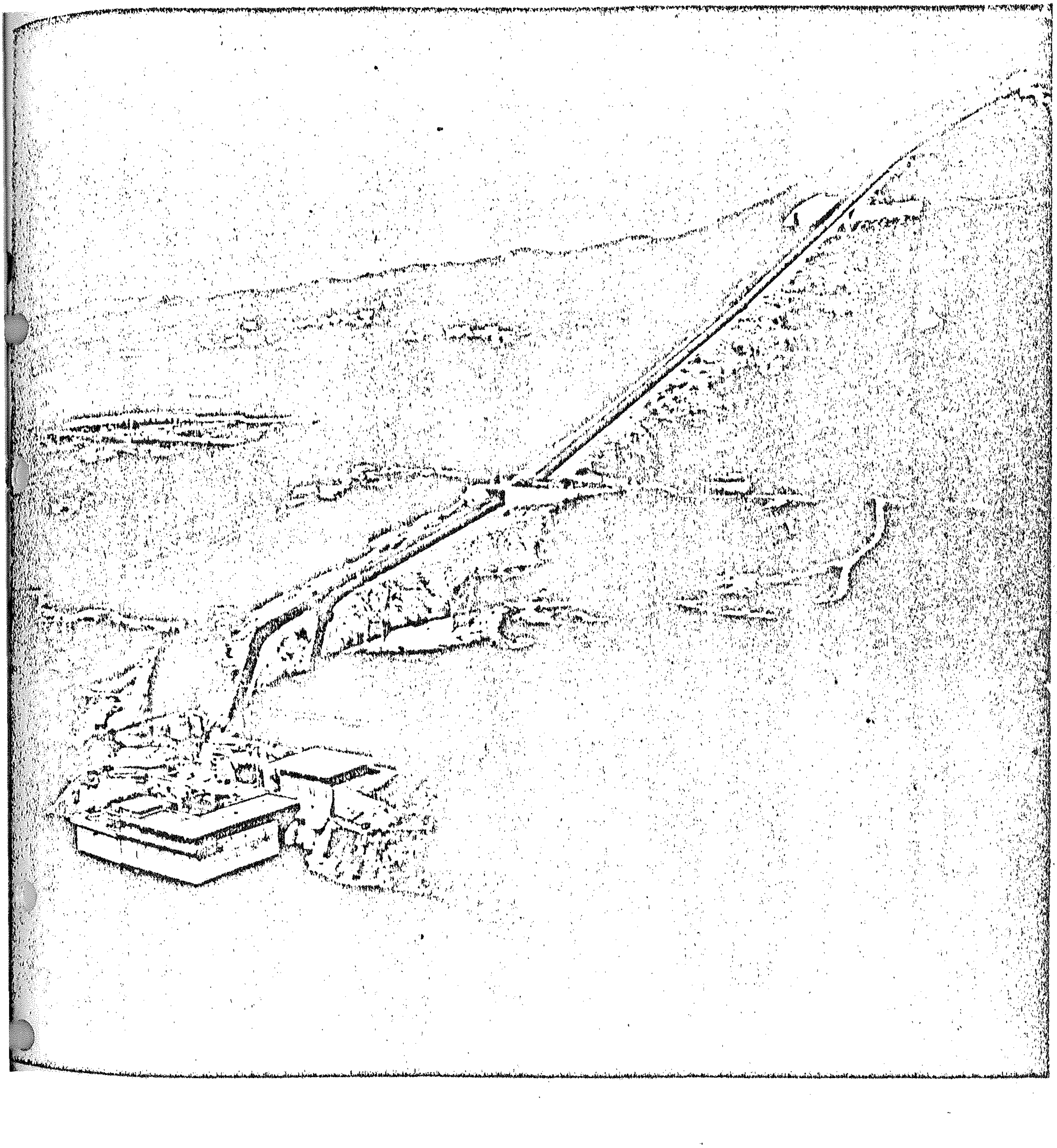


FIG. 7 - "Brasimone" pumped-storage plant

SLIDE 8

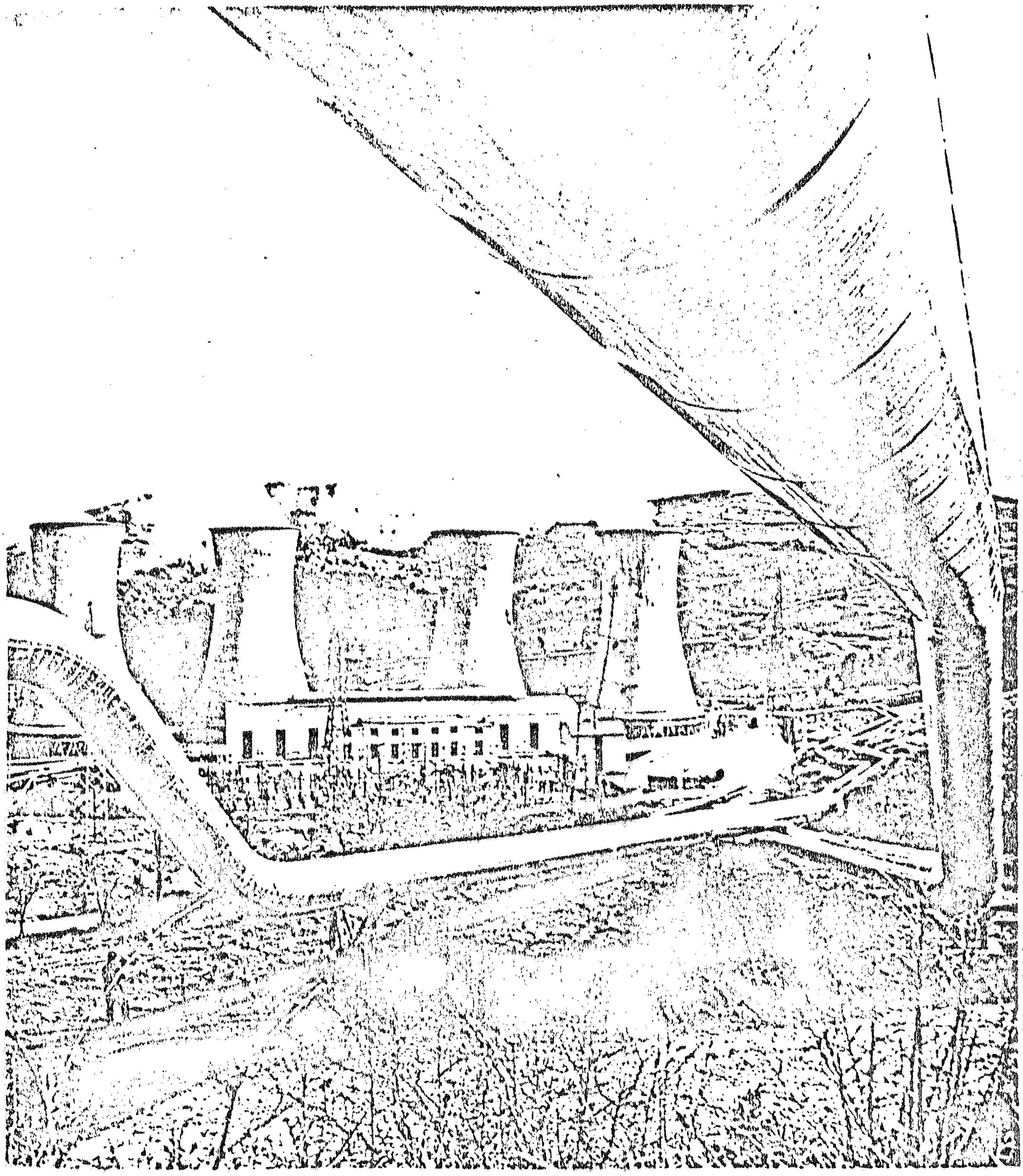


FIG. 8 - "Larderello -3" Geothermal power station

SLIDE 9

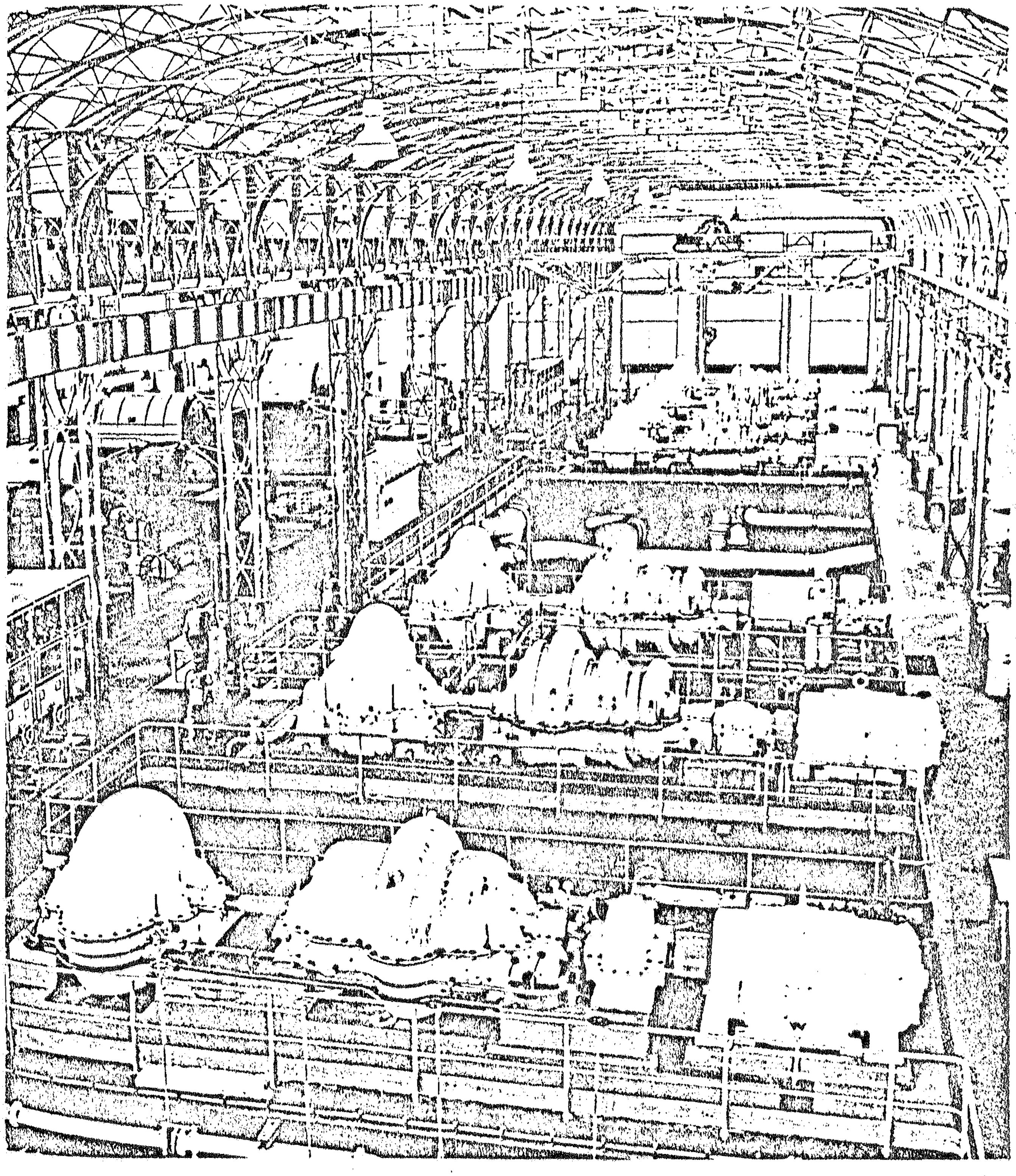


FIG. 9 - "Larderello -3" Geothermal power station : turbine hall

SLIDE 10

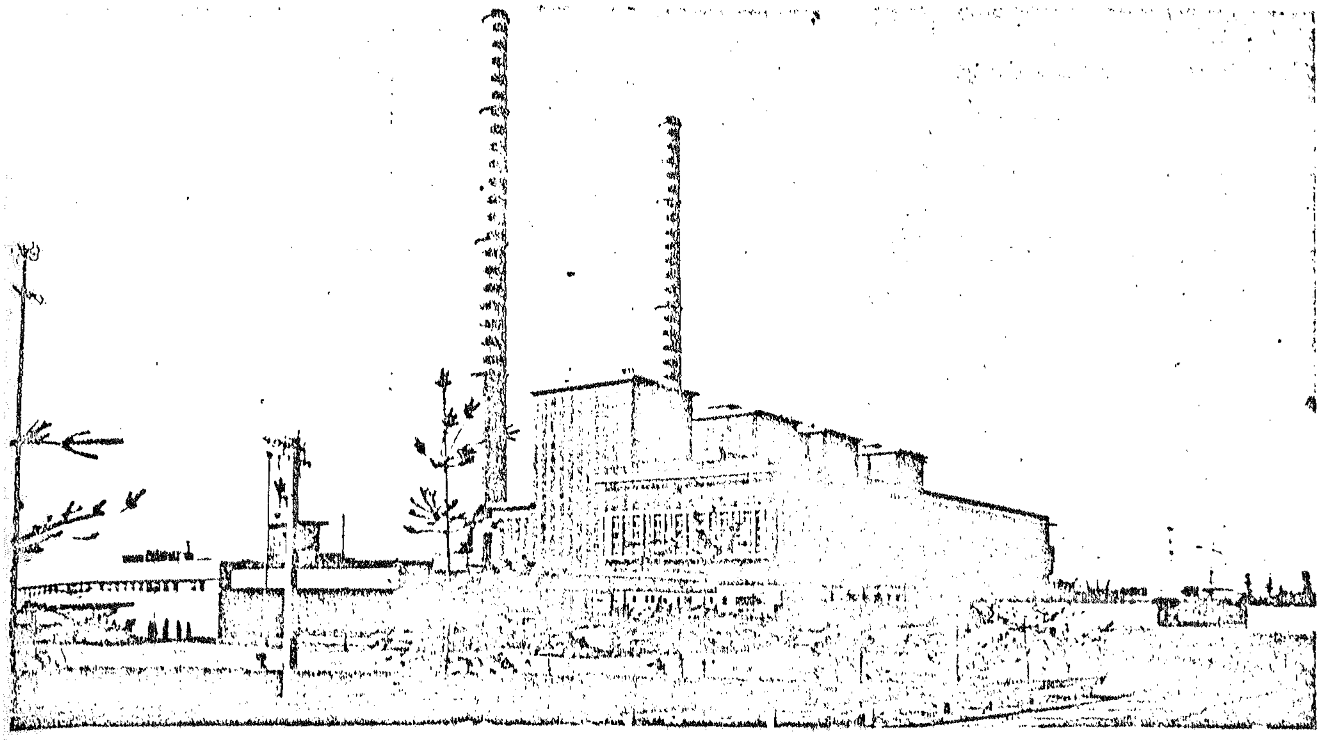


FIG. 10 - "La Casella" steam power station (4 x 320 MW)

SLIDE 12

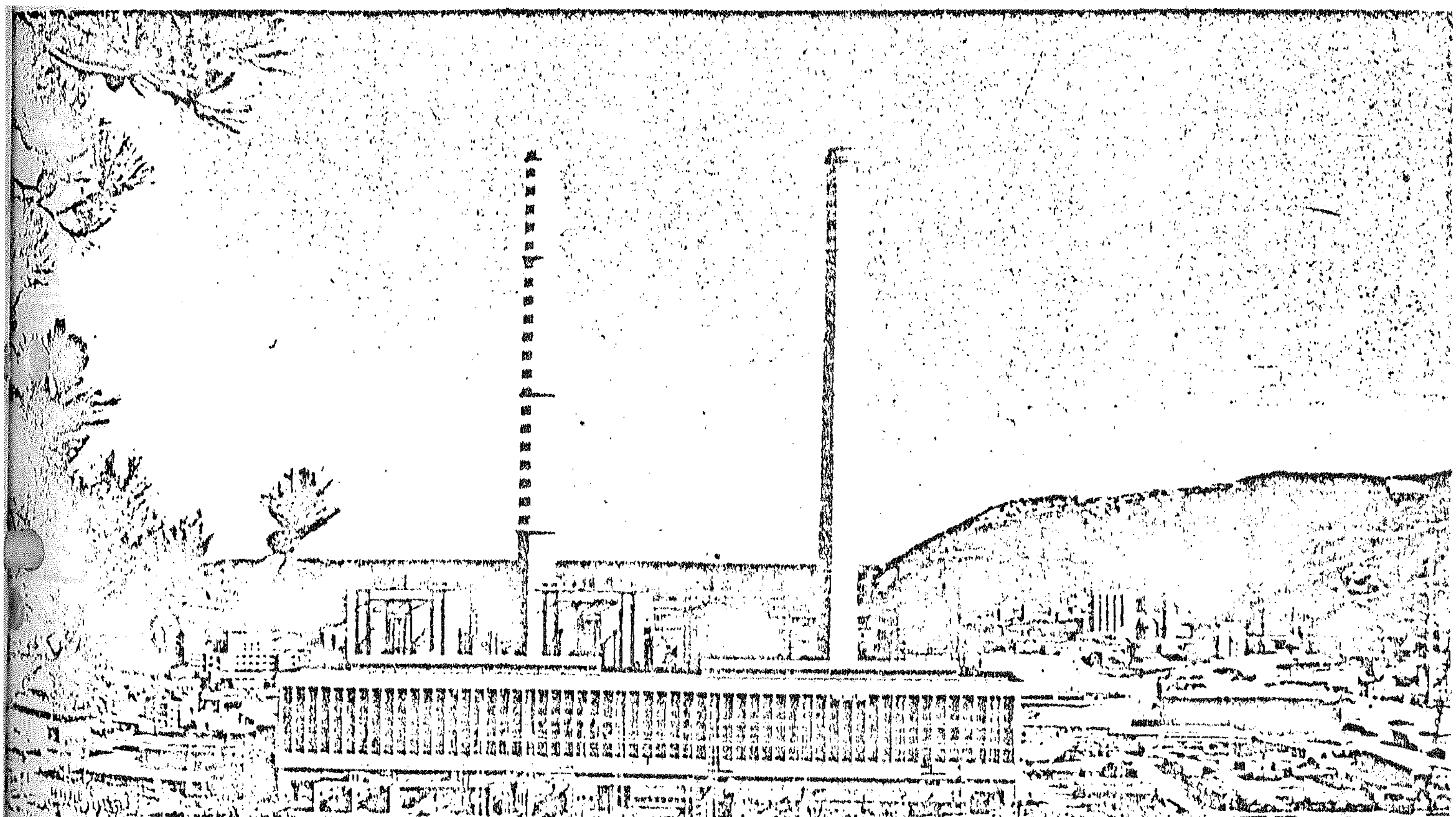


FIG. 11 - "Vado Ligure" steam power station (4 x 320 MW)

SLIDE 13

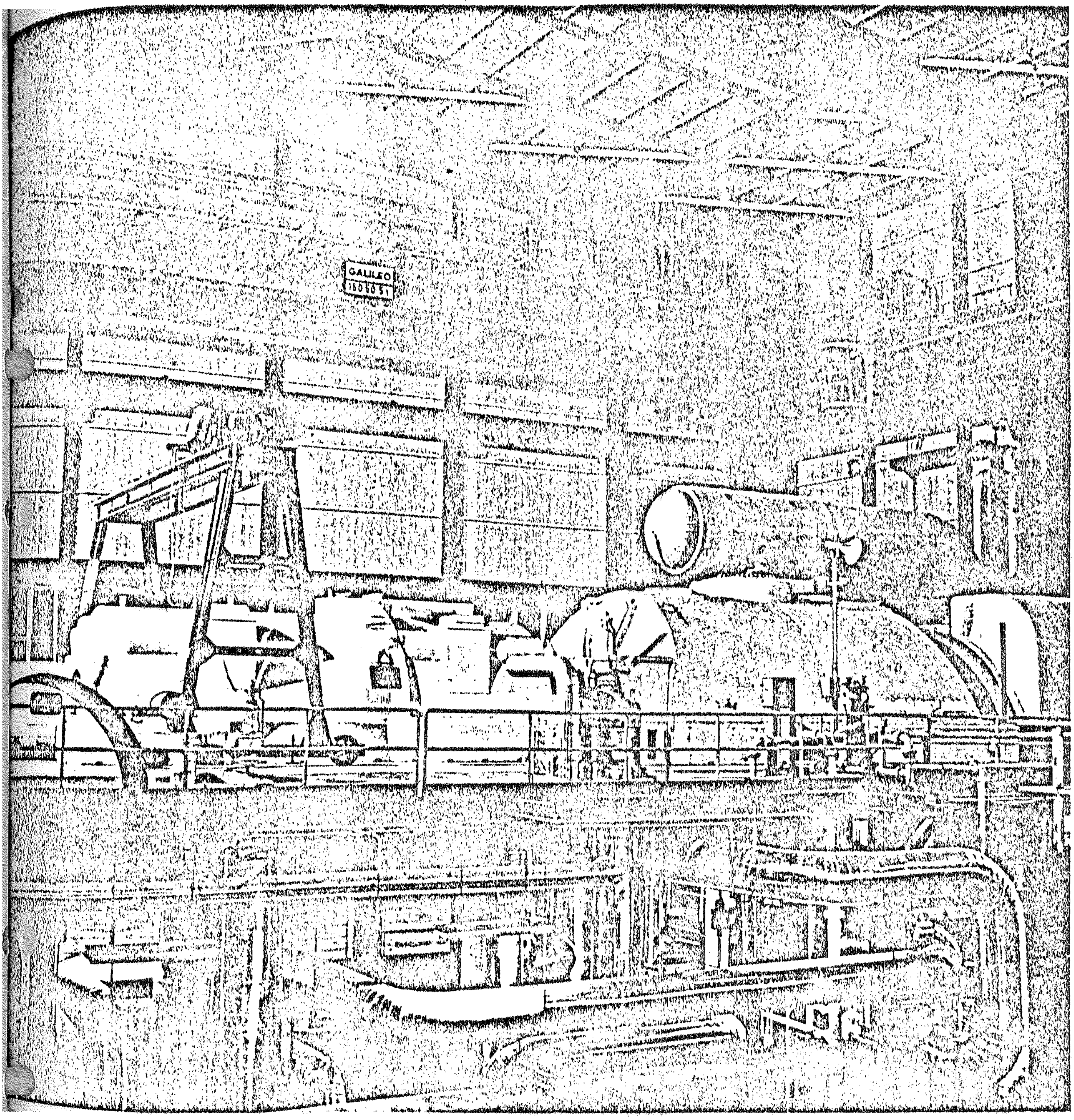


FIG. 12 - "Milazzo Levante" power station unit 5 & 6 (320 MWe):
view of turbogenerator hall

SLIDE 14

TABLE 2

ENEL Fossil-Fuelled Thermal Power Stations

Stations	Gross continuous capability (MW)	
	Steam power stations	Turbine-gas stations
In operation	19,200	430
Under construction or planned as of 31.12.1976 with commissioning within 1983	11,040	1790
Additional planned stations	6,440	-

SLIDE 15

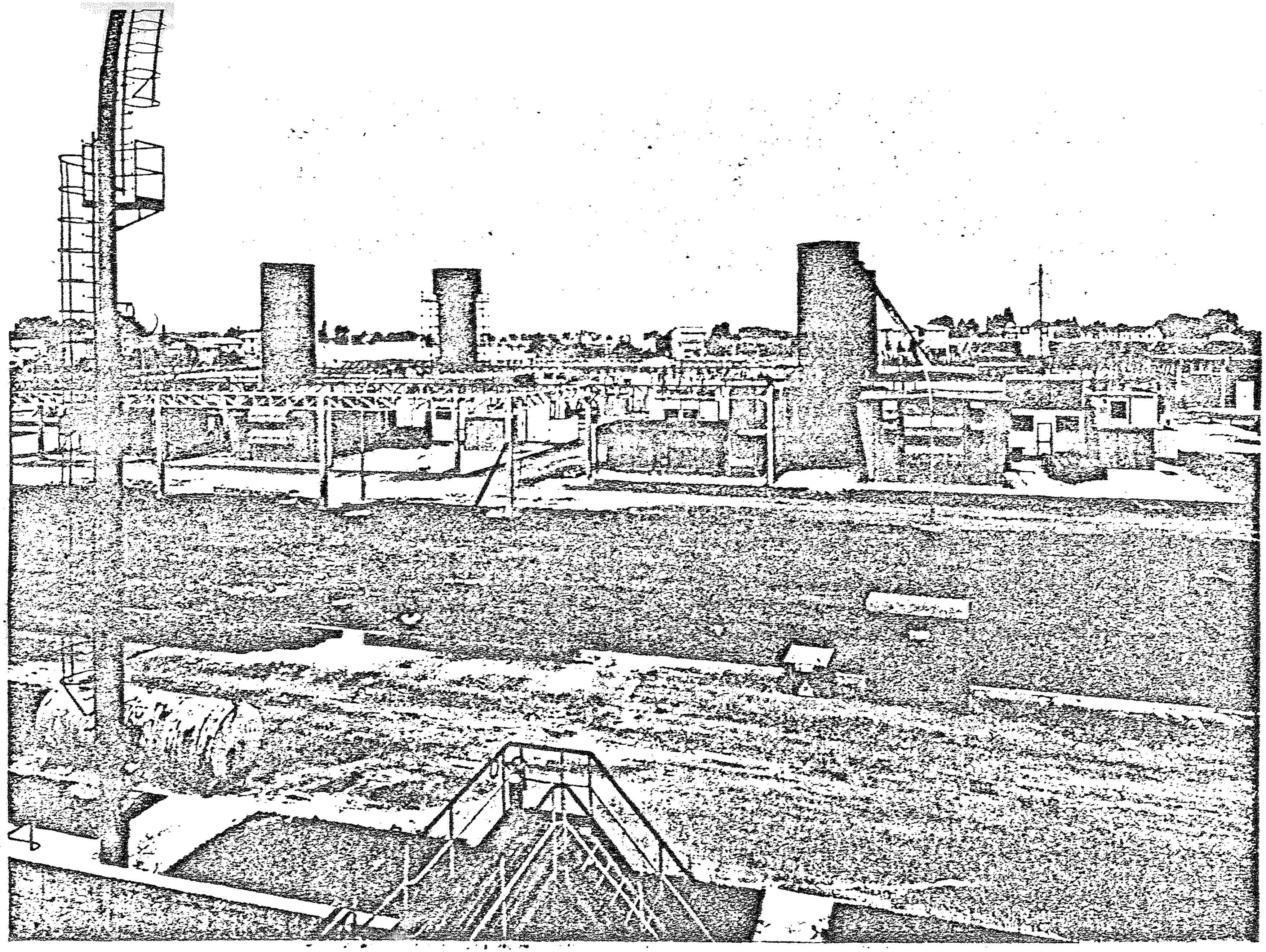


FIG. 13 - "Camerata Picena" gas turbine power station (4 x 25 MW)

SLIDE 16

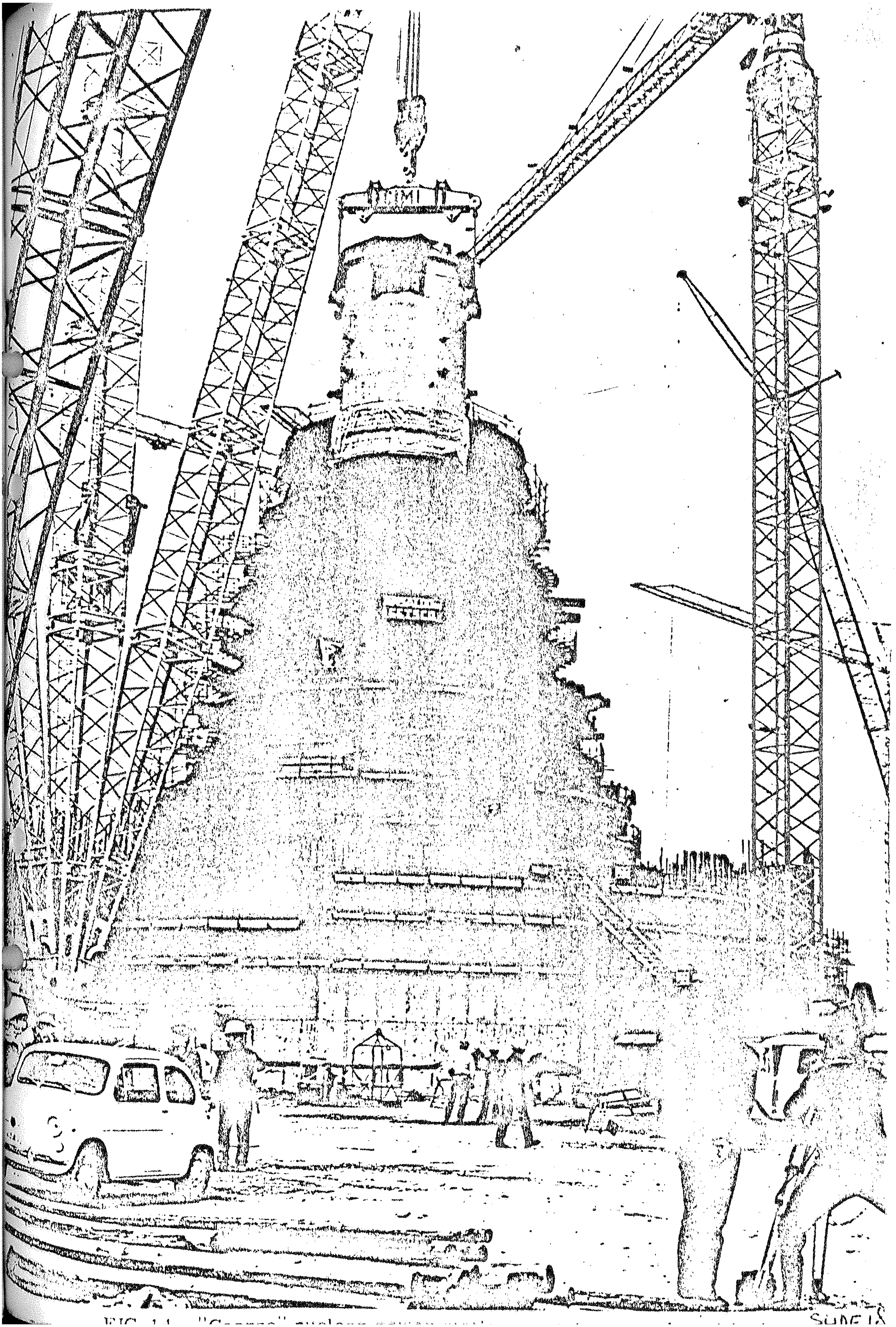


FIG. 11. "Garras" nuclear power stati[illegible]

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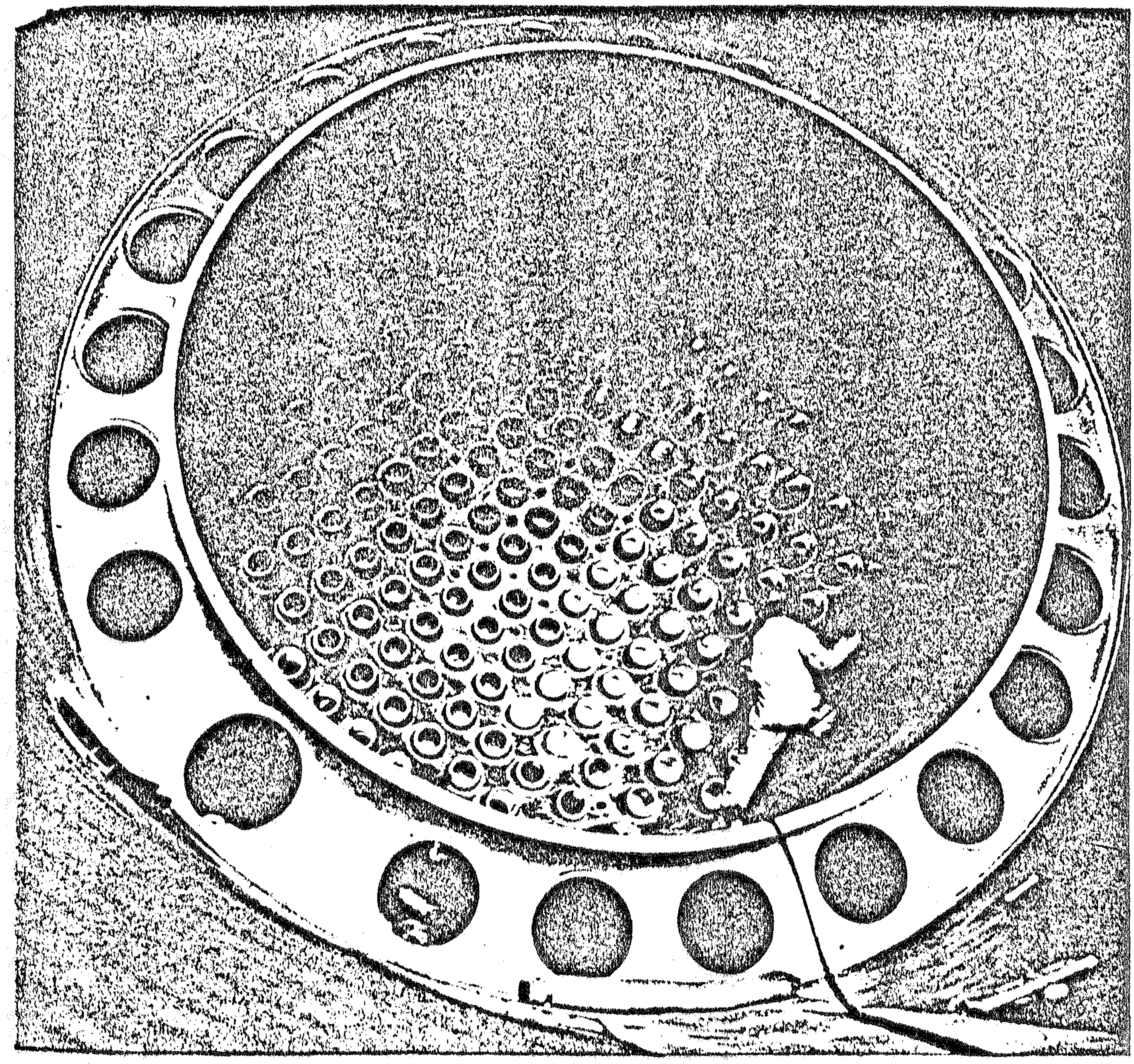


FIG. 15 - "Caorso" nuclear power station : bottom of vessel view

SLIDE 19

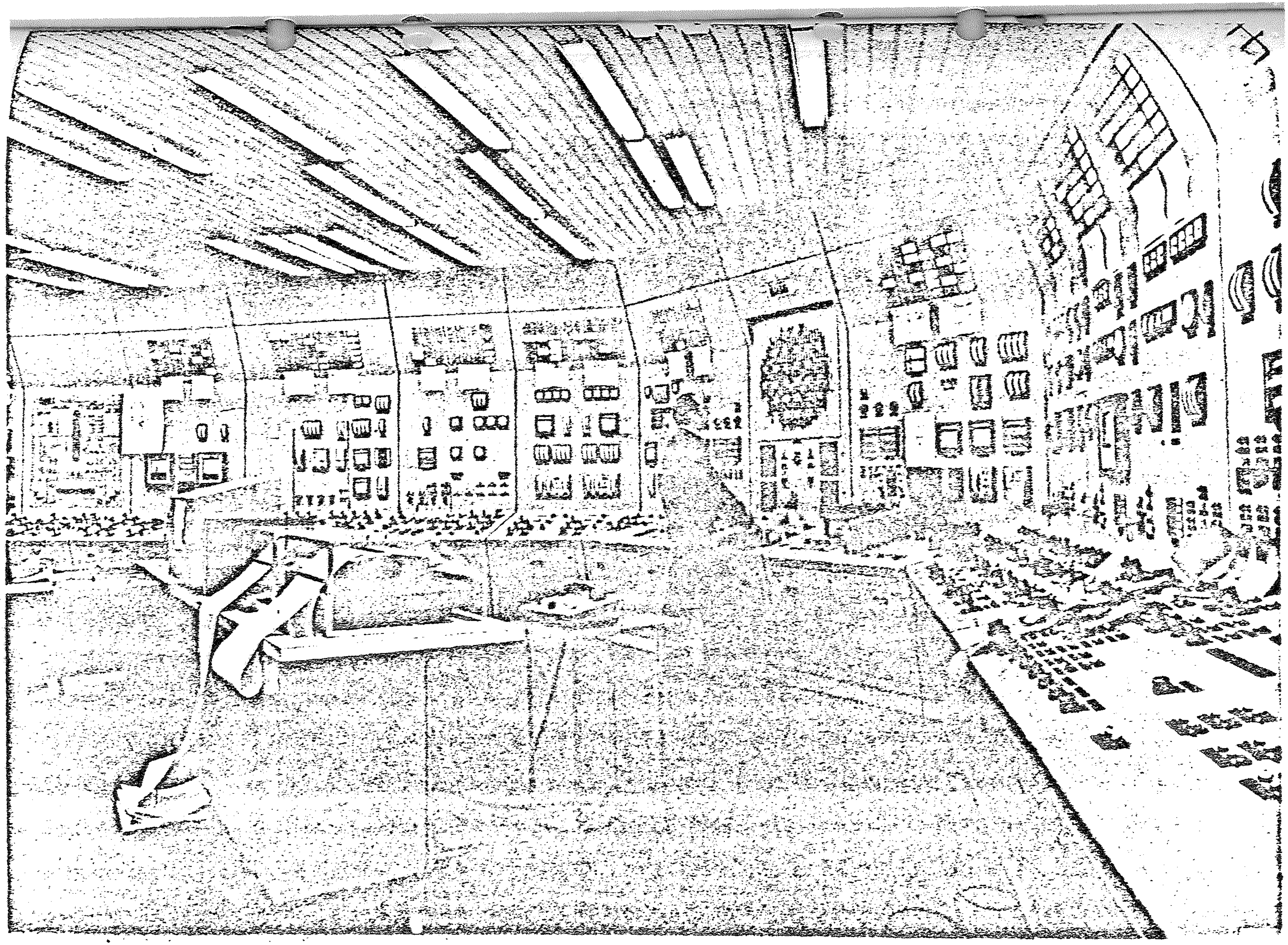


FIG. 16 - "Caorso" nuclear power station :control room

SLIDE 20

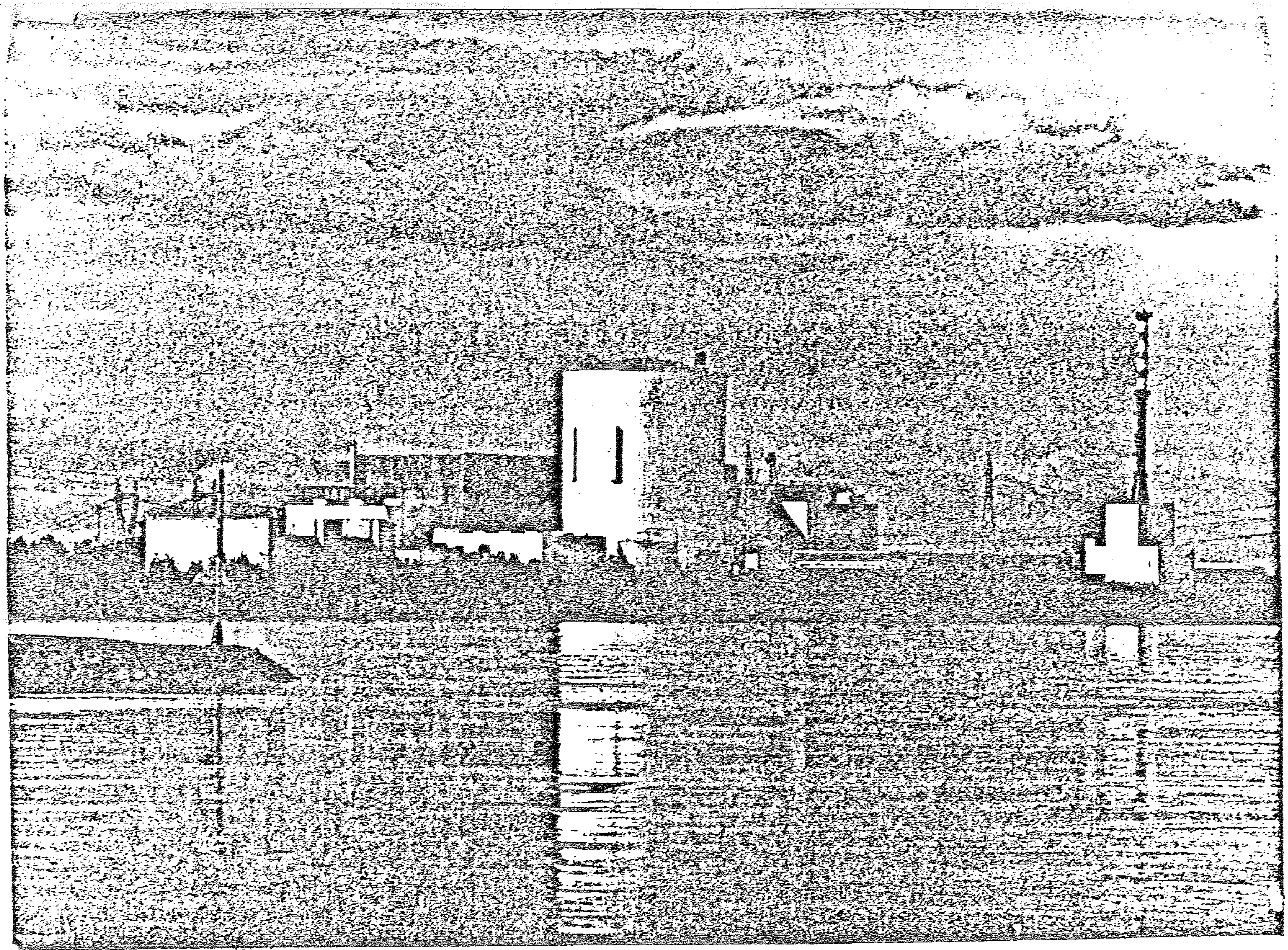


FIG. 17 - "Caorso" nuclear power station

SLIDE 21

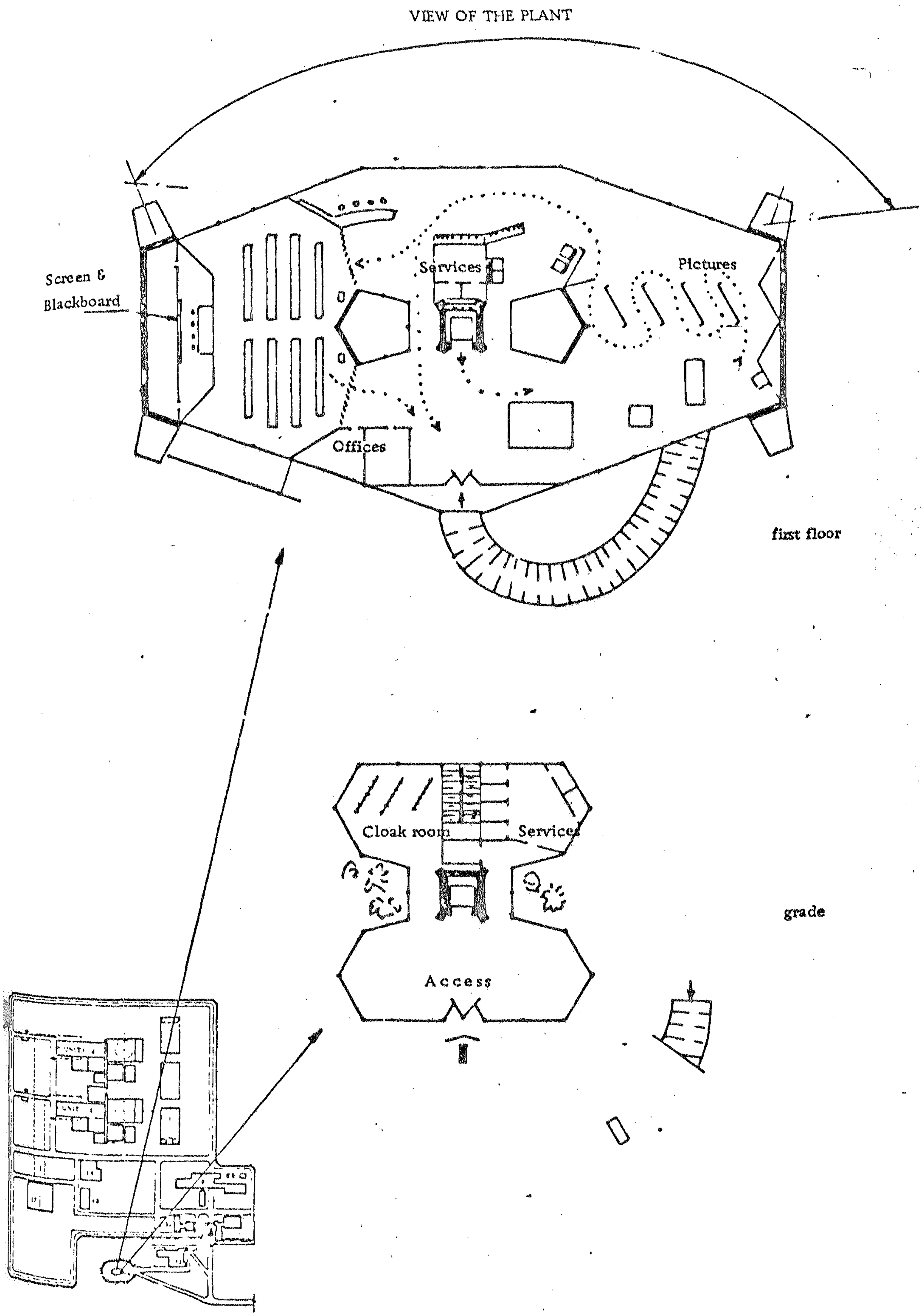


FIG. 18 - Information Center

SLIDE. 22

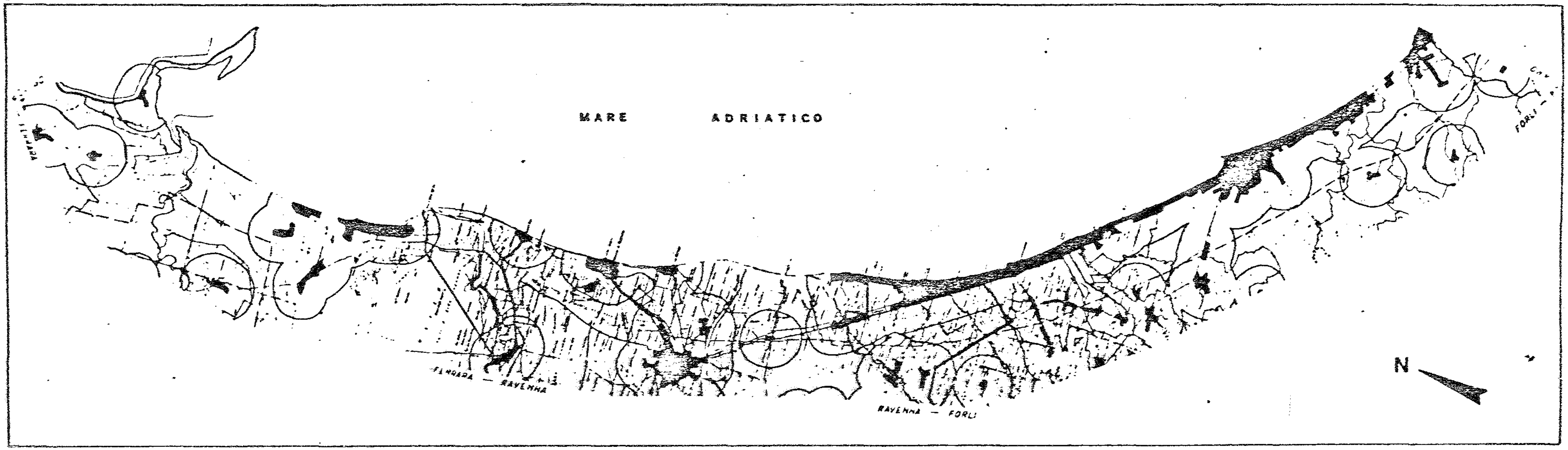
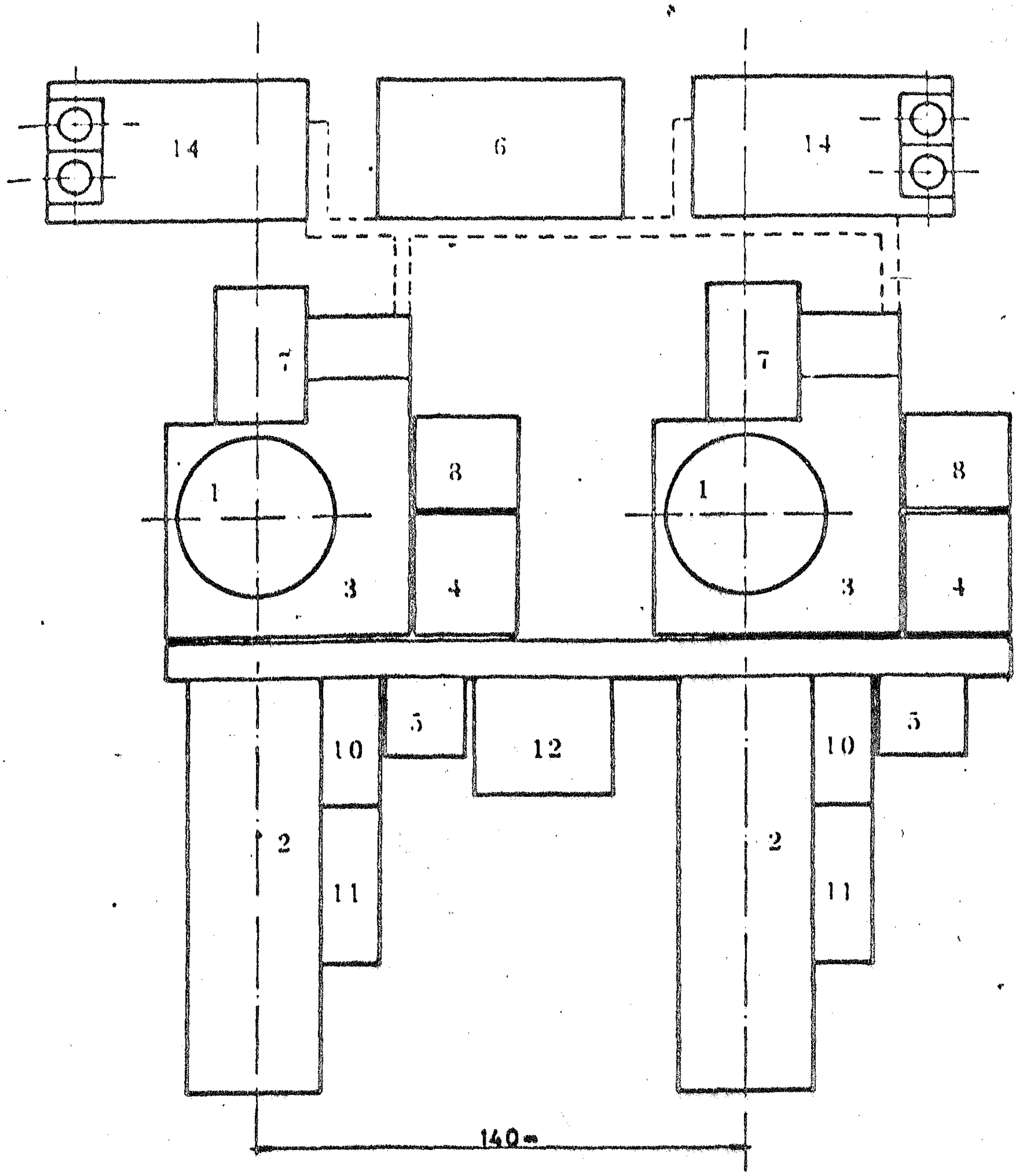


FIG. 19 - "Emilia - Romagna Coastline" Urban areas with over 2000 inhabitants/km^2 are marked in black

SLIDE 23



MAIN UNIT BUILDINGS

1. Reactor building
2. Turbine building
3. Reactor auxiliaries building
4. Control room building
5. Normal switchgear building
7. Fresh and spent fuel building
8. Emergency diesel generator
10. Condensate treatment building
11. Heater bay building
14. Emergency cooling tower building

MAIN BUILDINGS COMMON TO THE TWO UNITS

6. Radwaste storage and treatment building
12. Controlled area service building

SLIDE 24

FIG. 20 - General plant layout for PWR reactors

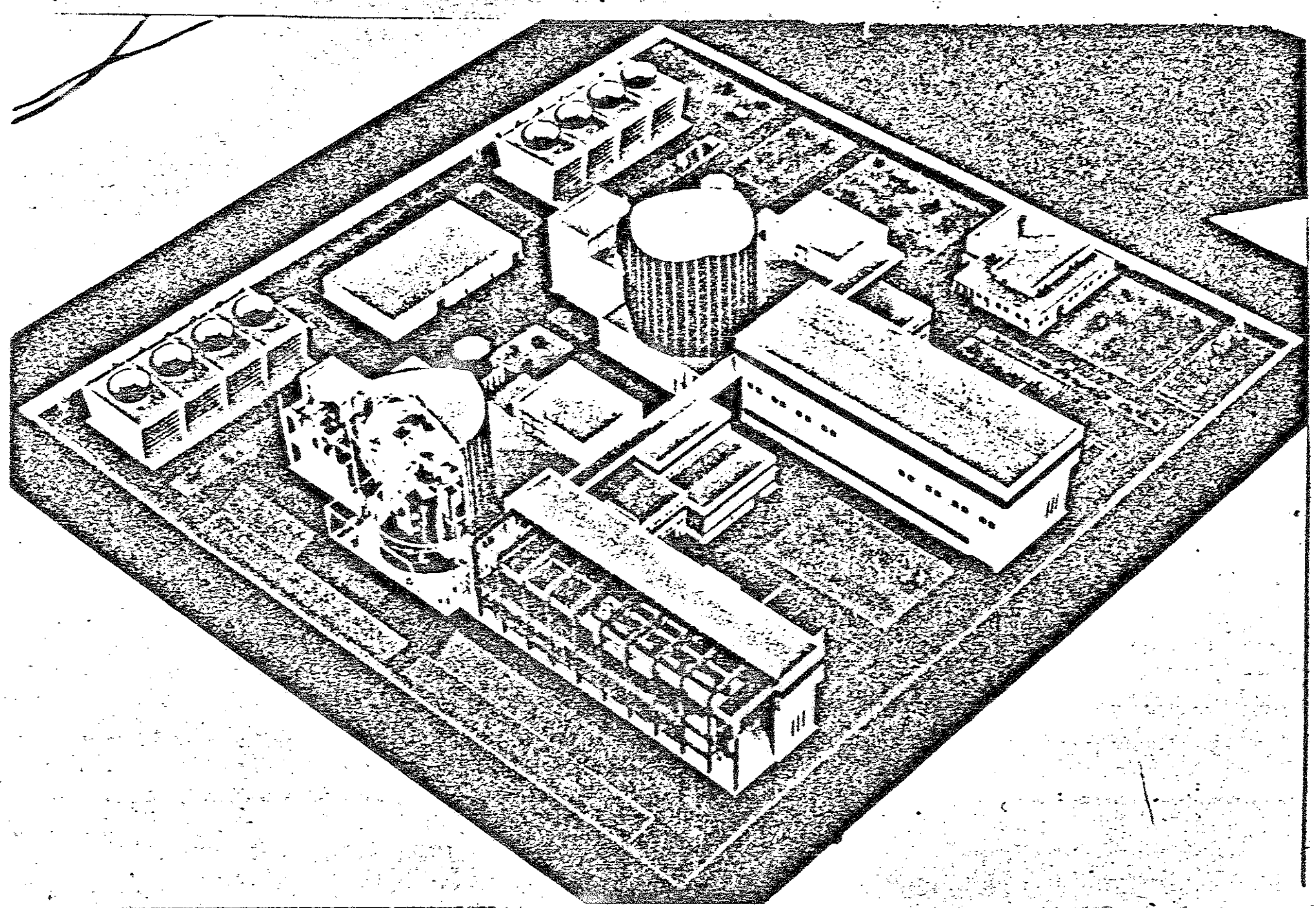


FIG. 21 - Model of the standardized PWR station

SLIDE 25

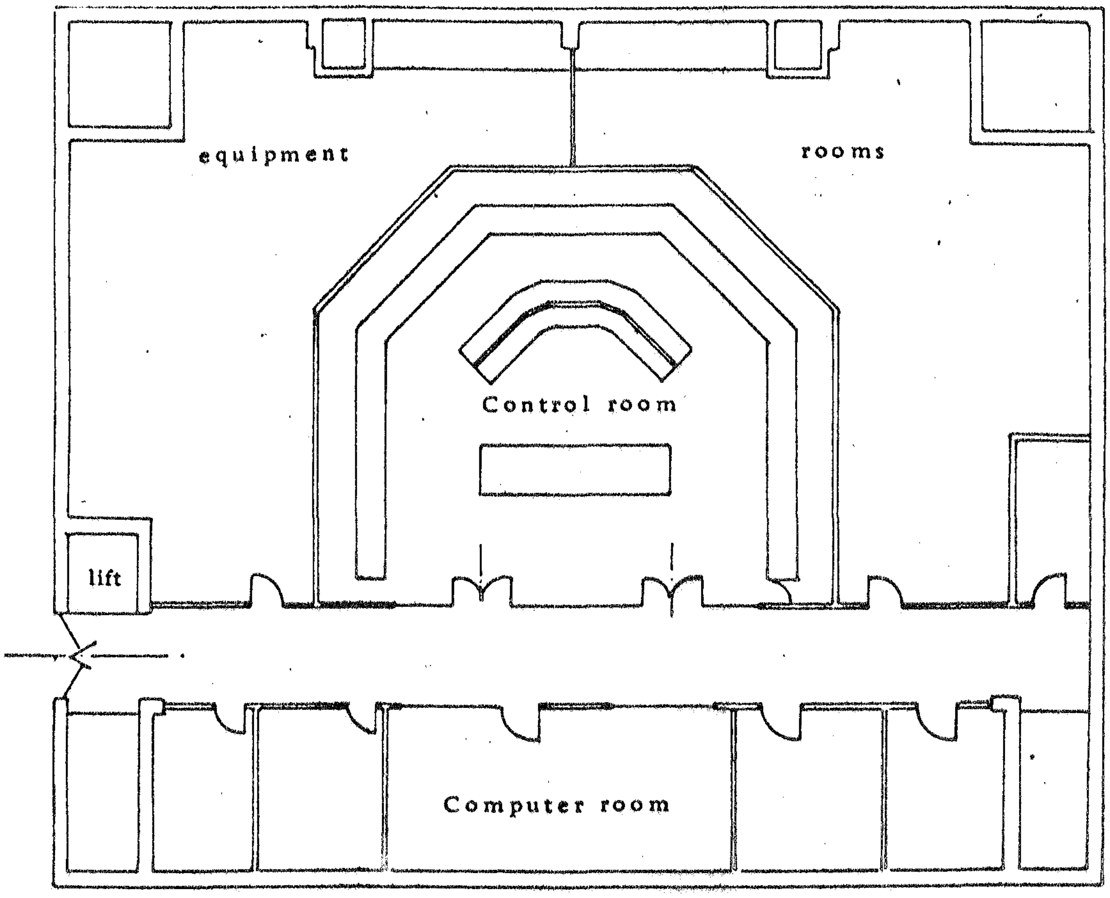
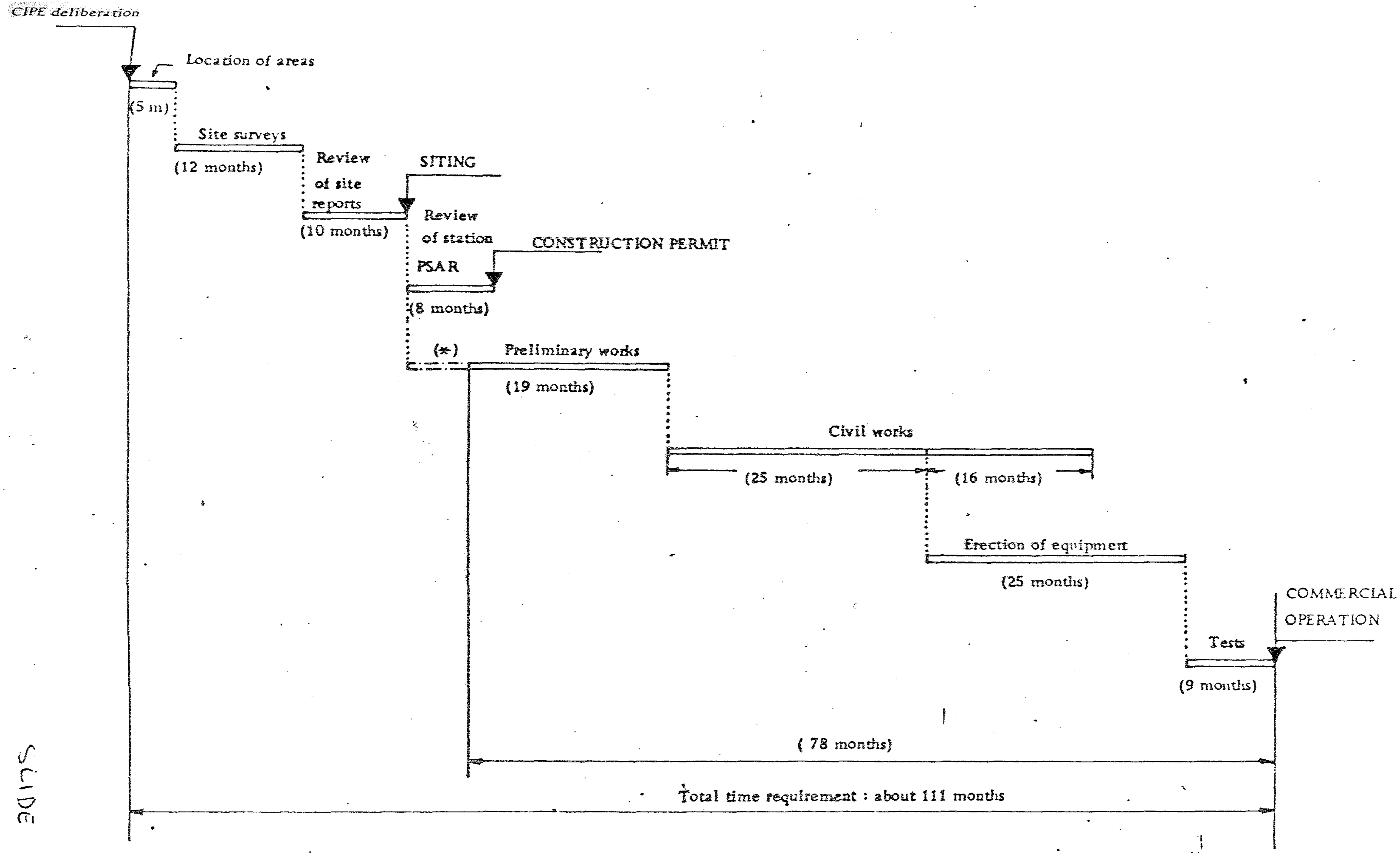


FIG. 22 - Control area layout

SLIDE 26



Note : (*). Estimated time requirement for land purchase : about 6 months

FIG. 23 - Total time required for the construction of a nuclear power plant

SLIDE 27

3/9 午後 第1セッション
ラーソン氏 本論文

④-1

"ENERGY QUESTIONS AND ATOMIC ENERGY DEVELOPMENT IN THE UNITED STATES - FROM INDUSTRY'S POINT OF VIEW"

REMARKS OF HOWARD J. LARSON
VICE-PRESIDENT, ATOMIC INDUSTRIAL FORUM
BEFORE THE
TENTH ANNUAL CONFERENCE OF THE
JAPAN ATOMIC INDUSTRIAL FORUM
MARCH 9, 1977
TOKYO, JAPAN

The United States has just weathered the most severe winter in recent history, at a time when domestic energy resources were insufficient. A new cry has gone up--"What's the real story on natural gas and why weren't we told before?"...a similar cry to those heard during the long gas lines of a few years ago. Even coal, our one plentiful domestic resource, was suffering--mines were frozen, transportation routes were uncertain, and there were instances when the train coal-hopper cars were frozen and could not be unloaded. At one time, at least two million additional people were out of work, states of emergency were declared in many areas--for a week or more--schools were closed, and heat was turned off in non-essential businesses using gas as a fuel.

Had the approximately 20 million kilowatt-hours of electricity estimated to have been produced by nuclear power plants in January not been available, these consequences would have resulted:

* More than 257,000 jobs lost in this month.
* Nearly $230 million lost in monthly wages.
* A reduction of some $3.8 billion in the month for various goods, products, and services that make up the gross national product.
* Additionally, the 10 million homes, 1 million stores, office building and schools; and 60,000 factories, industries and manufacturing plants that could have been served by this nuclear generation would have needed their energy requirements met by other means.

* Filling these demands for electricity by other sources would have required:

  ---32 million barrels of oil, nearly 13 per cent of current monthly domestic production, or

  ---182 billion cubic feet of natural gas, more than 10 per cent of current monthly production, or

  ---9.6 million tons of coal, about 17 per cent of current monthly production.

Much is heard in the United States today about the need for an energy policy. However, and with bowed head, I must admit that indeed we do have an energy policy that is just as real as one in writing. We have a "de facto" policy of non-policy, which shapes our thinking and actions with as much impact. The need to plan, rather than exist in a staccato fashion, is unquestioned...but undone.

However, in our society both public understanding and confidence in the real gravity of the situation is a necessity--and that we do not have. Although politicians have mouthed the words now and again, it was with mixed pleasure to hear the words loud and clear from President Carter, at his first fireside chat last month, that there is <u>no short range solution</u> to the energy crisis. As a nation, to make things right, we always have sought either a panacea or else faith in Divine Providence. I believe the constant reminders that the United States will undergo over the next several years will bring home to all but the most skeptical, the reality of our nation's energy distress. It has

been estimated that the energy needs of the United States in the next 15 years will require 450,000 new oil and gas wells, 31 new refineries, 200 large coal mines, 2,700 unit trains, 30 uranium mining and milling complexes and 17 synthetic fuel plants. The capital requirements for these new facilities alone, even without allowing for inflation, may amount to roughly $30 billion a year over the next 10 years--more than double the energy industry's annual investment rate of the past 10 years.

Conservation:

The first panacea we grasp for is conservation. At this juncture in our society, it is accepted that we have been wasteful of our resources.

We recognize we must trim our rate of energy growth, but we must also be mindful of the great disparities that exist among existing households for we have our energy rich and our energy poor. Those who advocate zero growth and spartanization of our energy economy--so, to speak a return to Walden Pond--should be required to take a hard look at the economic consequences of such a proposal.

There are 70 million households today and up to 30 million new households will be formed before the year 2000. A zero growth policy will deny existing households energy for satisfying their basic requirements of many energy poor millions of people. The advocates of zero growth must ponder where our households in formation will get their energy.

We cannot ratchet backward in time to the days of Walden Pond. Perhaps we should recall Thoreau's advice: "It is a characteristic of wisdom not to do desperate things."

We do expect, however, that efforts to conserve energy will prove beneficial over the next 25 years, with the possibility of a 25% savings. It is not generally understood by the American public, however, that energy requirements will demand increased generation capacity regardless of the effectiveness of our conservation program. It is expected that much greater emphasis will be placed on conservation as a national policy. Legislation with special tax incentives has been proposed both nationally and in several of the states.

Nuclear Power Plant Status:

Of course, I came here to talk about a recently much maligned program--nuclear. As an introduction, it might be worth noting the status of the United States nuclear program as of January 1, 1977:

	1976	1975	1974
Operating Licenses Issued	6	3	9
Construction Permits Issued	9	9	14
New Orders	3	5	
Deferrals	7		
Cancellations	2		
Reactors Operating	64		
Reactors Under Construction	90		
Reactors Commited	228		

It should be pointed out that the 90 units under construction represent a backlog of over $60 billion and that the 228 nuclear units thus far commited have a capacity about three times that of the country's entire electric power grid 25 years ago, when man first produced electricity from nuclear energy. By 1980, it is quite likely that nuclear power will displace petroleum and will be second only to coal as a source of electric power.

Ten of our 50 states get more than a quarter of the electricity from nuclear power. Connecticut draws 50% of its electricity from the atom, followed by Nebraska, 47%; Vermont, 44%;, Maine, 40%; South Carolina, 36%; Minnesota, 31%; Illinois, 30%; North Carolina, 30%; Wisconsin, 29%; and Arkansas, 25%. During the recent cold wave, Chicago derived 48% of its power from 6 of its 7 nuclear plants and the New England area as a whole, over 30%. As a recent press release noted, "with only slight exaggeration, nuclear power bailed the country out of an emergency on the morning of January 17."

Nuclear Performance:

There has been a lively discussion in the United States regarding the performance of nuclear versus fossil. I believe it is generally accepted that there is little difference between the two. A recent report notes that a comparison of the cumulative unit availability for all fossil fired plants of 390 Mw or more with comparable units fired only with coal and with pressurized water reactors gives values of 77.9%, 75.8%, and 74.7%. An

objective of 80% availability for mature nuclear power plants is sometimes used in the industry, particularly as related to regulatory activity. Our nuclear opponents frequently use this figure to claim that nuclear power is not living up to its promise. However, a study by one major United States nuclear steam system supplier, utilizing a base of 18 units, showed an average unit availability in 1975 of 78.6%--and the highest rated unit stood at 93.9%.

With performance records at this level, nuclear units are on their way toward exceeding the availability of conventional fossil-fired units.

It might do well to compare the availability factors for one of our nation's largest utilities, Commonwealth Edison, for large nuclear and coal-fired units for 1972, 1973, 1974, and 1975:

AVAILABILITY FACTOR

	1972	1973	1974	1975
Nuclear	72	82	68	64
Coal-fired	71	69	73	68

There is also a belief that the older reactors get, the more unreliable they become. There is little data on "old" reactors since nuclear power is still in its adolescence.

The number of shutdowns for the "old" nuclear power plant, Connecticut Yankee, is perhaps a good index of the reliability of the plant.

PLANT SHUTDOWNS

Year	Planned	Automatic	Manual	Total
1967	6	19	2	27
1968	13	12	1	26
1969	5	5	7	17
1970	9	6	2	17
1971	4	4	2	10
1972	5	3	0	8
1973	6	0	1	7
1974	5	4	0	9
1975	5	1	0	6

The data would indicate that perhaps plant performance improves with age.

Nuclear Generation Costs:

Nuclear power plant costs have also been the subject of much study and discussion during the past year.

From an analysis of the various data available, it is evident that the difference in capital costs for nuclear power and coal plants with stack-gas scrubbers will narrow considerably in the mid-1980's, making electricity generated by nuclear far cheaper because of lower fuel costs.

One projection indicates that a 1200-megawatt nuclear plant build in the northeast United States to operate in 1985-1987 will cost $1300 per kilowatt, assuming 7% inflation.

The capital cost of a coal-fired plant of equivalent capacity will be nearly $1200 per kilowatt, if scrubbers are required.

Another study gave similar results--conventional nuclear plant, $975/Kw. (This is in 1985 dollars and includes interest during construction.)

For an 850 Mw coal plant without scrubbers, using western coal, and located in the northeast, capital costs of $765/Kw are estimated. (If cooling towers are required, add $85/Kw to nuclear capital cost and $55/Kw to the coal-fired plants' capital costs.) The nuclear plant has a total energy cost, including capital, fuel, and operation and maintenance, of 3.85 cents/Kwh (1985 dollars), the coal plant without scrubbers, 5.24 cents; the coal plant with scrubbers, 5.93 cents. These numbers are based on a 66% capacity factor for the nuclear plant, 70% for the coal plant without scrubbers, and 67% for the other coal plant.

The assumptions used: long term inflation rate, 7% to 1981, 5% thereafter; nuclear fuel cost, 60 cents/million Btu (1985 cost), eastern high sulfur coal, 240 cents, western low sulfur coal, 300 cents; uranium, $34/pound; enrichment, $100/Swu; fuel fabrication, $120 per Kg; reprocessing and waste disposal, $200,000/tonne; and plutonium credit, $14 gram.

To provide the electric generating needs of the nation, the investor-owned utilities expect to spend about $122 billion on construction over the next 5 years, of which 60% of the total will be outside financing. In 1976, utilities spent $17 billion on new electric plants and equipment. About $13 billion is expected to be raised in 1977 for new electric generating capacity. These are large numbers and will strain utility finances. Operating revenues in 1976 were up 13%, indicative of the nation's recovery from the recent recession--and electrical useage continues to

climb--up to about 6.3% growth rate for the year just ended. Predictions for 1977 show a similar growth rate. Zero growth advocates, who felt the 1974-75 period was indicative of a change in the public's perception of the need for conservation, have had to recant their predictions.

The Nuclear Debate:

In a sense, the nuclear debate is a classic example in which much of the public has perceptions not based on real facts. Yet those perceptions are leading to behavior which the energy industry has to deal with--citizen action to slow down nuclear power.

Let's look more closely at the dynamics in this nuclear debate.

The current state of public attitudes in the area of energy and nuclear power can be outlined as follows:

1. There is still little public awareness of America's real energy problems and the reality of energy shortages. The public continues to believe that the "crisis" is essentially caused by the oil industry, with its allies the utilities, in their mutual quest for higher profits.

2. The relationship between plentiful energy in America and the overall health of the economy is also not clear to the public. While the people want increased employment opportunities and a rising standard of living in the years ahead, they sense little urgency for making decisions now on basic energy supply questions, like nuclear power or expanded coal development. (The recent gas shortage, has however hit home, but there is still a question as to whether it is contrived or not.)

3. This combination of disbelief in the basic energy problem and no clear sense of the energy/economy linkage allows the public the opportunity of looking very favorably on those who say "Why rush into a decision on nuclear?", "Let's be extra careful", "We should stop strip-mining of coal", "Let's not allow the utilities to raise their rates some more."

   While no one argues that development of new energy sources, be they nuclear, coal, synthetic gas, shale, off-shore drilling, should proceed without all prudent attention to issues of safety and environmental concern, the attitudinal climate in the country today is one which allows the public to weigh these decisions without properly considering the trade-offs involved, i.e., decreased economic growth, lower job opportunities, higher energy costs.

4. The oil and electric utilities industries are seen to be making excessive profits today. Fully 71% of the American public believe the electric utilities have a profit margin significantly "too high."

5. With regard to nuclear power, the public has serious doubts about the safety of the technology. They label nuclear power the "most dangerous" energy source, and a majority believe a nuclear power plant can actually explode like an atomic bomb. Coupled with this is a belief that nuclear power is the most expensive form of energy.

6. With regard to greater reliance on coal as a source of energy for electric utilities, the public opposes relaxing air pollution standards so that more coal can be burned. And it supports greater limitations on strip-mining, particularly in the West.

7. There is a strong belief among the public that new energy sources, particularly solar, are currently available, or soon will be. This belief in other alternatives again allows the public to avoid making the hard, "real" choices about developing nuclear energy and coal as the realistic ways of satisfying America's energy needs for the next 25 years.

Once one understands these public attitudes, it is easy to see why advocates of expanded coal usage and nuclear power

have been put increasingly on the defensive.

The fact to remember, however, is that the American people are as yet undecided on the future role various energy sources, including nuclear, should play. The biggest problem hindering a sophisticated judgment on this question is basic lack of knowledge and facts. Within this current attitudinal milieu, scare stories, confusion and irrationality often triumph. Only through careful education of facts and knowledge can the people know what the real choices are and can thereafter make the decisions wisely.

Nuclear Initiatives:

In spite of what I have just said above, generally, in the United States, the operating record of the nuclear generating stations is accepted by the general public as evidenced by the results of last year's moratorium votes. Without belaboring you with the results, which you are undoubtedly fully aware of, let me reiterate the percentages.

STATE	FOR/AGAINST PERCENTAGE
Arizona	30/70
Colorado	29/71
Montana	42/58
Oregon	42/58
Ohio	32/68
Washington	33/67

Counting the June 8, 1976 California vote, some 12 million Americans, representing seven states containing about 20% of the total United States population, have had the opportunity to cast their vote on nuclear power. To put this in perspective, the recent Carter/Ford presidential margin was 51/48, so the significance of these figures is very obvious.

Further confirmation of this public attitude was indicated in a Roper Report released in mid-October. Seventy per cent favor continued advances in nuclear energy, 13% believe we have gone as far as we should, 8% said we have gone too far now, and 9% did not answer or know.

In 1977-78, there is a possibility of two further votes--Maine in 1977 and Michigan in 1978. Signature gathering is in progress now in these states. However, we believe this small number of new initiatives is indicative that the referendum/initiative process to challenge nuclear expansion has probably run its course.

Nuclear Fuel Cycle:

Now, however, it is probably time to turn to the most emotional part of the industry--the nuclear fuel cycle.

The problems associated with the front end of the fuel cycle are comparatively easily understood and the solutions obvious.

In the front end, uranium supply and enrichment are the two current problem areas. Insofar as the former, an increased uranium exploration program is underway, with its objective being the better definition and resolution of known and proven reserves. It is generally accepted that there are enough reserves to fuel all plants in operation, under construction or commited at this time and even beyond for their full lifetime.

The table below shows that ERDA's enrichment capacity in 1986, nine years hence, even assuming completion of a 9 million swu add-on at Portsmouth, will not be adequate to meet anticipated demand. Demand includes enrichment services for 141-189 Gwe of domestic nuclear power plant capacity (96% of which is already under contract) and 108 Gwe of foreign nuclear power plant capacity (100% of which is already under contract). The table is based on 0.2% U-235 tails, the most economically favorable assay with U_3O_8 at $52/lb. and enrichment charge at $110/swu. The table also assumes no reprocessing of spent fuel.

Table I
ERDA SWU Demand/Supply

	Gwu Forecast for 1986			SWU Demand* (millions)	ERDA Supply** w/Portsmouth / Add-On (millions)
	U.S.	Foreign	Total		
Low Forecast	141	108	249	39.3	36.7
Mid Forecast	167	108	275	40.5	36.7
High Forecast	189	108	297	43.2	36.7

* Includes 1.6 mm swu's for military use.
** Capacity with CIP and CUP complete will be 27.7 mm swu's and with the Portsmouth add-on will total 36.7 mm swu's.

Some observations:

* The Portsmouth add-on is a necessity and must be given priority to meet its scheduled completion date for full operation in 1986. The supply/demand crossover occurs in 1982/1983. The Portsmouth add-on is the best assurance of obtaining the next increment of supply.

* Construction lead times of 8-10 years necessitates a decision in 1977 to increase enrichment capacity beyond the Portsmouth add-on. Even with the addition of another 9 million swu's the supply/demand crossover occurs in 1989.

* ERDA should maintain "transaction" tails at 0.2% U-235 and seek to set "operating" tails at 0.2% U-235 at the earliest possible time.

There are many problems that need to be resolved associated with the end of the fuel cycle. I will not elaborate upon them other than to note that they relate to regulatory indecisiveness. And, since these problems are well known, I shall just touch upon a few.

1. GESMO - This document spans the scope of end-of-cycle activities. Its final determination will impact upon design, construction, operation and economic viability of most nuclear facilities. Whether Pu recycle is allowed or not, however U recycle should be permitted and the spent fuel storage problem must be addressed.

(It would seem like the best national policy interests could be served by the separation of usable products and wastes, and the resultant significant reduction, volume-wise, in the generation of both high-level and transuranic wastes, the ones that generate the most emotional reactions.)

2. Regulatory Uncertainty - Some of the facilities are licensed under Part 70, some under Part 50, 10 CFR. There are no real design criteria, Standard Review Plans, or any other guides to an applicant. Therefore, in a way, there is no such thing as the "ratcheting" that occurs with nuclear power plants because that term implies an understood acceptable starting point. There are basic licensing issues/decisions which NRC must face, but due to lack of applications, and the GESMO hearings, little, if any, effort is addressed to resolving these areas of contention. NRC itself possesses only a small cadre of knowledgeable people and the effort in some technical areas is diffuse. By that it is meant that in some areas the Office of Nuclear Reactor Regulation provides the technical support - and one cannot use the methods for a high pressure high energy system (reactor) and apply them without judgement to a low pressure (much in vacuum), low energy system such as a separations facility.

3. Foreign Policy Considerations - Without further explanation, suffice to say that this whole area is completely intermeshed with the State Department and Congress exercising an extremely heavy hand.

4. Radioactive Wastes - This subject, which has been debated nationally, requires little amplification. At this time, there is no technological reason why wastes cannot be solidified into a proper form. The problem lies with the lack of criteria as to waste classification, the acceptable form for disposition of each classification, and the establishment of the ultimate repository. Even low-level wastes, which used to be easily disposed of at burial sites, are the subject of much concern - the current sites are filling up, some have been closed, and new applications are being held up. A seemingly minor problem, but one with significant cost implications, is the eventual disposition of transuranic contaminated wastes (the definition is lacking), reactor cladding hulls and other hardware. Because of the major uncertainties in this whole area (including possible safeguards requirements), this part of a reprocessing facility could equal or exceed the costs of the separations facility.

The costs for disposal at the eventual government owned and operated repository are still unknown. Industry should participate in the establishment of the bases for these costs.

Opponents of nuclear power have exaggerated the problems involved in permanent waste disposal by confusing the issue with handling of liquid wastes from the military reactor program, by hyperbolizing plutonium risks and by implying that hugh quantities of wastes will be involved. Their charge

that there is no solution to the waste disposal issue misstates the issue; a number of feasible options exist and an orderly choice can be made if the public policy process is not excruciated.

One should also recognize that liquid and gaseous wastes also pose a significant uncertainty. Off-gas recovery for krypton and iodines, particularly, can result not only in as yet-to-be determined costs, but the lack of commercially demonstrated operating systems could impact on plant operation.

5. Plutonium - This is inextricably tied into GESMO and until the basic Pu recycle decision is made, it will be unlikely that criteria for solid form and acceptable packaging will be made. A small thing like packaging (design of container, its accident conditions, the number that can be shipped on any one vehicle, etc.) will require a late flurry of design and construction activity for the special vehicle. (This same problem, of course, applies to the waste carrying vehicle, for which, at this time, the designated container has not been specified to a sufficient degree to permit design to commence.) There is also a potential that Pu may not be separated out at this time, but no decision has yet been made. That indecisiveness requires, then, that the separations facility have another degree of flexibility, not only in the original separations process, but throughout the remainder of the facility as neutron fluxes and criticality considerations could influence piping design and layout.

As an aside, one must always remember that a reactor is designed for optimum criticality, a reprocessing plant to prevent it--and the latter has a multiplicity of streams and mixtures of varying enrichment and materials.

There is still some work that need to be done to improve the solubility (and thereby the separation efficiency) of mixed oxide fuels. Currently, they do not dissolve easily. This can mean either a slower process or the addition of equipment, which in either case costs money.

6. <u>Safeguards Uncertainties</u> - GESMO and the other activities underway in this area pose significant design and cost consideration. In addition, a reprocessing plant has another related analytical problem--that of materials accountability. While in a reactor, SNM accountability is a simple matter, the question of accuracy of measurement, of which streams, and frequency of complete inventory, can impact upon facility operation, layout and, in some cases, the lack of precise measuring equipment is still a significant technical problem.

Because many of these problems will be discussed in great detail by the speakers in following sessions, I will not elaborate further at this time other than to note that these problems have or can be solved. As noted, many of these problems result from the failure of government leadership to make decisions. Due to this apparent policy of only making decisions at the latest (and in some cases, too late) hour, industry finds itself in a position that does not permit it to make the necessary investment due to an uncertain capital return. This uncertainty

is hydra-headed in that the timing of the decision, the nature of the proposed action or whether a moratorium or prohibition will result, are all possibilities. Prudent businessmen, without some form of government guaranty, cannot commit their organization's funds in what must be construed as an extremely risky investment. Insofar as just the reprocessing segment of the end of the fuel cycle is concerned, hundreds of millions of dollars of private funds have been expended but, as you are aware, not one commercial plant is in operation at this time in the United States.

National Environmental Policy Act and the Public Interest -

Not mentioned in the above listing, but of equal importance, is the leniency exercised by the various appeal boards and courts to people with obvious bias, marginal interests and paltry arguments. The saddest element of this situation is that even these judicial (or quasi-judicial) tribunals fully recognize that their "widest latitude in the public interest" admissibility criteria is perhaps not in the public interest. So, the charade goes on, with many dollars and hours spent answering semi-facetious questions for many groups whose only real interest is simple--cause delay which causes increased costs, which can eventually cause investors to lose interest in the nuclear option.

To be sure, there are genuinely concerned citizens and groups that fully deserve to be heard and answered as completely as possible. The age of the consumer voice is here and a

failure to recognize it will only result in the failure of a democratic society to function properly for its citizens. Genuine public concern is everyone's concern, but phony litigation should be recognized for what it is and the agencies that are to deal with it should deal sharply and mercifully with it.

The Seabrook case in New Hampshire is an example of an agency bending over backwards to air an argument that resulted in an investment of over $300 million so far being stopped. And even if the decision is reversed, an increased cost to the consumer for his electricity will result--for which he will pay. The magnitude of the argument boils down to this: the plankton damage caused by the increased temperature equals that consumed by four healthy blue whales everyday. Somehow we must regain our perspective.

The purpose of our National Environmental Policy Act of 1969 was to protect man--sometimes this seems to be forgotten in the process. And, I seriously doubt whether the whale population of the world, given they had a voice, would object to this incursion into their dominion. The rhetoric, however, has progressed almost to the point where the real "guts" of the issue will be difficult to surface. The arguments have many times devolved into a crusade for principle without a reasoned recognition of the needs of man.

One wonders not whether man can live in peace with nature, but whether he can live in harmony with his own narrow beliefs of nature. The apparent martyrdom of the pseudo-environmentalists is admired by many citizens. What they fail to recognize is that in the end it is they themselves, the citizens, who have been crucified by those they admired.

The plutonium spectre has been raised and dragged across the pages of the press as if it were something that had been secreted from the public. Five years ago I went to the Council of Environmental Quality and explained to them what reprocessing was all about and they complimented us on doing just what this nation needed--reducing wastes, more efficiently using resources through recycling, and utilizing the self-generated plutonium. A few years later, that same facility, with improved waste recovery systems, was labeled an extremely dangerous facility that must be stopped until detailed scrutiny could be applied to it. The prior plaudits had evaporated.

Nothing, however, had changed except a response to politically active "environmentalists." The technical arguments of the company had actually improved, but the societal-political arguments, which had largely been ignored due to their incalculable nature, came to the top. This is an area where industry has not been sufficiently alert.

Energy Policy -

The potential for a meaningful solution to many of these problems rests with the development and resolution of a national energy policy that recognizes the proper contribution that fossil, nuclear, conservation and advanced energy systems can make and in what time frame.

The development of that policy will require a concerted effort between the legislative and executive branches of our government. In January, Congress reorganized its committee operations and essentially dissolved the principal nuclear focal point--the Joint Committee on Atomic Energy. This will make the development of a program more difficult as the new Congress attempts to evolve a policy. In addition, new faces in leadership roles must get up to speed. So, we are faced with a new administration, a Congress with a diffused committee structure, led by new faces with an as-yet undetermined position in many vital areas.

One example area of confusion is the future fate of the breeder. Public utterances by the new administration have not been reassuring. Industry itself is not certain of the direction that it desires the program to take--the development of the next generation of commercial breeders is most confusing. How it will occur, how many, what the mechanism will be for its development (government/industry participation), and the time frame will be subjects that need to be resolved.

Industry experience in the efforts for development of the Clinch River Breeder Reactor have not been as anticipated. Future similar arrangements will be entered into probably only with different terms and conditions. It is also difficult to imagine much in the way of industry commitment without a closing of the LWR fuel cycle and reasonable assurance that the breeder cycle will also be closed. The utility industry needs the reassurance that it has failed to receive thus far.

Conclusion -

It is too early to indicate the policy that the Carter Administration will follow. It has announced its intention to submit a comprehensive energy policy by mid-April. Insofar as nuclear, we do know that prior to taking office they queried the breeder program; viewed with caution private commercial enrichment; and believed that insofar as nuclear reactors, they should be located below ground in vacuum containments, in sparsely populated areas, with a federal employee with shut-down authority stationed in the control room. Only time will see whether this evolves into the announced program. One of the real difficulties in our political system is that the solution to these problems will take a long time, but many politicians are interested only in what will occur during their term of office. We may see short term fictitious solutions when viewed from the reality of the long term nature of the problem, and the question is whether the pressure on the

new Administration to produce solutions now will subvert the proper "payoff" ten to fifteen years from now. We do have a cautious optimism that the problems will be overcome by a policy that provides the needed direction and leadership.

There has been a semi-official attitude that nuclear is the last resort. We in the industry will accept that if the interpretation is that instead of the slogan "nuclear and coal", it becomes "coal and nuclear." All energy sources are needed, not just a select one or two. As noted above, the "last resort" brought this country through a crisis a few weeks ago. We are trying to tell that story as well as look ahead. We must focus on the fact that industry's fuel cycle options are limited and governmental decisions are needed now.

In closing, I would like to repeat the words of Robert Frost, quoted as the lead in Amory Lovin's recent article:

> "Two roads diverged in a yellow wood,
> And I took the one less travelled by-
> And that has made all the difference."

Twenty-five years ago was the birth of generation of electricity from nucear power--certainly "a road less travelled by." The dedication of thousands of people has produced safe, clean, economical nuclear power plants that have over 200 accident free years of operating experience and whose worth to our nation's industry and balance of payments has been clearly demonstrated. Only by turning our back to these facts in search of unproven sources will we really know the true meaning of those alluring words "and that has made all the difference." To ignore nuclear

will only make Puck's utterance more pertinent--"What fools these mortals be." That we cannot be if we are to pursue the ethical path of permitting our less fortunate neighbors and the unborn generations their rights to a society that has sufficient energy to provide for its needs. Our use of the chemical hydrocarbons--coal, oil and gas--must be critically analyzed in that light. Nuclear fission reactors, including the breeder, and fusion hold the promise for our future.

〈訂正サンプル〉 ④-2

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ラーソン氏 本論文

"ENERGY QUESTIONS AND ATOMIC ENERGY DEVELOPMENT IN THE UNITED STATES - FROM INDUSTRY'S POINT OF VIEW"

REMARKS OF HOWARD J. LARSON
VICE-PRESIDENT, ATOMIC INDUSTRIAL FORUM
BEFORE THE
TENTH ANNUAL CONFERENCE OF THE
JAPAN ATOMIC INDUSTRIAL FORUM
MARCH 9, 1977
TOKYO, JAPAN

The United States has just weathered the most severe winter in recent history, at a time when domestic energy resources were insufficient. A new cry has gone up--"What's the real story on natural gas and why weren't we told before?"...a similar cry to those heard during the long gas lines of a few years ago. Even coal, our one plentiful domestic resource, was suffering--mines were frozen, transportation routes were uncertain, and there were instances when the train coal-hopper cars were frozen and could not be unloaded. At one time, at least two million additional people were out of work, states of emergency were declared in many areas--for a week or more--schools were closed, and heat was turned off in non-essential businesses using gas as a fuel.

Had the approximately 20 million kilowatt-hours of electricity estimated to have been produced by nuclear power plants in January not been available, these consequences would have resulted:

* More than 257,000 jobs lost in this month.
* Nearly $230 million lost in monthly wages.
* A reduction of some $3.8 billion in the month for various goods, products, and services that make up the gross national product.
* Additionally, the 10 million homes, 1 million stores, office building and schools; and 60,000 factories, industries and manufacturing plants that could have been served by this nuclear generation would have needed their energy requirements met by other means.

* Filling these demands for electricity by other sources would have required:

  ---32 million barrels of oil, nearly 13 per cent of current monthly domestic production, or

  ---182 billion cubic feet of natural gas, more than 10 per cent of current monthly production, or

  ---9.6 million tons of coal, about 17 per cent of current monthly production.

Much is heard in the United States today about the need for an energy policy. However, and with bowed head, I must admit that indeed we do have an energy policy that is just as real as one in writing. We have a "de facto" policy of non-policy, which shapes our thinking and actions with as much impact. The need to plan, rather than exist in a staccato fashion, is unquestioned...but undone.

However, in our society both public understanding and confidence in the real gravity of the situation is a necessity--and that we do not have. Although politicians have mouthed the words now and again, it was with mixed pleasure to hear the words loud and clear from President Carter, at his first fireside chat last month, that there is <u>no short range solution</u> to the energy crisis. As a nation, to make things right, we always have sought either a panacea or else faith in Divine Providence. I believe the constant reminders that the United States will undergo over the next several years will bring home to all but the most skeptical, the reality of our nation's energy distress. It has

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Conservation:

The first panacea we grasp for is conservation. At this juncture in our society, it is accepted that we have been wasteful of our resources.

We recognize we must trim our rate of energy growth, but we must also be mindful of the great disparities that exist among existing households for we have our energy rich and our energy poor. Those who advocate zero growth and spartanization of our energy economy--so, to speak a return to Walden Pond--should be required to take a hard look at the economic consequences of such a proposal.

There are 70 million households today and up to 30 million new households will be formed before the year 2000. A zero growth policy will deny existing households energy for satisfying their basic requirements of many energy poor millions of people. The advocates of zero growth must ponder where our households in formation will get their energy.

We cannot ratchet backward in time to the days of Walden Pond. Perhaps we should recall Thoreau's advice: "It is a characteristic of wisdom not to do desperate things."

We do expect, however, that efforts to conserve energy will prove beneficial over the next 25 years, with the possibility of a 25% savings. It is not generally understood by the American public, however, that energy requirements will demand increased generation capacity regardless of the effectiveness of our conservation program. It is expected that much greater emphasis will be placed on conservation as a national policy. Legislation with special tax incentives has been proposed both nationally and in several of the states.

Nuclear Power Plant Status:

Of course, I came here to talk about a recently much maligned program--nuclear. As an introduction, it might be worth noting the status of the United States nuclear program as of January 1, 1977:

	1976	1975	1974
Operating Licenses Issued	6	3	9
Construction Permits Issued	9	9	14
New Orders	3	5	
Deferrals	7		
Cancellations	2		
Reactors Operating	64		
Reactors Under Construction	90		
Reactors Commited	228		

It should be pointed out that the 90 units under construction represent a backlog of over $60 billion and that the 228 nuclear units thus far commited have a capacity about three times that of the country's entire electric power grid 25 years ago, when man first produced electricity from nuclear energy. By 1980, it is quite likely that nuclear power will displace petroleum and will be second only to coal as a source of electric power.

Ten of our 50 states get more than a quarter of the electricity from nuclear power. Connecticut draws 50% of its electricity from the atom, followed by Nebraska, 47%; Vermont, 44%;, Maine, 40%; South Carolina, 36%; Minnesota, 31%; Illinois, 30%; North Carolina, 30%; Wisconsin, 29%; and Arkansas, 25%. During the recent cold wave, Chicago derived 48% of its power from 6 of its 7 nuclear plants and the New England area as a whole, over 30%. As a recent press release noted, "with only slight exaggeration, nuclear power bailed the country out of an emergency on the morning of January 17."

Nuclear Performance:

There has been a lively discussion in the United States regarding the performance of nuclear versus fossil. I believe it is generally accepted that there is little difference between the two. A recent report notes that a comparison of the cumulative unit availability for all fossil fired plants of 390 Mw or more with comparable units fired only with coal and with pressurized water reactors gives values of 77.9%, 75.8%, and 74.7%. An

objective of 80% availability for mature nuclear power plants is sometimes used in the industry, particularly as related to regulatory activity. Our nuclear opponents frequently use this figure to claim that nuclear power is not living up to its promise. However, a study by one major United States nuclear steam system supplier, utilizing a base of 18 units, showed an average unit availability in 1975 of 78.6%--and the highest rated unit stood at 93.9%.

With performance records at this level, nuclear units are on their way toward exceeding the availability of conventional fossil-fired units.

It might do well to compare the availability factors for one of our nation's largest utilities, Commonwealth Edison, for large nuclear and coal-fired units for 1972, 1973, 1974, and 1975:

	AVAILABILITY FACTOR			
	1972	1973	1974	1975
Nuclear	72	82	68	64
Coal-fired	71	69	73	68

There is also a belief that the older reactors get, the more unreliable they become. There is little data on "old" reactors since nuclear power is still in its adolescence.

The number of shutdowns for the "old" nuclear power plant, Connecticut Yankee, is perhaps a good index of the reliability of the plant.

PLANT SHUTDOWNS

Year	Planned	Automatic	Manual	Total
1967	6	19	2	27
1968	13	12	1	26
1969	5	5	7	17
1970	9	6	2	17
1971	4	4	2	10
1972	5	3	0	8
1973	6	0	1	7
1974	5	4	0	9
1975	5	1	0	6

The data would indicate that perhaps plant performance improves with age.

Nuclear Generation Costs:

Nuclear power plant costs have also been the subject of much study and discussion during the past year.

From an analysis of the various data available, it is evident that the difference in capital costs for nuclear power and coal plants with stack-gas scrubbers will narrow considerably in the mid-1980's, making electricity generated by nuclear far cheaper because of lower fuel costs.

One projection indicates that a 1200-megawatt nuclear plant build in the northeast United States to operate in 1985-1987 will cost $1300 per kilowatt, assuming 7% inflation.

The capital cost of a coal-fired plant of equivalent capacity will be nearly $1200 per kilowatt, if scrubbers are required.

Another study gave similar results--conventional nuclear plant, $975/Kw. (This is in 1985 dollars and includes interest during construction.)

For an 850 Mw coal plant without scrubbers, using western coal, and located in the northeast, capital costs of $765/Kw are estimated. (If cooling towers are required, add $85/Kw to nuclear capital cost and $55/Kw to the coal-fired plants' capital costs.) The nuclear plant has a total energy cost, including capital, fuel, and operation and maintenance, of 3.85 cents/Kwh (1985 dollars), the coal plant without scrubbers, 5.24 cents; the coal plant with scrubbers, 5.93 cents. These numbers are based on a 66% capacity factor for the nuclear plant, 70% for the coal plant without scrubbers, and 67% for the other coal plant.

The assumptions used: long term inflation rate, 7% to 1981, 5% thereafter; nuclear fuel cost, 60 cents/million Btu (1985 cost), eastern high sulfur coal, 240 cents, western low sulfur coal, 300 cents; uranium, $34/pound; enrichment, $100/Swu; fuel fabrication, $120 per Kg; reprocessing and waste disposal, $200,000/tonne; and plutonium credit, $14 gram.

To provide the electric generating needs of the nation, the investor-owned utilities expect to spend about $122 billion on construction over the next 5 years, of which 60% of the total will be outside financing. In 1976, utilities spent $17 billion on new electric plants and equipment. About $13 billion is expected to be raised in 1977 for new electric generating capacity. These are large numbers and will strain utility finances. Operating revenues in 1976 were up 13%, indicative of the nation's recovery from the recent recession--and electrical useage continues to

climb--up to about 6.3% growth rate for the year just ended. Predictions for 1977 show a similar growth rate. Zero growth advocates, who felt the 1974-75 period was indicative of a change in the public's perception of the need for conservation, have had to recant their predictions.

<u>The Nuclear Debate</u>:

In a sense, the nuclear debate is a classic example in which much of the public has perceptions not based on real facts. Yet those perceptions are leading to behavior which the energy industry has to deal with--citizen action to slow down nuclear power.

Let's look more closely at the dynamics in this nuclear debate.

The current state of public attitudes in the area of energy and nuclear power can be outlined as follows:

1. There is still little public awareness of America's real energy problems and the reality of energy shortages. The public continues to believe that the "crisis" is essentially caused by the oil industry, with its allies the utilities, in their mutual quest for higher profits.

2. The relationship between plentiful energy in America and the overall health of the economy is also not clear to the public. While the people want increased employment opportunities and a rising standard of living in the years ahead, they sense little urgency for making decisions now on basic energy supply questions, like nuclear power or expanded coal development. (The recent gas shortage, has however hit home, but there is still a question as to whether it is contrived or not.)

3. This combination of disbelief in the basic energy problem and no clear sense of the energy/economy linkage allows the public the opportunity of looking very favorably on those who say "Why rush into a decision on nuclear?", "Let's be extra careful", "We should stop strip-mining of coal", "Let's not allow the utilities to raise their rates some more."

   While no one argues that development of new energy sources, be they nuclear, coal, synthetic gas, shale, off-shore drilling, should proceed without all prudent attention to issues of safety and environmental concern, the attitudinal climate in the country today is one which allows the public to weigh these decisions without properly considering the trade-offs involved, i.e., decreased economic growth, lower job opportunities, higher energy costs.

4. The oil and electric utilities industries are seen to be making excessive profits today. Fully 71% of the American public believe the electric utilities have a profit margin significantly "too high."

5. With regard to nuclear power, the public has serious doubts about the safety of the technology. They label nuclear power the "most dangerous" energy source, and a majority believe a nuclear power plant can actually explode like an atomic bomb. Coupled with this is a belief that nuclear power is the most expensive form of energy.

6. With regard to greater reliance on coal as a source of energy for electric utilities, the public opposes relaxing air pollution standards so that more coal can be burned. And it supports greater limitations on strip-mining, particularly in the West.

7. There is a strong belief among the public that new energy sources, particularly solar, are currently available, or soon will be. This belief in other alternatives again allows the public to avoid making the hard, "real" choices about developing nuclear energy and coal as the realistic ways of satisfying America's energy needs for the next 25 years.

Once one understands these public attitudes, it is easy to see why advocates of expanded coal usage and nuclear power

have been put increasingly on the defensive.

The fact to remember, however, is that the American people are as yet undecided on the future role various energy sources, including nuclear, should play. The biggest problem hindering a sophisticated judgment on this question is basic lack of knowledge and facts. Within this current attitudinal milieu, scare stories, confusion and irrationality often triumph. Only through careful education of facts and knowledge can the people know what the real choices are and can thereafter make the decisions wisely.

Nuclear Initiatives:

In spite of what I have just said above, generally, in the United States, the operating record of the nuclear generating stations is accepted by the general public as evidenced by the results of last year's moratorium votes. Without belaboring you with the results, which you are undoubtedly fully aware of, let me reiterate the percentages.

STATE	FOR/AGAINST PERCENTAGE
Arizona	30/70
Colorado	29/71
Montana	42/58
Oregon	42/58
Ohio	32/68
Washington	33/67

Counting the June 8, 1976 California vote, some 12 million Americans, representing seven states containing about 20% of the total United States population, have had the opportunity to cast their vote on nuclear power. To put this in perspective, the recent Carter/Ford presidential margin was 51/48, so the significance of these figures is very obvious.

Further confirmation of this public attitude was indicated in a Roper Report released in mid-October. Seventy per cent favor continued advances in nuclear energy, 13% believe we have gone as far as we should, 8% said we have gone too far now, and 9% did not answer or know.

In 1977-78, there is a possibility of two further votes--Maine in 1977 and Michigan in 1978. Signature gathering is in progress now in these states. However, we believe this small number of new initiatives is indicative that the referendum/initiative process to challenge nuclear expansion has probably run its course.

Nuclear Fuel Cycle:

Now, however, it is probably time to turn to the most emotional part of the industry--the nuclear fuel cycle.

The problems associated with the front end of the fuel cycle are comparatively easily understood and the solutions obvious.

In the front end, uranium supply and enrichment are the two current problem areas. Insofar as the former, an increased uranium exploration program is underway, with its objective being the better definition and resolution of known and proven reserves. It is generally accepted that there are enough reserves to fuel all plants in operation, under construction or commited at this time and even beyond for their full life-time.

The table below shows that ERDA's enrichment capacity in 1986, nine years hence, even assuming completion of a 9 million swu add-on at Portsmouth, will not be adequate to meet anticipated demand. Demand includes enrichment services for 141-189 Gwe of domestic nuclear power plant capacity (96% of which is already under contract) and 108 Gwe of foreign nuclear power plant capacity (100% of which is already under contract). The table is based on 0.2% U-235 tails, the most economically favorable assay with U_3O_8 at $52/lb. and enrichment charge at $110/swu. The table also assumes no reprocessing of spent fuel.

Table I
ERDA SWU Demand/Supply

	Gwu Forecast for 1986				ERDA Supply** w/Portsmouth / Add-On
	U.S.	Foreign	Total	SWU Demand* (millions)	(millions)
Low Forecast	141	108	249	39.3	36.7
Mid Forecast	167	108	275	40.5	36.7
High Forecast	189	108	297	43.2	36.7

* Includes 1.6 mm swu's for military use.
** Capacity with CIP and CUP complete will be 27.7 mm swu's and with the Portsmouth add-on will total 36.7 mm swu's.

Some observations:

* The Portsmouth add-on is a necessity and must be given priority to meet its scheduled completion date for full operation in 1986. The supply/demand crossover occurs in 1982/1983. The Portsmouth add-on is the best assurance of obtaining the next increment of supply.

* Construction lead times of 8-10 years necessitates a decision in 1977 to increase enrichment capacity beyond the Portsmouth add-on. Even with the addition of another 9 million swu's the supply/demand crossover occurs in 1989.

* ERDA should maintain "transaction" tails at 0.2% U-235 and seek to set "operating" tails at 0.2% U-235 at the earliest possible time.

There are many problems that need to be resolved associated with the end of the fuel cycle. I will not elaborate upon them other than to note that they relate to regulatory indecisiveness. And, since these problems are well known, I shall just touch upon a few.

1. GESMO - This document spans the scope of end-of-cycle activities. Its final determination will impact upon design, construction, operation and economic viability of most nuclear facilities. Whether Pu recycle is allowed or not, however U recycle should be permitted and the spent fuel storage problem must be addressed.

(It would seem like the best national policy interests could be served by the separation of usable products and wastes, and the resultant significant reduction, volume-wise, in the generation of both high-level and transuranic wastes, the ones that generate the most emotional reactions.)

2. Regulatory Uncertainty - Some of the facilities are licensed under Part 70, some under Part 50, 10 CFR. There are no real design criteria, Standard Review Plans, or any other guides to an applicant. Therefore, in a way, there is no such thing as the "ratcheting" that occurs with nuclear power plants because that term implies an understood acceptable starting point. There are basic licensing issues/decisions which NRC must face, but due to lack of applications, and the GESMO hearings, little, if any, effort is addressed to resolving these areas of contention. NRC itself possesses only a small cadre of knowledgeable people and the effort in some technical areas is diffuse. By that it is meant that in some areas the Office of Nuclear Reactor Regulation provides the technical support - and one cannot use the methods for a high pressure high energy system (reactor) and apply them without judgement to a low pressure (much in vacuum), low energy system such as a separations facility.

3. Foreign Policy Considerations - Without further explanation, suffice to say that this whole area is completely intermeshed with the State Department and Congress exercising an extremely heavy hand.

4. Radioactive Wastes - This subject, which has been debated nationally, requires little amplification. At this time, there is no technological reason why wastes cannot be solidified into a proper form. The problem lies with the lack of criteria as to waste classification, the acceptable form for disposition of each classification, and the establishment of the ultimate repository. Even low-level wastes, which used to be easily disposed of at burial sites, are the subject of much concern - the current sites are filling up, some have been closed, and new applications are being held up. A seemingly minor problem, but one with significant cost implications, is the eventual disposition of transuranic contaminated wastes (the definition is lacking), reactor cladding hulls and other hardware. Because of the major uncertainties in this whole area (including possible safeguards requirements), this part of a reprocessing facility could equal or exceed the costs of the separations facility.

The costs for disposal at the eventual government owned and operated repository are still unknown. Industry should participate in the establishment of the bases for these costs.

Opponents of nuclear power have exaggerated the problems involved in permanent waste disposal by confusing the issue with handling of liquid wastes from the military reactor program, by hyperbolizing plutonium risks and by implying that hugh quantities of wastes will be involved. Their charge

that there is no solution to the waste disposal issue misstates the issue; a number of feasible options exist and an orderly choice can be made if the public policy process is not excruciated.

One should also recognize that liquid and gaseous wastes also pose a significant uncertainty. Off-gas recovery for krypton and iodines, particularly, can result not only in as yet-to-be determined costs, but the lack of commercially demonstrated operating systems could impact on plant operation.

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5. Plutonium - This is inextricably tied into GESMO and until the basic Pu recycle decision is made, it will be unlikely that criteria for solid form and acceptable packaging will be made. A small thing like packaging (design of container, its accident conditions, the number that can be shipped on any one vehicle, etc.) will require a late flurry of design and construction activity for the special vehicle. (This same problem, of course, applies to the waste carrying vehicle, for which, at this time, the designated container has not been specified to a sufficient degree to permit design to commence.) There is also a potential that Pu may not be separated out at this time, but no decision has yet been made. That indecisiveness requires, then, that the separations facility have another degree of flexibility, not only in the original separations process, but throughout the remainder of the facility as neutron fluxes and criticality considerations could influence piping design and layout.

The U. S. Environmental Protection Agency has recently promulgated standards for the Fuel Cycle requiring for any such radioactive materials (Kr^{85} and I^{129}) generated by the fission process. After Jan. 1, 1983, these Isotopes must be collected. We expect EPA to also add to the standard C^{14}. The remainder of the standard (25 mrem/yr. whole body, 75 mrem/yr. to thyroid, 0.5 mc of Pu 239) will go into effect Dec. 1, 1979 except for Umills which goes into effect Dec. 1, 1980.

As an aside, one must always remember that a reactor is designed for optimum criticality, a reprocessing plant to prevent it--and the latter has a multiplicity of streams and mixtures of varying enrichment and materials.

There is still some work that need to be done to improve the solubility (and thereby the separation efficiency) of mixed oxide fuels. Currently, they do not dissolve easily. This can mean either a slower process or the addition of equipment, which in either case costs money.

6. Safeguards Uncertainties - GESMO and the other activities underway in this area pose significant design and cost consideration. In addition, a reprocessing plant has another related analytical problem--that of materials accountability. While in a reactor, SNM accountability is a simple matter, the question of accuracy of measurement, of which streams, and frequency of complete inventory, can impact upon facility operation, layout and, in some cases, the lack of precise measuring equipment is still a significant technical problem.

Because many of these problems will be discussed in great detail by the speakers in following sessions, I will not elaborate further at this time other than to note that these problems have or can be solved. As noted, many of these problems result from the failure of government leadership to make decisions. Due to this apparent policy of only making decisions at the latest (and in some cases, too late) hour, industry finds itself in a position that does not permit it to make the necessary investment due to an uncertain capital return. This uncertainty

is hydra-headed in that the timing of the decision, the nature of the proposed action or whether a moratorium or prohibition will result, are all possibilities. Prudent businessmen, without some form of government guaranty, cannot commit their organization's funds in what must be construed as an extremely risky investment. Insofar as just the reprocessing segment of the end of the fuel cycle is concerned, hundreds of millions of dollars of private funds have been expended but, as you are aware, not one commercial plant is in operation at this time in the United States.

National Environmental Policy Act and the Public Interest -

Not mentioned in the above listing, but of equal importance, is the leniency exercised by the various appeal boards and courts to people with obvious bias, marginal interests and paltry arguments. The saddest element of this situation is that even these judicial (or quasi-judicial) tribunals fully recognize that their "widest latitude in the public interest" admissibility criteria is perhaps not in the public interest. So, the charade goes on, with many dollars and hours spent answering semi-facetious questions for many groups whose only real interest is simple--cause delay which causes increased costs, which can eventually cause investors to lose interest in the nuclear option.

To be sure, there are genuinely concerned citizens and groups that fully deserve to be heard and answered as completely as possible. The age of the consumer voice is here and a

failure to recognize it will only result in the failure of a democratic society to function properly for its citizens. Genuine public concern is everyone's concern, but phony litigation should be recognized for what it is and the agencies that are to deal with it should deal sharply and mercifully with it.

The Seabrook case in New Hampshire is an example of an agency bending over backwards to air an argument that resulted in an investment of over $300 million so far being stopped. And even if the decision is reversed, an increased cost to the consumer for his electricity will result--for which he will pay. The magnitude of the argument boils down to this: the plankton damage caused by the increased temperature equals that consumed by four healthy blue whales everyday. Somehow we must regain our perspective.

The purpose of our National Environmental Policy Act of 1969 was to protect man--sometimes this seems to be forgotten in the process. And, I seriously doubt whether the whale population of the world, given they had a voice, would object to this incursion into their dominion. The rhetoric, however, has progressed almost to the point where the real "guts" of the issue will be difficult to surface. The arguments have many times devolved into a crusade for principle without a reasoned recognition of the needs of man.

Energy Policy -

The potential for a meaningful solution to many of these problems rests with the development and resolution of a national energy policy that recognizes the proper contribution that fossil, nuclear, conservation and advanced energy systems can make and in what time frame.

The development of that policy will require a concerted effort between the legislative and executive branches of our government. In January, Congress reorganized its committee operations and essentially dissolved the principal nuclear focal point--the Joint Committee on Atomic Energy. This will make the development of a program more difficult as the new Congress attempts to evolve a policy. In addition, new faces in leadership roles must get up to speed. So, we are faced with a new administration, a Congress with a diffused committee structure, led by new faces with an as-yet undetermined position in many vital areas.

One example area of confusion is the future fate of the breeder. Public utterances by the new administration have not been reassuring. Industry itself is not certain of the direction that it desires the program to take--the development of the next generation of commercial breeders is most confusing. How it will occur, how many, what the mechanism will be for its development (government/industry participation), and the time frame will be subjects that need to be resolved.

One wonders not whether man can live in peace with nature, but whether he can live in harmony with his own narrow beliefs of nature. The apparent martyrdom of the pseudo-environmentalists is admired by many citizens. What they fail to recognize is that in the end it is they themselves, the citizens, who have been crucified by those they admired.

The plutonium spectre has been raised and dragged across the pages of the press as if it were something that had been secreted from the public. Five years ago I went to the Council of Environmental Quality and explained to them what reprocessing was all about and they complimented us on doing just what this nation needed--reducing wastes, more efficiently using resources through recycling, and utilizing the self-generated plutonium. A few years later, that same facility, with improved waste recovery systems, was labeled an extremely dangerous facility that must be stopped until detailed scrutiny could be applied to it. The prior plaudits had evaporated.

Nothing, however, had changed except a response to politically active "environmentalists." The technical arguments of the company had actually improved, but the societal-political arguments, which had largely been ignored due to their incalculable nature, came to the top. This is an area where industry has not been sufficiently alert.

Industry experience in the efforts for development of the Clinch River Breeder Reactor have not been as anticipated. Future similar arrangements will be entered into probably only with different terms and conditions. It is also difficult to imagine much in the way of industry commitment without a closing of the LWR fuel cycle and reasonable assurance that the breeder cycle will also be closed. The utility industry needs the reassurance that it has failed to receive thus far.

Conclusion -

It is too early to indicate the policy that the Carter Administration will follow. It has announced its intention to submit a comprehensive energy policy by mid-April. Insofar as nuclear, we do know that prior to taking office they queried the breeder program; viewed with caution private commercial enrichment; and believed that insofar as nuclear reactors, they should be located below ground in vacuum containments, in sparsely populated areas, with a federal employee with shut-down authority stationed in the control room. Only time will see whether this evolves into the announced program. One of the real difficulties in our political system is that the solution to these problems will take a long time, but many politicians are interested only in what will occur during their term of office. We may see short term fictitious solutions when viewed from the reality of the long term nature of the problem, and the question is whether the pressure on the

new Administration to produce solutions now will subvert the proper "payoff" ten to fifteen years from now. We do have a cautious optimism that the problems will be overcome by a policy that provides the needed direction and leadership.

There has been a semi-official attitude that nuclear is the last resort. We in the industry will accept that if the interpretation is that instead of the slogan "nuclear and coal", it becomes "coal and nuclear." All energy sources are needed, not just a select one or two. As noted above, the "last resort" brought this country through a crisis a few weeks ago. We are trying to tell that story as well as look ahead. We must focus on the fact that industry's fuel cycle options are limited and governmental decisions are needed now.

In closing, I would like to repeat the words of Robert Frost, quoted as the lead in Amory Lovin's recent article:

> "Two roads diverged in a yellow wood,
> And I took the one less travelled by-
> And that has made all the difference."

Twenty-five years ago was the birth of generation of electricity from nucear power--certainly "a road less travelled by." The dedication of thousands of people has produced safe, clean, economical nuclear power plants that have over 200 accident free years of operating experience and whose worth to our nation's industry and balance of payments has been clearly demonstrated. Only by turning our back to these facts in search of unproven sources will we really know the true meaning of those alluring words "and that has made all the difference." To ignore nuclear

will only make Puck's utterance more pertinent--"What fools these mortals be." That we cannot be if we are to pursue the ethical path of permitting our less fortunate neighbors and the unborn generations their rights to a society that has sufficient energy to provide for its needs. Our use of the chemical hydrocarbons--coal, oil and gas--must be critically analyzed in that light. Nuclear fission reactors, including the breeder, and fusion hold the promise for our future.

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"ENERGY QUESTIONS AND ATOMIC ENERGY DEVELOPMENT IN THE UNITED STATES - FROM INDUSTRY'S POINT OF VIEW"

REMARKS OF HOWARD J. LARSON
VICE-PRESIDENT, ATOMIC INDUSTRIAL FORUM
BEFORE THE
TENTH ANNUAL CONFERENCE OF THE
JAPAN ATOMIC INDUSTRIAL FORUM
MARCH 9, 1977
TOKYO, JAPAN

The United States has just weathered the most severe winter in recent history, at a time when domestic energy resources were insufficient. A new cry has gone up--"What's the real story on natural gas and why weren't we told before?"...a similar cry to those heard during the long gas lines of a few years ago. Even coal, our one plentiful domestic resource, was suffering--mines were frozen, transportation routes were uncertain, and there were instances when the train coal-hopper cars were frozen and could not be unloaded. At one time, at least two million additional people were out of work, states of emergency were declared in many areas--for a week or more--schools were closed, and heat was turned off in non-essential businesses using gas as a fuel.

Had the approximately 20 million kilowatt-hours of electricity estimated to have been produced by nuclear power plants in January not been available, these consequences would have resulted:

* More than 257,000 jobs lost in this month.
* Nearly $230 million lost in monthly wages.
* A reduction of some $3.8 billion in the month for various goods, products, and services that make up the gross national product.
* Additionally, the 10 million homes, 1 million stores, office building and schools; and 60,000 factories, industries and manufacturing plants that could have been served by this nuclear generation would have needed their energy requirements met by other means.

* Filling these demands for electricity by other sources would have required:

  ---32 million barrels of oil, nearly 13 per cent of current monthly domestic production, or

  ---182 billion cubic feet of natural gas, more than 10 per cent of current monthly production, or

  ---9.6 million tons of coal, about 17 per cent of current monthly production.

Much is heard in the United States today about the need for an energy policy. However, and with bowed head, I must admit that indeed we do have an energy policy that is just as real as one in writing. We have a "de facto" policy of non-policy, which shape.. our thinking and actions with as much impact. The need to plan, rather than exist in a staccato fashion, is unquestioned...but undone.

However, in our society both public understanding and confidence in the real gravity of the situation is a necessity-- and that we do not have. Although politicians have mouthed the words now and again, it was with mixed pleasure to hear the words loud and clear from President Carter, at his first fireside chat last month, that there is <u>no short range solution</u> to the energy crisis. As a nation, to make things right, we always have sought either a panacea or else faith in Divine Providence. I believe the constant reminders that the United States will undergo over the next several years will bring home to all but the most skeptical, the reality of our nation's energy distress. It has

been estimated that the energy needs of the United States in the next 15 years will require 450,000 new oil and gas wells, 31 new refineries, 200 large coal mines, 2,700 unit trains, 30 uranium mining and milling complexes and 17 synthetic fuel plants. The capital requirements for these new facilities alone, even without allowing for inflation, may amount to roughly $30 billion a year over the next 10 years--more than double the energy industry's annual investment rate of the past 10 years.

Conservation:

The first panacea we grasp for is conservation. At this juncture in our society, it is accepted that we have been wasteful of our resources.

We recognize we must trim our rate of energy growth, but we must also be mindful of the great disparities that exist among existing households for we have our energy rich and our energy poor. Those who advocate zero growth and spartanization of our energy economy--so, to speak a return to Walden Pond--should be required to take a hard look at the economic consequences of such a proposal.

There are 70 million households today and up to 30 million new households will be formed before the year 2000. A zero growth policy will deny existing households energy for satisfying their basic requirements of many energy poor millions of people. The advocates of zero growth must ponder where our households in formation will get their energy.

We cannot ratchet backward in time to the days of Walden Pond. Perhaps we should recall Thoreau's advice: "It is a characteristic of wisdom not to do desperate things."

We do expect, however, that efforts to conserve energy will prove beneficial over the next 25 years, with the possibility of a 25% savings. It is not generally understood by the American public, however, that energy requirements will demand increased generation capacity regardless of the effectiveness of our conservation program. It is expected that much greater emphasis will be placed on conservation as a national policy. Legislation with special tax incentives has been proposed both nationally and in several of the states.

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Reactors Commited	228		

It should be pointed out that the 90 units under construction represent a backlog of over $60 billion and that the 228 nuclear units thus far commited have a capacity about three times that of the country's entire electric power grid 25 years ago, when man first produced electricity from nuclear energy. By 1980, it is quite likely that nuclear power will displace petroleum and will be second only to coal as a source of electric power.

Ten of our 50 states get more than a quarter of the electricity from nuclear power. Connecticut draws 50% of its electricity from the atom, followed by Nebraska, 47%; Vermont, 44%;, Maine, 40%; South Carolina, 36%; Minnesota, 31%; Illinois, 30%; North Carolina, 30%; Wisconsin, 29%; and Arkansas, 25%. During the recent cold wave, Chicago derived 48% of its power from 6 of its 7 nuclear plants and the New England area as a whole, over 30%. As a recent press release noted, "with only slight exaggeration, nuclear power bailed the country out of an emergency on the morning of January 17."

Nuclear Performance:

There has been a lively discussion in the United States regarding the performance of nuclear versus fossil. I believe it is generally accepted that there is little difference between the two. A recent report notes that a comparison of the cumulative unit availability for all fossil fired plants of 390 Mw or more with comparable units fired only with coal and with pressurized water reactors gives values of 77.9%, 75.8%, and 74.7%. An

objective of 80% availability for mature nuclear power plants is sometimes used in the industry, particularly as related to regulatory activity. Our nuclear opponents frequently use this figure to claim that nuclear power is not living up to its promise. However, a study by one major United States nuclear steam system supplier, utilizing a base of 18 units, showed an average unit availability in 1975 of 78.6%--and the highest rated unit stood at 93.9%.

With performance records at this level, nuclear units are on their way toward exceeding the availability of conventional fossil-fired units.

It might do well to compare the availability factors for one of our nation's largest utilities, Commonwealth Edison, for large nuclear and coal-fired units for 1972, 1973, 1974, and 1975:

	AVAILABILITY FACTOR			
	1972	1973	1974	1975
Nuclear	72	82	68	64
Coal-fired	71	69	73	68

There is also a belief that the older reactors get, the more unreliable they become. There is little data on "old" reactors since nuclear power is still in its adolescence.

The number of shutdowns for the "old" nuclear power plant, Connecticut Yankee, is perhaps a good index of the reliability of the plant.

PLANT SHUTDOWNS

Year	Planned	Automatic	Manual	Total
1967	6	19	2	27
1968	13	12	1	26
1969	5	5	7	17
1970	9	6	2	17
1971	4	4	2	10
1972	5	3	0	8
1973	6	0	1	7
1974	5	4	0	9
1975	5	1	0	6

The data would indicate that perhaps plant performance improves with age.

Nuclear Generation Costs:

Nuclear power plant costs have also been the subject of much study and discussion during the past year.

From an analysis of the various data available, it is evident that the difference in capital costs for nuclear power and coal plants with stack-gas scrubbers will narrow considerably in the mid-1980's, making electricity generated by nuclear far cheaper because of lower fuel costs.

One projection indicates that a 1200-megawatt nuclear plant build in the northeast United States to operate in 1985-1987 will cost $1300 per kilowatt, assuming 7% inflation.

The capital cost of a coal-fired plant of equivalent capacity will be nearly $1200 per kilowatt, if scrubbers are required.

Another study gave similar results--conventional nuclear plant, $975/Kw. (This is in 1985 dollars and includes interest during construction.)

For an 850 Mw coal plant without scrubbers, using western coal, and located in the northeast, capital costs of $765/Kw are estimated. (If cooling towers are required, add $85/Kw to nuclear capital cost and $55/Kw to the coal-fired plants' capital costs.) The nuclear plant has a total energy cost, including capital, fuel, and operation and maintenance, of 3.85 cents/Kwh (1985 dollars), the coal plant without scrubbers, 5.24 cents; the coal plant with scrubbers, 5.93 cents. These numbers are based on a 66% capacity factor for the nuclear plant, 70% for the coal plant without scrubbers, and 67% for the other coal plant.

The assumptions used: long term inflation rate, 7% to 1981, 5% thereafter; nuclear fuel cost, 60 cents/million Btu (1985 cost), eastern high sulfur coal, 240 cents, western low sulfur coal, 300 cents; uranium, $34/pound; enrichment, $100/Swu; fuel fabrication, $120 per Kg; reprocessing and waste disposal, $200,000/tonne; and plutonium credit, $14 gram.

To provide the electric generating needs of the nation, the investor-owned utilities expect to spend about $122 billion on construction over the next 5 years, of which 60% of the total will be outside financing. In 1976, utilities spent $17 billion on new electric plants and equipment. About $13 billion is expected to be raised in 1977 for new electric generating capacity. These are large numbers and will strain utility finances. Operating revenues in 1976 were up 13%, indicative of the nation's recovery from the recent recession--and electrical useage continues to

climb--up to about 6.3% growth rate for the year just ended. Predictions for 1977 show a similar growth rate. Zero growth advocates, who felt the 1974-75 period was indicative of a change in the public's perception of the need for conservation, have had to recant their predictions.

The Nuclear Debate:

In a sense, the nuclear debate is a classic example in which much of the public has perceptions not based on real facts. Yet those perceptions are leading to behavior which the energy industry has to deal with--citizen action to slow down nuclear power.

Let's look more closely at the dynamics in this nuclear debate.

The current state of public attitudes in the area of energy and nuclear power can be outlined as follows:

1. There is still little public awareness of America's real energy problems and the reality of energy shortages. The public continues to believe that the "crisis" is essentially caused by the oil industry, with its allies the utilities, in their mutual quest for higher profits.

2. The relationship between plentiful energy in America and the overall health of the economy is also not clear to the public. While the people want increased employment opportunities and a rising standard of living in the years ahead, they sense little urgency for making decisions now on basic energy supply questions, like nuclear power or expanded coal development. (The recent gas shortage, has however hit home, but there is still a question as to whether it is contrived or not.)

3. This combination of disbelief in the basic energy problem and no clear sense of the energy/economy linkage allows the public the opportunity of looking very favorably on those who say "Why rush into a decision on nuclear?", "Let's be extra careful", "We should stop strip-mining of coal", "Let's not allow the utilities to raise their rates some more."

   While no one argues that development of new energy sources, be they nuclear, coal, synthetic gas, shale, off-shore drilling, should proceed without all prudent attention to issues of safety and environmental concern, the attitudinal climate in the country today is one which allows the public to weigh these decisions without properly considering the trade-offs involved, i.e., decreased economic growth, lower job opportunities, higher energy costs.

4. The oil and electric utilities industries are seen to be making excessive profits today. Fully 71% of the American public believe the electric utilities have a profit margin significantly "too high."

5. With regard to nuclear power, the public has serious doubts about the safety of the technology. They label nuclear power the "most dangerous" energy source, and a majority believe a nuclear power plant can actually explode like an atomic bomb. Coupled with this is a belief that nuclear power is the most expensive form of energy.

6. With regard to greater reliance on coal as a source of energy for electric utilities, the public opposes relaxing air pollution standards so that more coal can be burned. And it supports greater limitations on strip-mining, particularly in the West.

7. There is a strong belief among the public that new energy sources, particularly solar, are currently available, or soon will be. This belief in other alternatives again allows the public to avoid making the hard, "real" choices about developing nuclear energy and coal as the realistic ways of satisfying America's energy needs for the next 25 years.

Once one understands these public attitudes, it is easy to see why advocates of expanded coal usage and nuclear power

have been put increasingly on the defensive.

The fact to remember, however, is that the American people are as yet undecided on the future role various energy sources, including nuclear, should play. The biggest problem hindering a sophisticated judgment on this question is basic lack of knowledge and facts. Within this current attitudinal milieu, scare stories, confusion and irrationality often triumph. Only through careful education of facts and knowledge can the people know what the real choices are and can thereafter make the decisions wisely.

Nuclear Initiatives:

In spite of what I have just said above, generally, in the United States, the operating record of the nuclear generating stations is accepted by the general public as evidenced by the results of last year's moratorium votes. Without belaboring you with the results, which you are undoubtedly fully aware of, let me ~~reiterate the percentages~~ show you the next slide.

STATE	FOR/AGAINST PERCENTAGE
Arizona	30/70
Colorado	29/71
Montana	42/58
Oregon	42/58
Ohio	32/68
Washington	33/67

Counting the June 8, 1976 California vote, some 12 million Americans, representing seven states containing about 20% of the total United States population, have had the opportunity to cast their vote on nuclear power. To put this in perspective, the recent Carter/Ford presidential margin was 51/48, so the significance of these figures is very obvious.

Further confirmation of this public attitude was indicated in a Roper Report released in mid-October. Seventy per cent favor continued advances in nuclear energy, 13% believe we have gone as far as we should, 8% said we have gone too far now, and 9% did not answer or know.

At the time I wrote this paper, it was felt that

In 1977-78, there ~~is~~ a possibility of two further votes--Maine in 1977 and Michigan in 1978. Signature gathering is in progress now in these states. (The Maine vote is now considered "dead" for this year) However, we believe this small number of new initiatives is indicative that the referendum/initiative process to challenge nuclear expansion has probably run its course.

Nuclear Fuel Cycle:

Now, however, it is probably time to turn to the most emotional part of the industry--the nuclear fuel cycle.

The problems associated with the front end of the fuel cycle are comparatively easily understood and the solutions obvious.

In the front end, uranium supply and enrichment are the two current problem areas. Insofar as the former, an increased uranium exploration program is underway, with its objective being the better definition and resolution of known and proven reserves. It is generally accepted that there are enough reserves to fuel all plants in operation, under construction or commited at this time and even beyond for their full lifetime.

The ~~table below~~ next slide shows that ERDA's enrichment capacity in 1986, nine years hence, even assuming completion of a 9 million swu add-on at Portsmouth, will not be adequate to meet anticipated demand. Demand includes enrichment services for 141-189 Gwe of domestic nuclear power plant capacity (96% of which is already under contract) and 108 Gwe of foreign nuclear power plant capacity (100% of which is already under contract). The table is based on 0.2% U-235 tails, the most economically favorable assay with U_3O_8 at $52/lb. and enrichment charge at $110/swu. The table also assumes no reprocessing of spent fuel.

Table I
ERDA SWU Demand/Supply

	Gwu Forecast for 1986			SWU Demand* (millions)	ERDA Supply** w/Portsmouth / Add-On (millions)
	U.S.	Foreign	Total		
Low Forecast	141	108	249	39.3	36.7
Mid Forecast	167	108	275	40.5	36.7
High Forecast	189	108	297	43.2	36.7

* Includes 1.6 mm swu's for military use.
** Capacity with CIP and CUP complete will be 27.7 mm swu's and with the Portsmouth add-on will total 36.7 mm swu's.

Some observations:

* The Portsmouth add-on is a necessity and must be given priority to meet its scheduled completion date for full operation in 1986. The supply/demand crossover occurs in 1982/1983. The Portsmouth add-on is the best assurance of obtaining the next increment of supply.

* Construction lead times of 8-10 years necessitates a decision in 1977 to increase enrichment capacity beyond the Portsmouth add-on. Even with the addition of another 9 million swu's the supply/demand crossover occurs in 1989.

* ERDA should maintain "transaction" tails at 0.2% U-235 and seek to set "operating" tails at 0.2% U-235 at the earliest possible time.

There are many problems that need to be resolved associated with the end of the fuel cycle. I will not elaborate upon them other than to note that they relate to regulatory indecisiveness. And, since these problems are well known, I shall just touch upon a few.

Generic Environment Statement on Mixt Oxcide

1. GESMO - This document spans the scope of end-of-cycle activities. Its final determination will impact upon design, construction, operation and economic viability of most nuclear facilities. Whether Pu recycle is allowed or not, however U recycle should be permitted and the spent fuel storage problem must be addressed.

(It would seem like the best national policy interests could be served by the separation of usable products and wastes, and the resultant significant reduction, volume-wise, in the generation of both high-level and transuranic wastes, the ones that generate the most emotional reactions.)

2. Regulatory Uncertainty - Some of the facilities are licensed under Part 70, some under Part 50, Title 10, code of federal regulation 10 CFR. There are no real design criteria, Standard Review Plans, or any other guides to an applicant. Therefore, in a way, there is no such thing as the "ratcheting" that occurs with nuclear power plants because that term implies an understood acceptable starting point. There are basic licensing issues/decisions which NRC must face, but due to lack of applications, and the GESMO hearings, little, if any, effort is addressed to resolving these areas of contention. NRC itself possesses only a small cadre of knowledgeable people and the effort in some technical areas is diffuse. By that it is meant that in some areas the Office of Nuclear Reactor Regulation provides the technical support - and one cannot use the methods for a high pressure high energy system (reactor) and apply them without judgement to a low pressure (much in vacuum), low energy system such as a separations facility.

3. Foreign Policy Considerations - Without further explanation, suffice to say that this whole area is completely intermeshed with the State Department and Congress exercising an extremely heavy hand.

4. Radioactive Wastes - This subject, which has been debated nationally, requires little amplification. At this time, there is no technological reason why wastes cannot be solidified into a proper form. The problem lies with the lack of criteria as to waste classification, the acceptable form for disposition of each classification, and the establishment of the ultimate repository. Even low-level wastes, which used to be easily disposed of at burial sites, are the subject of much concern - the current sites are filling up, some have been closed, and new applications are being held up. A seemingly minor problem, but one with significant cost implications, is the eventual disposition of transuranic contaminated wastes (the definition is lacking), reactor cladding hulls and other hardware. Because of the major uncertainties in this whole area (including possible safeguards requirements), this part of a reprocessing facility could equal or exceed the costs of the separations facility.

The costs for disposal at the eventual government owned and operated repository are still unknown. Industry should participate in the establishment of the bases for these costs.

Opponents of nuclear power have exaggerated the problems involved in permanent waste disposal by confusing the issue with handling of liquid wastes from the military reactor program, by hyperbolizing plutonium risks and by implying that hugh quantities of wastes will be involved. Their charge

that there is no solution to the waste disposal issue misstates the issue; a number of feasible options exist and an orderly choice can be made if the public policy process is not excruciated.

One should also recognize that liquid and gaseous wastes also pose a significant uncertainty. Off-gas recovery for krypton and iodines, particularly, can result not only in as yet-to-be determined costs, but the lack of commercially demonstrated operating systems could impact on plant operation.

*> 5. Plutonium - This is inextricably tied into GESMO and until the basic Pu recycle decision is made, it will be unlikely that criteria for solid form and acceptable packaging will be made. A small thing like packaging (design of container, its accident conditions, the number that can be shipped on any one vehicle, etc.) will require a late flurry of design and construction activity for the special vehicle. (This same problem, of course, applies to the waste carrying vehicle, for which, at this time, the designated container has not been specified to a sufficient degree to permit design to commence.) There is also a potential that Pu may not be separated out at this time, but no decision has yet been made. That indecisiveness requires, then, that the separations facility have another degree of flexibility, not only in the original separations process, but throughout the remainder of the facility as neutron fluxes and criticality considerations could influence piping design and layout.

The U. S. Environmental Protection Agency has recently promulgated standards for the Fuel Cycle requiring for any such radioactive materials (Kr^{85} and I^{129}) generated by the fission process. After Jan. 1, 1983, these Isotopes must be collected. We expect EPA to also add to the standard C^{14}. The remainder of the standard (25 mrem/yr. whole body, 75 mrem/yr..to thyroid, 0.5 mc of Pu 239) will go into effect Dec. 1, 1979 except for Umills which goes into effect Dec. 1, 1980.

As an aside, one must always remember that a reactor is designed for optimum criticality, a reprocessing plant to prevent it--and the latter has a multiplicity of streams and mixtures of varying enrichment and materials.

There is still some work that need to be done to improve the solubility (and thereby the separation efficiency) of mixed oxide fuels. Currently, they do not dissolve easily. This can mean either a slower process or the addition of equipment, which in either case costs money.

6. Safeguards Uncertainties - GESMO and the other activities underway in this area pose significant design and cost consideration. In addition, a reprocessing plant has another related analytical problem--that of materials accountability. While in a reactor, SNM accountability is a simple matter, the question of accuracy of measurement, of which streams, and frequency of complete inventory, can impact upon facility operation, layout and, in some cases, the lack of precise measuring equipment is still a significant technical problem.

Because many of these problems will be discussed in great detail by the speakers in following sessions, I will not elaborate further at this time other than to note that these problems have or can be solved. As noted, many of these problems result from the failure of government leadership to make decisions. Due to this apparent policy of only making decisions at the latest (and in some cases, too late) hour, industry finds itself in a position that does not permit it to make the necessary investment due to an uncertain capital return. This uncertainty

is hydra-headed in that the timing of the decision, the nature of the proposed action or whether a moratorium or prohibition will result, are all possibilities. Prudent businessmen, without some form of government guaranty, cannot commit their organization's funds in what must be construed as an extremely risky investment. Insofar as just the reprocessing segment of the end of the fuel cycle is concerned, hundreds of millions of dollars of private funds have been expended but, as you are aware, not one commercial plant is in operation at this time in the United States.
As I indicated, these are just a few of the problems remaining at the end of the fuel cycle - all would be resolved quickly once a few basic decisions are made.

National Environmental Policy Act and the Public Interest -

Not mentioned in the above listing, but of equal importance, is the leniency exercised by the various appeal boards and courts to people with obvious bias, marginal interests and paltry arguments. The saddest element of this situation is that even these judicial (or quasi-judicial) tribunals fully recognize that their "widest latitude in the public interest" admissibility criteria is perhaps not in the public interest. So, the charade goes on, with many dollars and hours spent answering semi-facetious questions for many groups whose only real interest is simple--cause delay which causes increased costs, which can eventually cause investors to lose interest in the nuclear option.

To be sure, there are genuinely concerned citizens and groups that fully deserve to be heard and answered as completely as possible. The age of the consumer voice is here and a

failure to recognize it will only result in the failure of a democratic society to function properly for its citizens. Genuine public concern is everyone's concern, but phony litigation should be recognized for what it is and the agencies that are to deal with it should deal sharply and mercifully with it.

The Seabrook case in New Hampshire is an example of an agency bending over backwards to air an argument that resulted in an investment of over $300 million so far being stopped. And even if the decision is reversed, an increased cost to the consumer for his electricity will result--for which he will pay. The magnitude of the argument boils down to this: the [to the endangered] plankton damage [species – MYA ARENARIA – soft shell clam larvae] caused by the increased temperature equals that consumed by four healthy blue whales everyday. Somehow we must regain our perspective.

The purpose of our National Environmental Policy Act of 1969 was to protect man--sometimes this seems to be forgotten in the process. And, I seriously doubt whether the whale population of the world, given they had a voice, would object to this incursion into their dominion. The rhetoric, however, has progressed almost to the point where the real "guts" of the issue will be difficult to surface. The arguments [at Seabrook other places] have many times devolved into a crusade for principle without a reasoned recognition of the needs of man.

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Energy Policy -

The potential for a meaningful solution to many of these problems rests with the development and resolution of a national energy policy that recognizes the proper contribution that fossil, nuclear, conservation and advanced energy systems can make and in what time frame.

The development of that policy will require a concerted effort between the legislative and executive branches of our government. In January, Congress reorganized its committee operations and essentially dissolved the principal nuclear focal point--the Joint Committee on Atomic Energy. This will make the development of a program more difficult as the new Congress attempts to evolve a policy. In addition, new faces in leadership roles must get up to speed. So, we are faced with a new administration, a Congress with a diffused committee structure, led by new faces with an as-yet undetermined position in many vital areas.

One example area of confusion is the future fate of the breeder. Public utterances by the new administration have not been reassuring. Industry itself is not certain of the direction that it desires the program to take--the development of the next generation of commercial breeders is most confusing. How it will occur, how many, what the mechanism will be for its development (government/industry participation), and the time frame will be subjects that need to be resolved.

One wonders not whether man can live in peace with nature, but whether he can live in harmony with his own narrow beliefs of nature. The apparent martyrdom of the pseudo-environmentalists is admired by many citizens. What they fail to recognize is that in the end it is they themselves, the citizens, who have been crucified by those they admired.

The plutonium spectre has been raised and dragged across the pages of the press as if it were something that had been secreted from the public. Five years ago I went to the Council of Environmental Quality and explained to them what reprocessing was all about and they complimented us on doing just what this nation needed--reducing wastes, more efficiently using resources through recycling, and utilizing the self-generated plutonium. A few years later, that same facility, with improved waste recovery systems, was labeled an extremely dangerous facility that must be stopped until detailed scrutiny could be applied to it. The prior plaudits had evaporated.

Nothing, however, had changed except a response to politically active "environmentalists." The technical arguments of the company had actually improved, but the societal-political arguments, which had largely been ignored due to their incalculable nature, came to the top. This is an area where industry has not been sufficiently alert, but now, belatedly is recognized as being just as important as the technical uses.

Industry experience in the efforts for development of the Clinch River Breeder Reactor have not been as anticipated. Future similar arrangements will be entered into probably only with different terms and conditions. It is also difficult to imagine much in the way of industry commitment without a closing of the LWR fuel cycle and reasonable assurance that the breeder cycle will also be closed. The utility industry needs the reassurance that it has failed to receive thus far.

Conclusion -

It is too early to indicate the policy that the Carter Administration will follow. It has announced its intention to submit a comprehensive energy policy by mid-April. Insofar as nuclear, we do know that prior to taking office they queried the breeder program; viewed with caution private commercial enrichment; and believed that insofar as nuclear reactors, they should be located below ground in vacuum containments, in sparsely populated areas, with a federal employee with shut-down authority stationed in the control room. Only time will see whether this evolves into the announced program. One of the real difficulties in our political system is that the solution to these problems will take a long time, but many politicians are interested only in what will occur during their term of office. We may see short term fictitious solutions when viewed from the reality of the long term nature of the problem, and the question is whether the pressure on the

new Administration to produce solutions now will subvert the proper "payoff" ten to fifteen years from now. We do have a cautious optimism that the problems will be overcome by a policy that provides the needed direction and leadership.

There has been a semi-official attitude that nuclear is the last resort. We in the industry will accept that if the interpretation is that instead of the slogan "nuclear and coal", it becomes "coal and nuclear." All energy sources are needed, not just a select one or two. As noted above, the "last resort" brought this country through a crisis a few weeks ago. We are trying to tell that story as well as look ahead. We must focus on the fact that industry's fuel cycle options are limited and governmental decisions are needed now.

In closing, I would like to repeat the words of Robert Frost, quoted as the lead in Amory Lovin's recent article:

> "Two roads diverged in a yellow wood,
> And I took the one less travelled by-
> And that has made all the difference."

Twenty-five years ago was the birth of generation of electricity from nucear power--certainly "a road less travelled by." The dedication of thousands of people has produced safe, clean, economical nuclear power plants that have over 200 accident free years of operating experience and whose worth to our nation's industry and balance of payments has been clearly demonstrated. Only by turning our back to these facts in search of unproven sources will we really know the true meaning of those alluring words "and that has made all the difference." To ignore nuclear

will only make Puck's utterance more pertinent--"What fools these mortals be." That we cannot be if we are to pursue the ethical path of permitting our less fortunate neighbors and the unborn generations their rights to a society that has sufficient energy to provide for its needs. Our use of the chemical hydrocarbons--coal, oil and gas--must be critically analyzed in that light. Nuclear fission reactors, including the breeder, and fusion hold the promise for our future.

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JAPAN ATOMIC INDUSTRIAL FORUM ANNUAL CONFERENCE

SESSION 1 - WORLD ENERGY SITUATION AND NUCLEAR POWER DEVELOPMENT
(9th March 1977)

The contribution of international collaboration to nuclear power development

By I.G.K. Williams
Deputy Director General
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(NEA)

Mr. Chairman

It is a great pleasure to be here today and to have the opportunity to make a contribution at this important annual conference. We attach considerable value in the OECD Nuclear Energy Agency to the participation of Japan, which became the first non-European full member in 1972. This was, in fact, the first significant step in converting our Agency from a purely European institution into one concerned with the development and introduction of nuclear energy for peaceful purposes throughout the OECD area. I hope, by my contribution today, to demonstrate the value to your country and to our other Member countries of the contribution made by NEA and the other international organisations operating in the nuclear field.

General Energy Situation

Before attempting to assess the situation within the nuclear field, it is important to consider the place of nuclear energy in the wider energy scene. Nowadays, it is customary to relate such questions to the dramatic changes which have taken place in the oil market since the autumn of 1973. The effects of the shock-wave which then passed through the world economy have still not been fully dissipated and, as was shown by the "World Energy Outlook" published by the OECD in January, there remain acute risks in permitting current energy trends to continue.

After the initial shock had worn off, the industrialised countries of the OECD area recognised the importance of reducing their dependence on imported oil. The development of indigenous and other alternative energy sources became a matter of high priority and a considerable stimulus was given to research and development in solar energy, geothermal energy, wind power, wave power, biomass conversion and a number of other possibilities. Nevertheless, it soon became clear that these could offer some relief only in the longer term and that, for most of the remainder of this century at least, our collective salvation in meeting prospective energy demand depended on the application of rigorous policies of energy conservation and accelerating the utilisation of coal and of nuclear energy.

By a little over two years ago, it was therefore apparent that the energy crisis had transformed the prospects for nuclear power and in many countries accelerated programmes were adopted for its introduction. However, instead of witnessing a rapid growth in order books, both for nuclear stations and for the associated nuclear fuel cycle facilities, we find that the so-called "nuclear debate" is reaching a new intensity and are confronted with the paradox of increasing doubts, in many countries, about the wisdom of continuing with a major commitment to nuclear power. The political and social factors involved are, of course, of great complexity and it is not my purpose today to attempt an evaluation of them or a forecast of the probable outcome. What we can say is that decisions taken and policies adopted during the next year or two are likely to have a determining influence on the significance of nuclear power, at least until the end of this century. 1977 therefore promises to be a critical year for nuclear power development.

Factors influencing international co-operation

Meanwhile, those concerned in government and industry with the development and introduction of nuclear power must continue their efforts. My theme today is the contribution of international collaboration, with particular reference to collaboration between governments and government-sponsored agencies. I make this distinction because the emphasis in international collaboration has changed very considerably in the twenty years since NEA was formed. During the 1950's the development and improvement of reactor systems depended a great deal more than today on governmental initiative and government finance. These are, of course, still very important in relation to advanced reactor systems or back-up solutions in case of unforeseen difficulties with preferred choices.

Nevertheless, commercial prospects now offer a more encouraging foundation for industrial initiative and investment, including international collaborative ventures by industry. In this situation, the contribution made by collaboration between governments and governmental agencies is necessarily concerned with those aspects of nuclear development which concern the responsibilities of government, including of course impartial assessment of risks and benefits. International collaboration in this sense is remote from commercial and promotional interests. In view of the acute public sensitivity, this consideration has even probably enhanced its importance as a contribution to the development of nuclear power.

This point will perhaps be clearer when I explain that questions of safety and regulation now represent about two-thirds of the total effort in the NEA programme. Our work in these fields, about which I shall have more to say later, is based very largely on contributions made by specialists working in national licensing authorities, in Ministries concerned with public health or environmental protection and in research laboratories devoted to investigations on questions relating to regulatory practice. Among the many reasons why our Member countries find this work worthwhile is the consideration that the conclusions of an impartial international organisation can help to reassure an anxious public opinion that administrative judgements are respectable. For this reason alone, we attach great importance in NEA to our reputation for objectivity and are particularly sensitive to any suggestion that we are merely a vested nuclear interest.

The factors determining the scope for our sort of international collaboration are, of course, a great deal more elaborate than this. The emergence of the commercial phase of nuclear power may have diminished the scope for international development projects but there are many other factors having a determining influence on the scope for fruitful collaboration at the governmental level.

It is, for example, important to recognise that the primary justification for some international collaboration may be political and that, in such cases, the fact of the collaboration, as a demonstration of solidarity, is more important than the material benefits likely to accrue. Nevertheless, although this sort of collaboration can sometimes make a valuable contribution to technological progress, I am more concerned today with forms of collaboration in which the end is more important than the means. Thus, by definition, the motive for participation is the material benefits which collaboration is likely to provide.

By this token, recent experience in the nuclear field has demonstrated that the will to co-operate has again become strong, particularly in such fields as radioactive waste management and nuclear safety. The evolution of the world economy has greatly enhanced the inducement even to the largest countries to collaborate where large scale deployment of resources is required. The same consideration applies to quite modest programmes where a collaborative effort is more likely to produce mutually beneficial results than if countries seek independently to pursue the same aims. The great exception to this trend has undoubtedly been the competitive development of the sodium-cooled breeder reactor; but the scale of effort required has more recently encouraged joint efforts and it is notable that, in the field of LMFBR safety, all the major countries involved now recognise the need to work together.

Another consideration encouraging international collaboration is the desire to harmonise views and standards concerning the environmental and social impacts of nuclear development. On matters of lively controversy, the work of international institutions can sometimes help to raise the level of the debate. For example, it is appropriate for a body such as NEA to bring together expert opinion from several countries and publish their collective views as a contribution to public discussion and eventually to the formulation of considered policy decisions. We are, in fact, now working on just such a contribution on the whole range of problems of policy relating to radioactive waste management. For similar reasons, the development of international demonstration projects, particularly in such fields as safety technologies and radioactive waste management, often offers a more promising route to public understanding and acceptance than initiatives taken at a purely national or local level.

From what I have said already, it will be apparent that there are also important practical limitations to inter-governmental collaboration and these must obviously be taken carefully into account if failures and disappointments are to be avoided. Perhaps the most important point to make in this connection is that the work of international organisations is necessarily based very largely on work under way and the results achieved at national level. This gives a dual importance to active participation. I believe strongly that our Member countries can benefit fully from our programme only by direct involvement - which obviously poses difficult problems for the countries which are distant from Paris - and this is also necessary, of course, if they are to make their appropriate contribution.

When commercial interests are involved, the scope for inter-governmental collaboration is obviously affected and there undoubtedly comes a point when co-operative possibilities are best pursued by industry. Another consideration is that it is not always easy to reconcile the political wish to maximize participation with the need to establish forms of co-operation and processes for decision-making which can operate efficiently and without bureaucratic delay. One way of dealing with this is to focus particular attention on the factor of common interest which makes possible a particular form of collaboration. Even within the OECD area the interests of our Member countries are very diverse, if only for reasons of their differing economic structures, geography and population distribution. If insufficient attention is given to this factor of common interest, collective ventures can quickly grind to a halt.

Finally, there are two other obstacles to international collaboration which need to be frankly faced. The requirement to proceed by consent, when participants' interests are often divergent, makes re-orientation in changed circumstances less easy to achieve than for projects or programmes at national level. It also makes it difficult to stop a collective effort which has already gathered its own momentum. This fact and the consideration that cost/benefit relationships tend to favour the larger and more advanced countries is, no doubt, among the reasons why most countries adopt a cautious attitude towards new proposals for international collaboration.

<u>Forms of international collaboration</u>

The effect of all these considerations has been that the broadest scope for international collaboration now seems to be in the area of exchange of information and experience, in the widest sense of this term. There is also a considerable interest in co-ordination of national R & D efforts with a view to reducing wasteful duplication of effort and there remains a small but important possibility of creating major international joint undertakings. In addition, there are the traditional areas of inter-governmental collaboration in the joint development of standards and norms, the promotion of scientific research and the systematic compilation and dissemination of basic data. For all of these, the efficiency and success of international collaboration in the nuclear field probably depends on striking a correct balance between the necessary institutional and procedural framework and the substance this framework is designed to support. If too much attention is paid to the form and not enough to the substance, the results are likely to be disappointing. In other words, flexibility in determining the appropriate form for a particular exercise in international collaboration is particularly important.

Effects on the NEA programme

As an inter-governmental institution, NEA must be responsive to all these considerations as well as to the political views of its Member countries. Our programme is therefore necessarily more a reflection of the questions lending themselves to international collaboration than an attempt to cover comprehensively the nuclear field. This is among the reasons why we underwent a rapid evolution during 1975 and the major part of our effort is now devoted to the priority areas of nuclear safety, radioactive waste management and the problem of public understanding and acceptance. We also give first priority to economic and technical studies of the prospects for nuclear power and the nuclear fuel cycle and the promotion of co-operative programmes in related areas. To illustrate the application of what I have said earlier, I should now like to discuss briefly the signficance of our work in each of these priority fields.

Nuclear safety

As I have mentioned already, about two-thirds of our total effort is devoted to questions of safety and regulation. There are two main reasons for this: safety and licensing are a particular responsibility of public bodies; and there is a general recognition of the advantages of comparing experience and sharing the effort involved in responding to the risks associated with the applications of nuclear energy. Safety has always been a dominant consideration in the development of nuclear power and, until recently, effort was concentrated mainly on establishing safety criteria and standards derived from recognised principles of radiation protection. A great deal of effort in earlier years was devoted to accident analyses and the design of safety provisions to deal with postulated hypotheses. However, more recently, increasing thought has been given to the more sophisticated approach of risk assessments based on considerations of probability. Both these aspects are reflected in the NEA programme.

There is now a fairly general recognition that international collaboration is often the quickest and least costly way of achieving the objectives of nuclear safety research. Moreover, there is growing recognition that marked differences between the safety requirements and licensing procedures of different countries can both create undesirable obstacles to international trade and undermine public confidence in the acceptability of nuclear power. These considerations are, of course, primarily for those countries which are already committed to nuclear power programmes. However, by participating in international work, countries embarking on nuclear power programmes are enabled rapidly to gain access to the accumulated knowledge and experience required for sound and independent regulatory judgements.

Thus, the principal objectives of the NEA programme in the field of nuclear safety are to enrich, by means of technical exchanges and the co-ordination of safety research, the fund of knowledge on which licensing authorities in Member countries are able to base their decisions and to seek a consensus on key safety issues. The field of nuclear safety therefore offers enormous scope for international collaboration. The size of the

NEA programme is, in fact, largely determined by the level of resources our Member countries are willing to make available to support it. It is divided into four main areas.

Particular attention is, of course, devoted to thermal reactor safety research, with the main effort relating to water reactors and a much smaller effort devoted to problems associated with gas cooled reactors. In this area, particular attention has been given to the important and urgent problem of emergency core cooling, with the emphasis on information exchange and sharing of tasks. We have also been working for some years on a comparison of calculations for standard problems in loss of coolant accidents. These exercises are a way of comparing the mathematical models and computer codes used and of assessing them against a common experimental data base. The purpose is not a comparison of the computer codes as such, nor verification of the mathematical models. It is more to contribute to improved engineering decisions and to more reliable licensing procedures.

A growing effort is also being devoted to co-operation on fast reactor safety research. Exchanges have been under way during the past year between the five OECD countries having subtantial programmes of research in this field (France, the Federal Republic of Germany, Japan, the United Kingdom and the United States). These exchanges are leading to the development of a programme which will initially involve those countries possessing large in-pile test facilities and other interested OECD countries will be kept informed of progress. In the same field, we have for some years been concerned with the assessment of sodium/fuel interaction and there has been a very lively exchange of experience in this field, including an important specialist meeting here in Tokyo in March of last year.

The third main area of our programme is much more diverse. It concerns questions of general safety not related to specific reactor types and includes such matters as protection against external impacts (for example, man-made impacts such as aircraft crashes or external explosions and natural phenomena such as earthquakes). We have also detected a considerable development of interest in the analysis of rare events as a factor in the reliability of nuclear plants. An international Task Force has been created to look into the statistical analysis of rare events in nuclear power plants with the main objective of studying methods by which these can be taken into account as a design factor. Exchanges are also continuing on a whole range of mechanical and material problems relating to the safety aspects of steel components. Finally, in this area, we have recently begun a relatively modest examination of the safety problems associated with the operation of nuclear merchant ships and, in particular, with their reception in foreign ports.

The relationship of all these matters to licensing practices and procedures is kept under review by a standing body representative of national licensing authorities for nuclear installations. In addition, the authorities in our different Member countries have been enabled through these exchanges to become more familiar with each other's regulatory systems. This is preparing the way for exchanges of experience on regulatory procedures and practices and improved understanding of the practical and legal reasons for apparent differences. Mutual understanding on such matters is an important element in achieving assurance that Member countries are taking consistent attitudes on comparable problems.

The essential criterion for inclusion of work in the NEA programme concerning nuclear safety is its usefulness to Member countries and relevance to specifically defined aims. Only in this way can a consensus be reached on the key safety issues and this is, of course, a major contribution to nuclear power development.

Radioactive Waste Management

Many believe that the presentation of acceptable policies for radioactive waste management is the biggest single factor in gaining public confidence that nuclear power (and, in particular, the associated nuclear fuel cycle) can be adopted with assurance. The extent of the preoccupation with this aspect of nuclear development is, to some extent, a function of geographical and social considerations, and for this reason among others is of particular significance to Japan.

Radioactive waste management is concerned essentially with the technological means required for the treatment, storage, regulation and disposal of radioactive wastes in a manner presenting no unacceptable radiological hazards. The diversity of problems involved is a reflection not only of the very considerable variety of types of radioactive waste which have to be dealt with but also of the infinite variety of circumstances in which these problems may be met. Thus, there is a need for an overall strategy for radioactive waste management, based on defined objectives; recognition of the relevance of the variety of technologies available; continued research, development and demonstration work to achieve improvements in the technologies already established;

and wise administration at national and local levels to ensure that the best available solution is always adopted. Clearly, international collaboration can and must make a major contribution to this work.

As is well known, NEA has always given special attention to problems of radioactive waste management, with particular reference to those operational and R & D aspects of interest to our Member countries. Our experience in this field leads us to the conclusion that technologies already established provide satisfactorily for all current problems of radioactive waste management, at least for a period measured in decades. However, as is also well known, by far the most important radioactive waste management problem arising within the nuclear fuel cycle concerns materials of very high activity and involving major hazards for periods measured in tens of thousands of years. I refer, of course, to the highly active stream from reprocessing and, in particular, to inclusion in it of long-lived transuranium elements, or actinides as they are also called. It follows that the highest priority in international collaboration must be directed towards acceptable permanent solutions for these wastes.

In this connection, attention is being given to the feasibility of separating the actinides from the bulk of highly active fission products, which would immediately reduce the time scale to one measured in centuries. The actinide stream might possibly then be recycled or transmuted for separate disposal.

However, I must emphasise, that these are long term possibilities and it is entirely possible that a careful analysis of costs, risks and benefits will lead to the conclusion that actinide separation is not desirable. Our principal effort is therefore being devoted to the more immediately promising solution of conversion to solids (for safe handling and transportation) and disposal in deep geological formations. This method would also be very suitable and appropriate for highly active wastes from which actinides have been removed. Disposal into the sea bed is also being investigated and a number of countries, including Japan, have agreed to co-ordinate their research programmes into this possibility.

Work on the R & D and operational aspects of all these questions figures prominently in the NEA programme, both from the point of view of pooling information and experience and from that of developing collaborative demonstration projects. This matter has also been central to a review we have initiated of the objectives, concepts and strategies for radioactive waste management by a group of experts drawn from various Member countries, including Japan. In view of the considerable variations in outlook on many of the questions involved between our Member countries, the conclusions of the group are likely to stimulate a lively debate. I therefore hope that we shall be able to publish their work as a contribution to public discussion on these matters during the course of 1977. Meanwhile, it may be of interest to indicate the general directions of the group's thinking on a number of key issues.

It is likely to be proposed, for example, that the very long time-scale involved in the more difficult aspects of the radioactive waste management problem require that, for these, governmental authorities should assume direct responsibility. This would not mean that short term responsibilities should be removed from nuclear operators since these would normally, in any case, be specified among the conditions of operating licences. The indefinite nature of the long term problem also implies the need to make financial provisions; and the application of the "polluter pays" principle suggests that the required funds should be levied on the basis, for example, of electricity production. These funds should be sufficient not only to provide for long term operational management but also for the continuation of research and development to improve techniques and technologies.

Another emerging conclusion is that the current tendency towards a requirement that wastes should be returned to their country of origin could only lead to a proliferation of transportation problems and of disposal sites, to say nothing of a severe economic penalty. The need for regional and other international agreements to overcome this problem is evidently important.

As mentioned before, other types of radioactive waste can already be satisfactorily dealt with on a long term basis by established technologies. In general disposal solutions at the national level are feasible and most countries are likely to develop centralised facilities for the disposal of low and medium level wastes. For some, however, geological and population distribution considerations will indicate ocean dumping as a preferred solution and for this international co-operation is evidently imperative.

The NEA programme has given particular attention to the development of safe procedures for ocean dumping and we have been very glad to welcome Japanese participation in the control of the operations we have organised in the Atlantic Ocean for the past 10 years. We are now moving towards the replacement of these arrangements through the establishment of a multilateral consultation and surveillance mechanism based closely on the 1972 London Convention on the Prevention of Marine Pollution and the related recommendations of the International Atomic Energy Agency. Accession to the London Convention and to the Paris Convention on Nuclear Third Party Liability are evidently necessary steps to facilitate participation in our new arrangements.

In the field of radioactive waste management, there have been continuous exchanges of information and experience at the international level for many years and these have demonstrably led to a broad convergence of technical views in the various countries involved. There are, in fact, no fundamental differences of technical opinion in this field between those directly responsible at the national level. Nevertheless, there is much work to be done and this work is likely to continue to enjoy the highest priority for many years to come.

Public understanding and acceptance

No consideration of the development and introduction of nuclear power can ignore the evident public sensitivity to this matter in most Member countries. The intensity of this reaction varies from country to country and is a major consideration for the governments of all. We have to recognise that, whatever the success of international co-operation in this field, the severity of regulatory measures, the validity of technical advice or the accumulating evidence of the safety of nuclear installations already operating, more is needed to gain public confidence. On the other hand, although nuclear development has become a principal target, there is evidence of a more widespread opposition to the speed of technological progress and to the means employed in modern society to regulate such matters. Some would even see this trend as reflecting a disaffection with our established scale of values. This is not the place to attempt a penetrating analysis of this potentially significant social phenomenon. However, it is important to recognise that, to the extent that it involves wider considerations, no initiative restricted to the nuclear aspects could alone suffice. At the same time, we should be deluding ourselves if we did not also recognise that the problem reflects a genuine concern by many people based on their difficulty in understanding. There is therefore a clear responsibility on the part of regulatory authorities (who, by definition, can have no promotional motive) to contribute objectively to public information and understanding.

The role of international collaboration on these matters must necessarily be limited. The nature of the public response and the psychology of the people varies considerably from country to country and even within countries. Only national authorities are competent to appreciate these factors and to respond to them with sympathy and understanding. The role of international organisations should therefore be to support national authorities by the collection and dissemination of objective and authoritative information on matters of controversy. A mechanism with these objectives has been introduced experimentally by NEA and appears to have had an encouraging response from most of the regulatory authorities in our Member countries.

Economic and technical studies

My illustration of the current priorities for international collaboration has so far been related to those parts of the NEA programme concerned with safety and regulation. However, as part of the OECD, it is also appropriate that we should concern ourselves with those considerations relating to the prospects for nuclear power that are important for the forward planning of governments and industry. The difficult situation in the energy sector and the potentially important contribution of nuclear power make these analyses a high priority in our programme.

For some years, we have produced, on the basis of the work of experts nominated by Member governments, periodical reports on uranium resources, production and demand. There has always been a heavy demand for these reports, which is perhaps the best indication of their value. The reason for this is probably that the data concerning uranium resources included in the reports had in each case been subject to a searching scrutiny by some of the world's most knowledgeable people in this field. Our published figures have therefore enjoyed considerable authority.

Although these reports have reflected new discoveries and revised evaluations of older ones, they have shown only a gradual increase in total resources, and reserves for only about 15 years ahead. Given the size of the potential commitment to nuclear power, the inadequacy of this situation has caused much concern. This is among the reasons for a new activity, which we are now starting up in collaboration with the International Atomic Energy Agency, to evaluate the worldwide potential for discovery of additional uranium resources and to identify new areas for investigation. Quite obviously, such a project can only be undertaken on the basis of close international collaboration and, although it is being initiated on an inter-governmental basis, it is intended to complement work at the national level in which industrial undertakings are heavily involved.

Our analyses of the demand side of the equation have necessarily been more tentative and I must acknowledge that they have been coloured by the universal weakness of over-optimism in power growth forecasts. Unfortunately, this has caused some confusion among uranium producing circles and we must obviously try to improve our forecasting standards. National representatives are, however, obviously in a difficult position if we ask them to adopt a sceptical attitude towards the official figures of their national authorities.

Looking further ahead, we are now attempting to judge, from the long term uranium requirements point of view, the relative merits of advanced reactor systems and especially of breeders. Our purpose is to achieve a consensus on the basic reactor data required for power growth forecasts and consequently to encourage individual countries to consider their own planning in a wider international perspective. We hope that, since we shall evidently not be seeking to advance the merits of any particular reactor system, our results will gain in authority.

Finally, and I shall return to this later, I should mention that we have recently completed an analysis of the supply and demand situation in OECD countries relating to reprocessing and the technical options open to countries engaged in nuclear programmes. Our report on this study is intended as an objective source of reference for current policy-level discussions in this field. We believe that other analytical studies of this nature could also be a useful contribution in the same sense.

It is a natural extension of this work, which is essentially based on exchanges of information and experience, that we should promote co-operative R & D programmes on related questions. For example, in relation to uranium exploration we are planning international workshops on such priority subjects as gaseous geochemistry, borehole logging and biochemistry and we hope that this will lead to the selection of suitable subjects for collaborative R & D in the interest of improving the situation in relation to world uranium resources.

Relations with other international organisations

All these examples of the contribution of international collaboration to nuclear power development have been drawn from the NEA programme but I must emphasise that several of them are pursued in close collaboration with other bodies. We enjoy a particularly close collaboration with the International Atomic Energy Agency in Vienna, whose programme reflects its worldwide membership and wider responsibilities. Over the years, we have been able to develop a closely complementary relationship with IAEA and often to organise jointly work where our interests overlap. We also have a long association with the Commission of the European Communities concerning their work in the nuclear field. More recently, the establishment within OECD of the International Energy Agency has given a powerful stimulus to nuclear development and we naturally work very closely together to avoid wasteful duplication of effort.

Political aspects

In all this, as I mentioned earlier, I have been concerned with international collaboration based on technical or operational criteria. In an area as politically sensitive as nuclear energy, it would evidently be unrealistic to conclude an assessment of the contribution of international collaboration without reference to political problems which may, in fact, have a more decisive influence on the future of nuclear power than any of the aspects I have mentioned, including the problem of gaining public confidence.

In this context, the major current question is, of course, the acceptability on a large scale of reprocessing and of plutonium recycling, essentially in relation to non-proliferation objectives and to the dangers of diversion of hazardous materials by terrorists. These anxieties are at the root of what is probably the most important question confronting nuclear power development since its inception.

As I mentioned just now, we have recently completed an analysis of the supply and demand situation relating to reprocessing and this illustrates with brutal clarity the painful nature of the choices to be made. It has been estimated that the cumulative total of spent fuel arising in the OECD area by 1990 will be between 85,000 and 100,000 tonnes of uranium, including 10,000 to 12,000 tonnes in Japan alone. The technical and economic justification for reprocessing this material is that this would greatly improve the economy of uranium utilisation - in other words, that it would make the best use of a scarce resource - and, in particular, that it would be an essential foundation for a breeder reactor strategy.

A breeder reactor strategy, in turn, is needed if the limited world resources of uranium are to sustain more than a limited introduction of nuclear power. For example, it has been calculated that the energy potential of the known world reserves of uranium 235 (that is to say, 0.7% of the total known uranium reserves) is roughly equivalent to the known reserves of petroleum. With a breeder reactor strategy, nearly all of the other 99.3% of known uranium reserves would become available for conversion to plutonium whose potential as an energy resource would be ample to meet foreseeable demand for centuries. This is the answer to those who ask why such vast amounts have been invested in nuclear power development.

Clearly, abandonment of the glittering prospect of realising the full energy potential of world uranium resources, particularly in the present situation of acute difficulty in meeting prospective energy demand, would be decided upon only for the most compelling reasons. It is true that the abandonment of plutonium recycling and the breeder option would provide a powerful new stimulus for improvements in the uranium utilisation of thermal reactors and give a new attraction to reactor systems and fuel cycles which are at present in reserve. Nevertheless, most such improvements would themselves involve reprocessing and recycling of fissile materials. Thus it is clear that, with the elimination of the reprocessing option, the long term prospects for the contribution of nuclear power to energy supplies would be very considerably reduced.

What then are the compelling reasons which may lead us to abandon these options ? It cannot be denied that proliferation of reprocessing capacity would multiply dangerously the risks of diversion of nuclear materials and the potential for proliferation of nuclear weapons. Efficiently administered international safeguards would evidently be a powerful deterrent before world opinion. But this could not provide as absolute a guarantee as effective political control over a limited number of centres providing reprocessing services. In addition to this major political consideration, there is the more practical one that proliferation of reprocessing capacity would also aggravate the problem of achieving acceptable policies for the most important problems of radioactive waste management, which are those associated with reprocessing. In other words, determination of the place of reprocessing and of plutonium recycling in the future scheme of things is both a political and a technical matter of the first importance, which necessarily involves achieving an acceptable accommodation on the non-proliferation issue. This is a challenge which must be faced by the nuclear community.

Seen in this perspective it will be apparent that this difficult problem can be satisfactorily resolved only on the basis of the closest international accord. To achieve this accord, continuing international collaboration with political as well as technical and economic objectives is imperative. I said earlier that 1977 promises to be a critical year for nuclear power development. International collaboration in this wider sense would be its most important contribution to maintaining nuclear power as a continuing major factor in meeting world energy needs.

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THE GERMAN PROGRAMME OF A FUEL-CYCLE-CENTER FOR IRRADIATED NUCLEAR FUELS

by P. Zühlke

Nuclear energy is necessary to meet the actual and future demand for electricity. This is true and generally supported by all authorities and institutions responsible for a continuous and reliable supply of energy. The important nuclear power programmes in the industrial and developing countries have to be executed despite the various oppositions to and opponents of this type of energy in general or against special but indispensable parts of activities in the nuclear fuel cycle.

One of such special items on which interest is actually focused is the treatment of fuel assemblies after their discharge from the reactor of nuclear power plants. Since most activities in the past were devoted to developing and introducing a safe and economic reactor system and comprising the various steps of fuel procurement, adequate means to deal with the irradiated fuel have now to be established. Such a sequence in the realization of the new energy generating system seems to be justified if sufficient technical solutions for the subsequent steps are at hand.

The question of how to deal with nuclear fuel after its discharge from a reactor has not been raised only recently. The generally accepted answer to that question has been given some decades ago already with the development of comprehensive reprocessing techniques.

There is no reason to believe that this answer is no longer valid. On the contrary, tremendous research and development programmes in resprocessing have since then been executed in many countries and their results together with the experience gained through the operation of several reprocessing plants of various sizes have demonstrated a sufficient maturity of reprocessing for industrial application.

In the past the intererest in reprocessing resulted from the recovery of fissile material for further use in the fuel cycle. Although a remarkable increase in reprocessing cost-estimates has reduced the economic advantage, there is nevertheless a strong incentive for recovering uranium and plutonium from spent fuels, as their recycling in the light water reactor systems can save more than 20 % of fresh natural uranium and nearly 15 % of enrichment capacity. It goes without saying that the introduction of breeder systems is dependent on the availability of reprocessing.

In the meantime the treatment and conditioning of radioactive wastes for final storage has become another important aspect of reprocessing. The separation of fission products and the concentration of radioactive effluents through reprocessing open the way for converting the wastes into such physical forms which are especially suited for a permanent storage under safe conditions; and last but not least, burning plutonium in the reactor of a nuclear power plant must be regarded as the most advantageous way to its disposal.

Reprocessing, immediate refabrication of mixed oxide fuel, waste-conditioning and waste storage in deep on-site geological formations are therefore the main features of the philosophy for the fuel cycle center for irradiated fuels in the Federal Republic of Germany. The necessity for the early realization of this center with its various installations results from the post-irradiation requirements of the nuclear energy programme in Germany. The nuclear energy generating capacity will increase from 6,400 MW_e in operation at the beginning of 1977 to about 35,000 MW_e in the mid-eighties. It is unreasonable and unrealistic to believe that sufficient installations in other countries will or can be made available on a longer term to cater for the post-irradiation requirements of such a large programme. The strong tendency to put the responsibility for radioactive waste storage on the national governments of the countries from which the waste originates is another argument for the establishment of the center.

In accordance with their requirement that the further development of nuclear energy in Germany will be dependent on the realization of satisfactory measures for a reliable and safe treatment of spent fuel assemblies along the line mentioned before, the Federal Government has stipulated general rules under which the nuclear fuel cycle shall be closed. Such rules are:

1. Industry is responsible for the intermediate storage and the reprocessing of spent fuel assemblies as well as for the refabrication of the recovered fissile material and the treatment of radioactive effluents for final storage.

2. The final storage of radioactive waste, as conditioned into a suitable form is the responsibility of the Federal Government.

3. In order to minimize the potential risks involved in the treatment and especially the transport of radioactive and fissile material all facilities from the intermediate storage of fuel assemblies to the storage of wastes have to be combined in one nuclear center.

4. As the storage of waste is an integral part of the center the location of the site is dependent on the availability of suitable geological formations in the deep underground. Large salt deposits are considered to be a highly satisfactory solution.

5. All costs of the various treatments following the discharge of fuel assemblies from a nuclear reactor, including final waste storage have to be borne either directly or through respective payments by the electricity generating utilities.

6. The realization of the center as well as the operation of its installations shall be performed in accordance with an utmost strict safety and security concept to protect the population and the environment.

When the programme of the Federal Government for the fuel cycle center for irradiated nuclear fuels was announced some three years ago, it found industry, utilities and the total nuclear community easily prepared to agree, as it was in correspondance with the various activities devoted to establishing the remaining part of the nuclear fuel cycle in the country. The appropriate industrial structure to fulfill the Government's proposal did not yet exist at that time. However, the new situation in the field of reprocessing, marked by a change from an anticipated overcapacity in Europe to largely insufficient resources and much more severe economic conditions, led to a concentration of efforts and means under the lead of the utilities. As a result of this, a comprehensive description of the whole center is now available and will be the basis for the first application for the construction licence.

The center will consist of six distinct parts according to the different nuclear activities concentrated on the site. Such parts are:

1. Facilities for the reception and intermediate storage of irradiated fuel assemblies.

2. The reprocessing plant as the central part of the center covering all steps from the shearing of fuel bundles to the delivery of purified uranium and plutonium in the form of nitrates and including the intermediate storage of radioactive waste.

3. Facilities for the intermediate storage of uranyl-nitrate solutions and their conversion into uranium-oxide, so that the recovered uranium will leave the center in a solid form for further use especially after re-enrichment at plants not integrated into the center.

4. A mixed oxide fuel fabrication plant, where the recovered plutonium after intermediate storage is refabricated together with uranium to complete fuel assemblies, which shall be the only form in which plutonium can leave the center.

5. Comprehensive installations for the treatment of the various kinds of radioactive wastes collected from all facilities mentioned before. The treatment will be such that solid products are produced, which are best suited to their final storage.

6. A mine into a virginal salt deposit with two shafts and several systems of drifts especially laid out for the transport and final permanent storage of the solidified wastes.

The size required for a site combining all these facilities will be about 10 to 12 square kilometres. All the nuclear reprocessing and adjacent facilities are designed for the treatment of spent fuel equivalent to the production of 50,000 MW_e, that means for about 1,400·t uranium per year. Only fuel assemblies from light water reactors will be dealt with. The average burn-up of the fuel assemblies on which the concept is based is 36,000 MWd/t·uranium and the minimum cooling period before reprocessing shall be one year. This standard fuel contains about 1 % plutonium and 3 % fission products corresponding to an activity of about 2 million curies per ton of uranium.

The center will have a central storage facility for spent irradiated fuel assemblies. The fuel assemblies will be stored in compact racks under water. For reasons of sufficient operational availability several storage ponds will be constructed, which will be connected by under water locks. The total capacity of the storage facility will be 3,000 t· uranium in the form of fuel assemblies. This is more than would be required for a normal undisturbed operation of the reprocessing plant of the said capacity of 1,400 t.uranium per year.

However, in a situation where the nuclear utilities require urgently adequate means for disposing of their spent fuel assemblies advantage can be gained from the fact that storage ponds can be realized in a much shorter time than a reprocessing plant, so that the spent fuel arisings of several years can already be collected on the site before the operation of reprocessing.

The installations, for receiving and unloading of the fuel assemblies will be designed for a reception of two transport flasks per day to be delivered mainly by rail. Unloading will be under water and adequate techniques are available for cleaning of the flasks and their content.

The building,housing, the ponds and the reception facilities will be safe against outside-influences, such as earth-quakes, air-plane crashes and sabotage.
The reprocessing plant is the central part of the center. For the extraction the purex-process will be used, preceded by mechanical procedures for chopping of the fuel assemblies. After cutting the fuel rods by a bundle shear and dissolution in nitric acid the resulting feed-solution will be clarified by centrifuging. From a buffer store between the head-end and the extraction a three-cycle purex process is fed. In the first extraction cycle fission-products are separated as well as uranium and plutonium. For the purification of uranium and plutonium two further cycles each will be installed. Of great importance for the design of a reprocessing plant is the choice of the extraction apparatus for which centrifuges, mixer-settlers and pulsed columns are available.

Pulsed columns with heterogeneous poison will be used for the first extraction cycle. The second and third uranium cycle will have mixer-settlers of a design which has been tested during many years of operation. The possibility for comparatively large through-puts in a safe geometry were decisive for the choice of pulsed columns in the second and third plutonium cycle.

The capacity of single units of a production line is determined by the intended through-put of 1,400 t·uranium in each year of the life of the plant. Not taking into account the real availability of a single production line the through-put of 1,400 t·uranium per year is theoretically achieved by a capacity of 4 t·uranium per day. This unit size has been chosen mainly due to the fact that operating experience in this range is available. The assumptions on the availability of reprocessing installations, however, have to be very conservative. Assuming an availability of 50 % over the life of a unit the capacity has to be doubled. This will be achieved by installing production lines of the unit size in parallel.

In general the lay-out and design of the reprocessing plant - as well as of the other facilities in the center - are based on the following two fundamental criteria:

- Achieving a continuous operation to ensure the annual through-put of the plant; and

- Securing and maintaining the highest possible safety against incidents and accidents with the lowest possible impact on the environment.

These two criteria are not contradictory but in fact complement each other.

In order to obtain and maintain such level of reliability and safety special and in many cases expensive measures with respect to buildings, equipment and operational procedures will be taken such as

1. Protection against outside influences such as air-plane crashes, earth-quakes and sabotage.

2. Protection against even most unlikely incidents despite their extremely low probability of occurrence.

3. Redundant installation of important supply services and utilities such as electricity or cooling water.

4. Minimization of liquid waste arisings by an extensive rework and purification of waste solutions with recycling of purified products into the process.

5. Production of waste water only in low quantities and release to the environment with drinking water quality only.

6. Extensive off-gas cleaning with emphasis on the installation of aerosol-iodine retaining devices and the separation of krypton by low temperature rectification.

7. Design and construction of the equipment with extreme corrosion resistance and in a way to allow easy maintenance and repair work.

8. Installation of buffer storage for several days between different process steps in order to avoid a shut-down of the whole plant and

9. installation of parallel lines for all major parts of the process, each line connected to the supply and energy-units in such a way that an alternative or parallel operation is possible.

The actual planning and the forthcoming basic- and detailed engineering for the reprocessing plant are based on results of an extensive research and development programme performed at the Karlsruhe research center and on the know-how gained with the planning, construction and operation of the pilot plant at Karlsruhe. This comparatively flexible plant has so far reprocessed about 60 t of oxide fuel from light water reactors, some of which had a burn-up near to 30,000 MWd/t. Another important source of exploitable know-how is the exchange of information amongst European reprocessors, who have joined in United Reprocessors.

An extensive and reliable treatment of the radioactive wastes from reprocessing is of special importance. According to the concept for the fuel cycle center for irradiated fuels, as described earlier, none of such waste shall leave the center of which the final storage in a salt mine is an integral part.

Before the conditioning for final storage the wastes will undergo an interim storage the duration of which is dependent on the nature and radioactivity of the waste. Special treatment before the interim storage is required for most of the wastes.

High, medium and low active liquid effluents are concentrated and transferred into especially designed tanks of a size of up to 1,000 m^3. The distillates are transferred back into the reprocessing plant. Other treatments are the concentration and cementing of solid wastes or the separation of organic liquids. Some wastes such as bottled krypton or iodine fixed on solid absorbers undergo intermediate storage without special treatment.

The conditioning of wastes for final storage requires a variety of facilities. The purpose of all these facilities is to convert the wastes arising in various physical forms into solids which can easily be transported and stored in the adjacent salt mine.

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For the total center,treating 1,400 t uranium per year, about 15,000 m^3 of wastes have to be treated which after conditioning lead to a volume of about 60,000 m^3 to be stored, including the volume of the so-called lost-shielding of the waste-containers.

Such figures have only minor significance as they do not reflect the variety of problems associated with the different categories of waste especially with respect to the level of radioactivity.

Only 600 m^3 of high active liquid waste are produced by the reprocessing of 1,400 t uranium per year, which after denitration, calcination and vitrification lead to only 100 to 150 m^3 of solid waste. With their radioactivity of about 10 million curies per m^3 they contain the bulk of the fission products and require special efforts and care to deal with the radiation and the heat release. Boron-silicate glass put into stainless-steel lining is regarded as the most suitable stable and resistant form for this type of waste.

The high-active solid waste is put into 200 l containers, mixed with cement and after setting of the cement is transported to the salt mine. The containers have a cast-iron shielding which allows easy handling during the storage procedure.

The treatment of medium- und low-active wastes which present the bulk of the volume is performed in a similar way. Liquid waste will undergo a denitration before being mixed with binding agents such as cement or bitumen and filled into containers of 200 to 400 l volume. Solid wastes are wherever possible reduced in volume by burning or compacting before being treated the same way as the liquid waste.

The storage of low and medium active wastes in a salt mine has been performed in the well known Asse mine for many years, and a test-programme for storing high-active waste is expected to start soon. The experience gained with the operation of the Asse mine allows the design of a new mine into a virginal salt deposit especially adapted for waste storage. The many existing salt deposits in northern Germany are each large enough to collect all wastes arising during the life of the fuel cycle center for irradiated fuel. Techniques to close a salt mine in a water-proof way after having finished the operation are available.

The further treatment of uranium and plutonium recovered in the reprocessing plant as nitrate solutions has already been mentioned.

Uranyl nitrate will be converted into uranium dioxide by the ammonium uranyl carbonate process. Eight parallel production lines shall be installed for the conversion of 1,400 t uranium per year, corresponding to 3,500 m^3 of nitrate solution to be treated.

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The uranium dioxide powder is packed into containers, in which it will leave the center for further treatment such as conversion to uranium hexafluoride and subsequent re-enrichment.

Plutonium will be refabricated on site so that it leaves the center only as mixed oxide contained in finished fuel assemblies. After passing a buffer store with a capacity of 50,000 l the plutonium nitrate solution undergoes the following stages. The nitrate is converted into oxide by oxalate precipitation and calcination. The oxide powder is then mixed with uranium dioxide before the pellets are formed and sintered. Such pellets are then introduced into stainless-steel or zircaloy cans, which, after having been closed by welding, are assembled into fuel assemblies either for insertion in light-water or breeder reactors.

The "Entsorgung", a newly formed German word which cannot be translated into English and which means the procurement of services following the discharge of spent fuel assemblies from a nuclear power plant, has become the key-issue for the further development of nuclear energy in the Federal Republic of Germany. The licensing of new nuclear power plants is dependent on the demonstration of binding commitments in respect of the establishment of the nuclear fuel center for irradiated fuels.

According to the economic structure of the country, industry is responsible for the realization and operation of the installations in the center except for the final waste storage facilities. In accordance with the principle that all costs have to be borne and the necessary funds to be raised by those, who require the servizes the 12 electricity generating utilities have got together for the coordination of the project work and for the preparation of the financing of the investments. The utilities' joint company, known as PWK, has taken the lead in the elaboration of all documents, necessary for starting the licensing procedure. The planning work is mainly performed by KEWA as the company entirely involved in reprocessing, by KWU in as far as fuel assembly storage is concerned and by the nuclear fuel manufacturers RBU and Alkem.

The application for the first construction permit will be submitted at the end of March 1977 and it is hoped that site preparation can start soon. This is dependent on the further progress in making available the site by the Federal and local Government. The location of the site has been chosen recently out of four potential sites in northern Germany after an extensive site selection programme.

The time schedule further provides for the fuel assembly storage facilities to be in operation by 1984 and for the reprocessing plant by 1988. All efforts of industry and authorities are necessary to meet the urgent requirements of the utilities in the realization of their reasonable nuclear power programmes.

S L I D E S

No.	1	:	The "Entsorgungs"-Concept
No.	2	:	Activities in the "Entsorgungs"-Center
No.	3	:	Lay-out Criteria
No.	4	:	Reprocessing Process Scheme
No.	5	:	WAK - Plant (Photo)
No.	6	:	Waste Conditioning Scheme
No.	7	:	Waste Storage at Asse Mine

タランジェ氏本論文

才3セッション 3/10 午後

⑦

INTERNATIONAL COOPERATION RELATING TO THE FUEL CYCLE

(JAIF, Tokyo, March 1977)

Exposé by Mr. Taranger

What is known as the nuclear fuel cycle includes a series of industrial operations which are relatively distinct from each other, but which all contribute to the supply of fuel to nuclear power plants. A distinction is generally drawn between the exploration and production of natural uranium, followed by the enrichment of this uranium, and then by the fabrication of fuel elements which are loaded into power plant reactors, and ending with the reprocessing of irradiated fuels and subsequent waste packaging and storage.

Each link in this chain of operations has its own specific features, but, to various degrees, they all possess certain determining aspects in common.

To begin with, except perhaps for mineral exploration and production, they all draw on high quality techniques based on sophisticated, reliable technological research.

Furthermore, except perhaps for fuel element fabrication, they are all highly capital intensive, and the dimensions of economical plants are often impressive.

Finally, since technological development and investment financing exceed the resources of each individual country involved, their industries are often obliged to reach beyond their frontiers in the search for markets.

This explains why the nuclear fuel cycle industry needs international cooperation, and it is always this spirit which has guided the activities of French industries. As we shall see, the foremost among them, such as COGEMA, which handles all the operations in the cycle, and also Péchiney-Ugine-Kuhlmann, Saint-Gobain-Pont-à-Mousson, Total, Creusot-Loire etc, have joined hands with many foreign partners and concluded commercial relations - in buying and selling - crisscrossing our borders.

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The exploration and exploitation of uranium deposits, like any other mining industry, entails risks which should be distributed. French industries have therefore naturally diversified their efforts throughout the world.

On the one hand, they are exploring and producing uranium in Europe, Africa, North America, Indonesia and Australia, in association with over twenty partners belonging to the countries in which these operations are carried out, or to consumer countries. Furthermore, they have concluded long-term contracts both for buying and selling uranium concentrates.

A good example of this is the Compagnie Minière d'Akouta (COMINAK) which associates COGEMA (with the Republic of Niger and Spanish interests) with the Japanese company Overseas Uranium Research and Development (OURD) and which will shortly produce 2000 tons of uranium per year. In addition, uranium concentrate supply contracts have been concluded between French producers and Japanese utilities to ensure, in the words of one of their Chairmen, 'a friendly and safe supply'.

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In the area of uranium enrichment, based on the gaseous diffusion process developed fifteen years ago in the national Pierrelatte plant, French industries have been the promotors of EURODIF. This multinational company, grouping French, Italian, Belgian, Spanish and Iranian interests, is currently building, at Tricastin in France, a plant expected to go on stream in 1978, and to reach rapidly a capacity of 10.8 million separation units per year. Its output has already been entirely purchased to meet the needs of the utilities of shareholder countries, and also other countries such as Switzerland, West Germany and especially Japan, since the seven utilities of this country will receive jointly, from EURODIF, about one million units per year.

It is also because, after 1985, the EURODIF plant will be unable to meet the needs of its partners, that the latter, again joining hands in COREDIF, have decided to build a new plant, its location to be decided in forthcoming months, in accordance with the economic analysis under way.

The industries associated in EURODIF and COREDIF naturally do not intend to give these companies a monopoly in supplying the needs of their respective countries. In France, for example, we are already buyers of enrichment services in the USA; five years ago, we were the first to sign a contract with the USSR, and there is no reason to discontinue this practice.

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Fuel fabrication, as we have already seen, does not require investments as large as the other links in the cycle, and consequently international partnerships are unnecessary. However, international cooperation is extremely useful in the area of technology development, which requires considerable resources, especially for irradiation experiments.

Consequently, we in France produce the fuel required by our graphite-gas and fast neutron power plants, and for the light water reactors derived from the French Navy's nuclear propulsion program.

For the fabrication of PWR power plant fuels, it is important to note the existence of Franco-Belge de Fabrication de Combustible, which groups French, Belgian and American interests.

As for fast neutron reactor fuels, the cooperation with our German and Italian friends should also be noted.

With respect to the many cooperative ventures in the area of research and development, one should also mention the agreement binding the CEA with PNC, for the irradiation of fuels developed in Japan, in Rapsodie, the French fast neutron reactor.

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The reprocessing of irradiated fuels, which is indispensable for the economics and growth of nuclear energy, only enters the picture after power plants have operated for a few years, whereas, on the other hand, the other operations of the cycle just described precede, by a few years, the startup of these power plants. This is why the worldwide reprocessing industry has not yet attained a state of equilibrium.

In our country, however, we have unceasingly worked for twenty years to develop the techniques and corresponding installations at Marcoule and La Hague. The first case of international cooperation also dates from nearly twenty years ago: in 1957 the Eurochemic Company was created, grouping twelve European countries, to build a plant at Mol (Belgium). Based on essentially French technology, this plant has operated satisfactorily since 1966.

Also in the field is United Reprocessors (GmbH) which combines British, German and French resources. Also noteworthy is the participation of French technology and industry in building the Tokai Mura plant here in Japan.

Naturally, since last year, when the French plant at La Hague started reprocessing light water power plant fuels satisfactorily, we have agreed to handle irradiated fuels from other countries.

For this purpose, contracts have already been signed with ten utilities in five different countries, covering a total of 800 tons. Kansai Electric and Shikoku Electric are among them.

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Everyone is aware of the evergrowing importance of waste packaging and storage in the fuel cycle, at least when this involves high activity wastes and those which contain long half-life alpha emitters.

In the short term (a few decades) the problem has been satisfactorily resolved by storage in liquid form in specially designed tanks, which are permanently cooled and monitored, which we have been using without the slightest problem for nearly twenty years.

In the longer term, however, we shall have to leave the design of different storage facilities to future generations. We in France feel that wastes should be packed in solid form, and stored in suitable deep geological strata. This is why we are developing a continuous vitrification process. Furthermore, the discovery of several fossil nuclear reactors at Oklo, in Gabon, confirmed the existence of geological conditions in which substances produced by the decay of fission products and plutonium are found, more than one billion years later, exactly where they were produced.

The area of waste handling is one in which international cooperation is and will be most active.

One can therefore reasonably hope that the satisfactory short-term solutions achieved, as well as the research and pilot projects under way, should convince national leaders and the public that excellent solutions should be anticipated in the long term.

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In conclusion, it is easy to see that the nuclear fuel cycle industry is growing in the spirit of international cooperation. This provides a guarantee of its effectiveness, and the assurance for its clients of healthy competition, which is important for progress, as well as reasonable prices. In this context, Franco-Japanese cooperation is an exemplary factor.

第3セッション 3/10 午後 C.バック氏本論文 (8)

INTERNATIONAL COLLABORATION IN THE NUCLEAR FIELD

Presented by C Buck

BRITISH NUCLEAR FUELS LIMITED

There are a number of important objectives which encourage organisations to enter into international collaborative activities,

- the practical need to rationalise the deployment of resources
- the advantage of sharing risks
- the need to ensure supplies and markets
- the exchange of technical information and know-how

and - a desire to coordinate policies internationally.

In the nuclear field the efficient international deployment of resources and the sharing of risks are particularly important because of the massive expenditures which are involved, the length of time required to develop, construct and commission facilities and the economic advantages of operating on the largest practicable scale.

Nuclear activities which are organised on an international basis should be less dependent upon the current power strategy and the financial and industrial climate in any one country and should therefore enjoy a more even supply and market position.

In an industry which has a very high technical content and which requires the highest standards of operation and safety to be maintained, it is beneficial for all collaborating parties to exchange technical information and know-how. The importance of these exchanges ranges further than the immediate area of technology involved since a failure in any part of the industry can have repercussions which will affect the development of the whole industry.

In international organisations the opportunity to coordinate policies on an international basis may provide means of reducing the proliferation of nuclear weapons and a framework for the development of internationally-accepted standards for the protection of the environment, workers in the industry and the general public.

A number of organisations involved in international collaboration in the nuclear field may be mentioned,

- the International Atomic Energy Agency of the United Nations
- the Nuclear Energy Agency of the OECD
- the Research and Development Centres of the European Economic Community
- (Then in commercial field) the URENCO/CENTEC organisation devoted to the enrichment of uranium

and - United Reprocessors (Pacific Nuclear Transport Ltd., British Japanese Organization dealing with Transport of irradiated fuel from Japan to Europe.

Each of these and many other organisations involved in international relations are daily contributing to the fruitful extension of international collaboration in the nuclear field and many substantial achievements may be mentioned, such as, the development of transport regulations for the international transport of radioactive materials, the development of new enrichment techniques and the construction of new fuel cycle facilities.

Although the record in international collaboration is so far impressive we must not become complacent and one should ask if there is any important area at present which is receiving less international attention than it merits.

In answer to this I would highlight the special problem of the final disposal of medium and high-level solid wastes which has only been pursued so far to a limited extent on an international basis.

I feel this subject is of the highest importance for the future development of the nuclear industry and that it should be singled out and vigorously pursued with the object of developing internationally-acceptable disposal techniques.

The disposal of low-level radioactive solid wastes by near-surface burial on land is already established practice in all countries with nuclear programmes, such operations being covered by national legislation in individual countries. The disposal of low-level waste to the deep ocean is already an internationally-established practice which is controlled under the terms of the international agreement generally referred to as the "London Convention". There is, however, no fully-developed procedure for the final disposal of medium and high-level solid wastes and it is in this area of development that future efforts should be concentrated.

Medium and high-level wastes which arise from power station and reprocessing operations are at present stored under safe conditions pending the development of a final disposal route.

The final conditioning and packaging of these wastes for disposal will depend upon the disposal route which is eventually selected and shown to be environmentally acceptable. In the meantime therefore it is necessary to maintain these wastes in a condition which will allow flexibility in the selection of future conditioning and packaging procedures.

In anticipation of final disposal operations, several methods of treatment are under development for these wastes.

For medium-level combustible wastes an incineration process is under development with an associated process for the recovery of plutonium from the ash, should this be required.

Methods for the incorporation of incinerator ash into ceramic blocks and for decontaminating non-combustible items of waste are also under development.

Processes for the solidification of high-level liquid waste are under development in a number of countries. The method generally preferred results in the dried waste being incorporated into glass blocks of extremely low solubility.

All of these treatment processes are at advanced stages of development and it is now timely that substantial progress towards an ultimate disposal route should be realised so that a complete waste management scheme can be introduced.

I also feel it is important to be clear in this respect, that such international efforts to develop treatment and ~~eliminate~~ ultimate disposal routes for waste should be pursued freely without commercial or other restrictions and should not be caught up in the political technology issue which relates specifically to the reprocessing operations.

Following the "International Symposium on the Management of Wastes from the LWR Fuel Cycle" held at Denver in July last year, an international working Committee, which included representatives from Japan and the UK among other countries, met at Hanover to discuss the possible extension of international collaboration on waste management. The two main options for the future disposal of medium and high-level solid wastes - disposal into deep geological formations or to the seabed of the deep ocean, were identified by the Committee as subjects which require investigations coordinated on an international basis. This field of development has also been recently discussed at OECD/NEA meetings at which both Japan and the UK are represented and I would suggest that these are important initiatives involving both our countries which should be strengthened and pushed forward to the overall benefit of the nuclear industry in Japan and the UK.

8 February 1977

第3セッション 3/10 午後
E.ベムデン氏 本論文

(9)

International Collaboration in the Pu Fuel Production Business

J. Van Dievoet - E. Vanden Bemden

Plutonium is a New Energy Resource presenting the advantage of being generated at the location where nuclear fission reactors are being used, and in direct proportion to that use. It is, therefore, independent of imports as long as the reactors can be fed with enriched uranium and as long as the necessary irradiated fuel reprocessing plants are available on location.

How important is plutonium as an energy resource ?

We have evaluated that, on the basis of a moderate energy growth, nuclear generated power could represent in the western world 3,500 GWe by 2010. On that basis, and assuming an orderly growth of the fast breeders, similar to the now historical growth curve of the LWR's, we have determined that 25% of the nuclear power, or 860 GWe, could be generated by plutonium using and breeding fast breeder reactors in 2010. Moreover, as plutonium availability would exceed by far the requirements of the fast breeders in the interim period 1977-2010, 15% of the LWR's energy could be produced by plutonium over the same period. This would certainly not be a negligible contribution to the western world energy resources.

today

This fundamental aim can be safely performed because today it is a fact that

1) plutonium bearing fuel is produced with full safety
2) plutonium waste, from production plants, is safely conditioned in view of its fullsafe ultimate disposal
3) plutonium bearing fuel achieves an identical behaviour in LWR power reactors as uranium enriched fuel.

Besides these three important facts which are now positively recognized by the informed technical people, our main concern is related presently to

1) the safeguarding and physical site protection of the plutonium production plants in particular
2) the economy of plutonium bearing fuel production.

As far as the safeguarding and physical site protection is concerned, it is a fact that in the present situation, all practical means are installed in order to avoid plutonium diversion and to physically protect the production sites. Nevertheless, if in the future the number of sites increases progressively, the probability of a diversion or other terrorist action will mathematically grow in proportion. The way to maintain this number of production sites to an acceptable level is to promote the principle of a form of internationalization of these plants. To go deeper into the concept of integration of fuel cycle nuclear plants, the grouping on single sites of a reprocessing plant, a plutonium fuel production plant and a waste management plant is essential from the safeguarding and physical protection point of view. First, with such an integration, transport on public roads of considerable amounts of high plutonium content liquids or powders is eliminated to a large extent. The only transports on public roads to be considered are related to the delivery to the power stations of finished fuel elements. These elements are inserted in very heavy containers, which cannot be easily diverted as one can note that each road transport grouping 4 assemblies represents a total weight of about 12 tons per 1.8 tons U + Pu and 50 kg of plutonium. If, in order to reduce the number of integrated sites, the internationalization principle is adopted, in addition, one could optimize all possible ways to physically protect the sites against robbery or sabotage, or other terrorist action, taking into account the existing measures already in application. This concept is sponsored by the IAEA in the frame of its regional fuel cycle centre project about which a report on first results is announced by the IAEA. This report will be presented at the IAEA Salzburg Conference in may of this year. To be practical and effective, the principle must not be obligatory extended to the ultimate waste disposal activity. This latter can either be colocated with an international integrated site or geographically separated from it. It can also be multinational or national without altering the fundamental bases of the international integrated site concept.

As far as the economy of plutonium bearing fuel production is concerned, the integration of reprocessing, production and waste plants in a multinational centre, e.g. will unavoidably reduce the fuel production costs since all support services such as general test and analytical laboratories, general workshops, fissile material accountability, general site protection, etc. can be organized to serve the centre as a whole and must not be duplicated. The parameters which most affect the economy of fuel production are

- the size of the batch to be produced in one continuous campaign
- the capacity of the plant
- the variability of the fuel characteristics.

If the plant is integrated in a high capacity complex like the one considered for a RFCC, the probability to combine the production of fuel for identical power stations increases. This means that the average batch size produced in one continuous fabrication campaign will increase which will have a beneficial effect on cost e.g. the production cost difference between a batch of 2.5 tons U + Pu and another one of 10 tons U + Pu plutonium bearing fuel elements is between 30 and 40% (1). Considering apart an increase in capacity of 40 tons U + Pu / year to 160 tons U + Pu / year leads to a cost decrease between 15 and 20% (1). The international concept allows also to split the very important initial investment costs among the participant countries and gives potentially to all countries the possibility to benefit from the experience gained in the considered fields at a world level.

International collaboration applied in the frame of fast reactor projects projects, very close collaboration exists in the field of plutonium fuel design and production between Germany and Belgium specialized research centres and industries. In Belgium at Dessel, Eurochemic, a pilot reprocessing plant has been operated since 1966. The company had been formed by 13 nations and has reached its assigned goal to demonstrate at an industrial level the soundness of the purex process now adopted by all existing and future reprocessing plants. The company has procured more than 180 tons of light water reactor fuel and has been operated with a full international team demonstrating the real validity to put people of different nationalities together to achieve an effective work. Such project, besides its first goal, contributes also to a better understanding between people of different nations which should be a world goal for the future. Very recently, in December last year, the Board of Directors of Eurochemic has decided to build a semi-industrial plant for the solidification of high level active waste. In connection with this project, the OECD (Organization for Economic Cooperation and Development) starts progressively an international cooperation program, grouping besides the Enrochemic member countries in particular the USA and Japan with whom the negotiations are already far advanced.

It is worthwhile to note here that at the same site, the Belgonucleaire Pu fuel fabrication plant and waste management plant have been operated successfully for many years.

Conclusion

The limitation in the number of integrated fuel cycle sites and consequently the internationalization of these sites favours the safeguarding, the physical protection of the site, as well as the economy of the fuel cycle and in particular, the one of plutonium fuel production.

One has also to add that it facilitates the personnel formation and training through a better centralization. One should not forget that an efficient personnel training is the best guaranty for safety, especially in the plutonium fuel cycle industry.

(1) Topical and meeting toronto - April 1975.

ANS Meeting, Toronto, April, 1975

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今井氏 本論文

(10)

NUCLEAR FUEL CYCLE; INTERNATIONAL MARKET, INTERNATIONAL CONSTRAINTS AND INTERNATIONAL COOPERATION

by Ryukichi Imai

I New Approaches to Nuclear Fuel Cycle

There are thirteen power reactors (7,428 MW) in operation in Japan, while fifteen more (13,363 MW) are under construction. Uranium reserve is only 9,053 tons at 0.053% average ore grade. Fifty tons per year (SWU) centrifuge pilot plant is under construction. LWR fuel fabrication plants have total annual capacity of about one thousand tons and are expanding. 200 tons/year reprocessing plant is awaiting hot test at Tokai, while 100 MW(Th) experimental breeder will go critical in April. This, in brief, is what constitute Japan's nuclear fuel cycle today.

Rather than dwelling further on their details, I would like to take up the international aspects of nuclear fuel cycle, and discuss

a. major problem areas

b. constraints that should be expected in future, and

c. possible international cooperation.

Under research contract with the Ministry of International Trade and Industries, the Institute for Policy Science has been conducting fuel cycle analysis for the past three years using system dynamic model in order to calculate quantative effects of different factors of constraints on nuclear fuel cycle. Although this is not the place to give details about this model study, it is at least worthwhile to point out that optimization of fuel cycle strategy is not simply governed by mills/kwh type of considerations. Much more strategic factors such as maximum utilization of energy from imported ore, trade-off between construction lead time of centrifuge enrichment plant and fuel reprocessing plant seem to influence the fuel cycle strategies of a country like Japan.

In other words, the study has led us to realize that for a very long time we have been living under the impression that the concept of nuclear fuel cycle as given at the beginning of the Atoms for Peace would come about naturally and without any major modification to the concept. It has been assumed the once scale of nuclear power program has been determined, necessary fuel cycle technology and facilities would follow. What one is faced with today is that constraints on nuclear fuel cycle are such that they have an determining influence on the size of nuclear program itself. Among such constraints one can mention:

i) ones arising from economic and financial reasons,

ii) those caused by uranium resources and their distribution,

iii) those arising from technical reasons,

iv) issues of public acceptance, and

v) those quite independent of normal industrial considerations, but caused by elements of international politics.

II. Energy Situations in Japan

It seems to be an accepted theme within the international energy community that production capacity in the Arabian Penninsula would invite "the second oil crisis" by the middle of the 1980's. Consideration of the North/South relations indicate that the industrially advanced countries of North will have to depend increasingly on technological means for alternative energy supply. For a country like Japan, without large reserves of oil, gas or economically and environmentally available coal, nuclear power offers very important energy option.

The official forcast for energy supply in 1985 says:

domestic hydro	3.7 %
domestic oil and gas	1.8 %
domestic coal	1.9 %
geothermal	0.5 %
imported oil	63.3 %
imported coal	11.2 %
imported LNG	7.9 %
nuclear	9.6 %

making the total of 830 million kl of oil equivalent minus 9.4 % as effects of energy conservation. Oil import figure is 485 million kl which is a great deal of increase compared to 318 million kl (5.5 million b/d) in 1973. 9.6 % nuclear is on the basis of 49,000 MW capacity.

Each one of these sources has major difficulties in order to achieve the above-mentioned target figure, while whatever shortage therein would mean that much shortage in attainment of GNP growth rate. For a country who depends so much on export of industrial commodities for her economic existence, and with the expected changes in demographic structure of the population, this will be a very grave situation. Without going too much into the energy forcast of the country, however, such considerations would be sufficient to conclude that Japan's basic strategy on nuclear fuel cycle is made up of the following four points:

a. For the short-term considerations up to the year 1985, Japan has to exert all possible efforts to increase energy supply from all the energy sources mentioned above.

b. Nuclear power is the only means at Japan's disposal which may provide increasingly large amount of energy through her own efforts, especially toward the medium-term considerations up to the year 2000.

c. Since development and deployment of modern energy technology requires very large investment of resources, it would obviously be more effective if such energy technology possesses a large potential to manage energy needs well into the twenty-first century. Plutonium burning through FBR is a very important and indispensable technology option for the country.

d. There are number of problems in technology, economics, financing etc. that will have to be overcome before burning of Plutonium in a very large scale becomes a well-established industrial technology. However, we need to realize that there is not a single easy option for Japan today. Forcasting cost of power on the basis of today's knowledge is not the recommended methodology to evaluate the options. (Solar electric power or nuclear fusion, then, will not stand a chance !)

With the 0.3 % tail, the following gives an easy comparison among different energy values of technologies. (% of potential)

LWR	without Pu recycle	0.5 %
LWR	with Pu recycle	0.7 %
FBR	without Pu recycle	0.5 %
FBR	with Pu recycle	better than 90 %

A trade-off relations exist between lowering enrichment tail to 0.2 % and conducting LWR Pu recycle. For a given condition, LWR Pu recycle has important effects in the energy supply consideration of Japan, especially since all uranium ore has to be imported and since development of Pu handling technology is already an important part of her energy option.

III Nuclear Fuel Cycle and International Market

This subject was rather extensively covered in a joint paper with Mr. D. Avery of BNFL which was presented at the November 1976 ANS Conference in Washington, D.C. Here, it will be sufficient to point out the following major characteristics of nuclear fuel cycle industry. The results from the afore-mentioned MITI study are also taken into consideration.

(i) Uranium reserves are found only in limited regions of the world. Except for the United States, expected demand and production forcast do not meet in the region, and thus uranium, by definition, is an international commodity which moves from producing areas to consumption areas. Newly discovered reserves are often in geographically or socially inaccessible areas, so that a large amount of investment and long lead time are required before they can become marketable. Consuming countries' participation in such investment will become a part of accepted norm.

(ii) Within the fuel cycle, facilities for reprocessing and enrichment have to have 50 to 90 1000 MWe class LWR's in order that these facilities may be commercially viable. This means that fuel cycle facilities always have to look at the international market.

(iii) Many of the facilities are known for their capital-intensive and technology-intensive characteristics as well as for their very long lead-time. At the same time, technology and facilities of nuclear fuel cycle serves a single purpose of producing nuclear electricity. There is very little inter-changeableness and this makes fuel cycle industry a very inflexible entity. It is natural that technically advanced regions of the world with a large scale nuclear power program of its own should become the world's centers of nuclear fuel cycle services.

Because of these considerations, and because its technology still have areas in which industrial scale demonstration is needed, it is extremely important that international flow of technology and services should be encouraged so that sound development of international fuel cycle market may be gradually established. This is because:

a) unnecessary repetition of investment in R & D or in plant construction has to be avoided, and effective utilitzation of service capacities should be aimed at, and

b) proper formula for sharing of investment risks should be worked out and sound development of the international industry encouraged.

IV Matters of Nuclear Non-Proliferation

The preceeding discussion is based on nuclear fuel cycle as an industrial entity. It is very well known that nuclear technology has an aspect related to the nuclear weapons. The two major themes need be considered in this connection, namely:

a. proliferation of nuclear weapons potential

b. realization of such potential in actual weapons.

IAEA safeguards provide adequate means to prevent b from occuring, while the basic nature of the fuel cycle industry which calls for a limited number of technology centers throughout the world offers important direction toward solving a . What need to be seriously evaluated are not any shortcomings in the nuclear fuel cycle industry but may be limited to the following two:

i) What needs to be really prevented from proliferating? and

ii) What extent of international assurance is really required?

If one should start from a fundamental conslusion, it is simply like this:

"If any potential for production of any crude nuclear explosive device (s) is to be prevented at any cost, then the recommended measure is to stop all peaceful nuclear activities right away."

To use a number from the Rassmussen Report, the conclusion is equivalent of:

"If a nuclear accident with a chance of killing more than ten persons should not take place even once in every 250,000 years, and even if such probaility may be smaller than a person getting killed by a falling meteorite, accident is still an accident, then the only thing to do is not to build or operate nuclear power plant."

Just as it would be too late for this policy to be enacted because so many operating nuclear power stations have radioactive f.p.'s in reactor cores and chances of their accidentally released to human environment is not absolutely nill, it would be too late to get nuclear genie back into the bottle. There has been sufficient proliferation of nuclear knowledge throughout the world so that a chance of somebody making a crude nuclear device is not zero even if no further industrial activities take place. "How safe is safe enough ?" is the question that may be equally asked in the case of nuclear non-proliferation.

Since non-proliferation is by definition a defensive measure, and since against any defensive means, there always is an offensive scenario, however absurd, which can beat this defense, non-proliferation can lead to an open-ended discussion ad infinitum. Just as in the case of safety argument, it is not going to contribute to the real cause.

What should be the level of proliferation that need to be prevented, and what degree of international assurance in doing so would be regarded adequate depends very much on the "threat level perception" among different countries. A country who do not foresee any need for nuclear power into a very long future may easily accept the extreme scenario and agree with complete ban on any nuclear industrial activities. For others, who feel the immediate need for a very large scale Plutonium based energy, or those who would like to take uranium energy as an interim but "last" resort, national security analysis will give different answers to such threat levels as:

a. capability to produce several crude explosive devices in five to ten years,

b. actual possession of such devices by immediate neighbours,

c. possession of small numbers of meaningful nuclear weapons with limited but efficient air-delivery capabilities.

Perception of threat levels will also be influenced by threats imposed on a country from other sources. Prospect of significant shortage of natural resources such as food or energy may mean much more serious situation to some countries than the nuclear weapons which their neighbours may develop in some distant future. It is worthwhile pointing out, what to many people seems like a common sense statement that thousands of megatons actually deployed means far larger threat compared to a small number of crude devices which somebody has not developed yet.

V Toward Meaningful International Cooperation

Factors involved in the non-proliferation are so diverse and so complicated that it is not possible to explain them all in a given short period of time. Considerations such as energy supply and demand, status of avaialbility of different natural resources, global political strategy of a country, all contribute in making this subject one of the most difficult dilemma of our time. It is also very important to bear in mind that technical capabilities do not necessarily lead to actual weapon acquisition. There have been many such examples in the world. There are many effective political means which would make weapons acquisition either undesirable or un-necessary. It should be particularly emphasized that to accord special priviledges to nuclear weapon states in the world non-proliferation regime is an absolute none-sense. It would be equivalent of denying proliferation on one hand and at the same time proving to the world that having nuclear weapons is indeed advantageous.

Based on these considerations, one may be able to point out that the following roughly represent general course of action to bring about effective international cooperation toward effective nuclear fuel cycle with adequate assurance of non-proliferation.

1) Long-term contractual commitments, exchange of technology, international joint venture, and other means should be encouraged to develop international fuel cycle market. When allowed to follow natural flow of supply and demand, this would lead to creation of several efficient fuel cyle technology centers of the world from which the rest of the world would receive necessary services. Restraints should be placed internationally in order to curve obviously uneconomic, unjustifiable development, but at the same time, politics should not try to dictate

or interfere with the internal logic of large technology-intensive industry.

2) Exporting critical or sensitive technology or material, when it cannot be justified from the considerations of 1) above will have to be placed under international control. The crucial requirement to make such a proposition meaningful would be to establish long-term credibility of supply of the necessary fuel cycle services.

3) IAEA Safeguards can provide adequate assuarance to prevent diversion, especially if its emphasis is shifted from current LWR and low enriched fuel fabrication to Plutonium handling and highly enriched uranium. More attention should be given to safeguarding research facilities. Physical protection requirement of nuclear material accountrancy with containment and surveillance can also re-inforce safeguards effectiveness.

With the expanding size of nuclear industry, what have so far been understood to be the amjor constraints on nuclear fuel cycle are proving themselves to be somewhat more difficult and more complicated than was originally thought of. In addition to these technical and economic problems, non-proliferation requirements have come to be very much emphasized now-a-days. These requirements, especially when they are presented to the world in abrupt and ill-defined manners, tend to threaten the very existence of nuclear industry itself by interjecting non-industrial elements into what should basically be an industrial problem. The starting point of international cooperation is to have common recognition of such basic nature of the nuclear non-proliferation problem.

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IAEA STUDY PROJECT
ON
REGIONAL NUCLEAR FUEL CYCLE CENTRES

Introduction

The IAEA Study Project on Regional Nuclear Fuel Cycle Centres (RFCC) was initiated in 1975 and the initial study phase is now nearing completion. A report on this Study will be presented at the Salzburg Conference in May.

The RFCC Study Project was undertaken to determine if multinational fuel cycle centres would have significant advantages for the activities related to the back-end of the nuclear fuel cycle. Preliminary studies made by the IAEA in late 1974 had indicated potential economic advantages from economies of scale in reprocessing and waste management operations. These potential economic advantages were subjected to thorough evaluation during the RFCC Study Project.

In addition to the economic potential, the RFCC concept appears to make substantial contributions towards the goals of non-proliferation and safeguards. A number of States joining together in multinational fuel cycle centres would reduce the tendency towards setting up separate national facilities, thereby easing the concerns about possible diversion of civilian reprocessing plants to weapons programmes. These possibilities for achieving non-proliferation objectives through the RFCC approach were also subjected to careful investigation.

Objectives

The overall objectives of the Study Project were four-fold:

1. To study the back-end of the nuclear fuel cycle - i.e., spent fuel storage, fuel reprocessing and recycle, and waste management - and to develop an RFCC concept based on multinational co-operation in planning and setting up the needed facilities;

2. To develop the information and methodology required for evaluation of alternative strategies for establishing regional fuel cycle centres, and for evaluation of the RFCC advantages and disadvantages relative to dispersed national fuel cycle facilities;

3. To prepare a report on these studies - including illustrative examples of strategies - for the use of Member States and other parties who may be interested in the implementation of such fuel cycle activities;

4. To provide a mechanism for establishing a forum where Member States and other interested parties can work out strategies pertinent to their nuclear fuel cycle activities.

Scope

The RFCC concept envisages several countries joining together to plan, build and operate facilities necessary to service the back-end of the nuclear fuel cycle. As shown in Figure 1, such a concept would be broad enough to include all steps in the management of spent fuel, from the time it leaves the reactors through all subsequent process steps including radioactive waste management, until recycled fuel in the form of mixed oxide elements is ready for use in a reactor.

The IAEA views the RFCC concept as being very flexible, so that any group of Member States could join together on the basis of their mutual fuel cycle needs and economic, geographical and socio-political interests and needs. The Study Project did not, therefore, attempt to determine any actual regions or groupings where RFCC's would appear most suitable. Such determination would need to be made by the interested Member States in the early stages of the implementation phase.

This concept of the RFCC does not require that all the facilities be entirely new. Existing or planned national installations could serve as the initial core of an RFCC. This could be particularly useful in leading to earlier implementation of the RFCC concept than would be possible if entirely new facilities were involved.

Study Project organization

As shown in Figure 2, the Study Project was divided into three broad categories of effort:

(1) Quantitative studies of process steps involved in an RFCC with reprocessing and recycle facilities were carried out to develop process flow models and characteristic cost data for each step. These included spent fuel storage, reprocessing, mixed oxide (MOX) fuel fabrication, waste management, and transportation of spent fuel and radioactive wastes.

(2) Associated qualitative studies were carried out to analyze and evaluate some of the important considerations in any decisions to participate in an RFCC, as well as to determine the merits, problems and possible forms of such a multinational enterprise. These studies covered institutional-legal aspects; organizational and administrative arrangements; financing considerations; health, safety and environmental factors; nuclear materials control, physical protection and safeguards.

(3) Mathematical models and computer programmes were developed to provide a methodology for economic analysis of various strategies for spent fuel management, by reprocessing and recycle using large size RFCC or smaller national facilities, or by long-term storage without reprocessing. These models and programmes were based on the qualitative and quantitative studies of spent fuel management strategies, and the data developed in those studies were used in carrying out illustrative strategy evaluations and sensitivity analyses.

As the technical and economic data, as well as the socio-political factors, with respect to spent fuel management are in a state of continuing change, it was necessary that the relevant data be developed on an up-to-date basis. For purposes of this Study Project, it was also essential that the developed information reflect current conditions in Member States and hence could serve as "characteristic data" for general economic studies. Accordingly, contributions to all areas of the Study were obtained through meetings of experts from many Member States. With the assistance of the experts, efforts were made to develop material specifically relevant to the RFCC concept. The information thus generated was compiled through the process of consensus, rather than taking the view of an individual expert or a single Member State.

General Conclusions

The results of the Study indicate a very encouraging potential for the RFCC approach to the management of spent fuel. Non-proliferation considerations, waste management aspects, and economic evaluations show advantages to be gained by the multinational approach in establishing sufficiently large facilities in contrast to the alternative States setting in their own smaller national plants.

The RFCC concept would meet the spent fuel storage, reprocessing, recycle and waste management needs of States on an economic and assured basis through multinational co-operation and participation in a joint project.

The RFCC should provide, and convey to the public, assurance of adequate control over nuclear materials and facilities. Thus, it should help to allay concern about proliferation and misuse of nuclear facilities and materials.

The results from this Study Project are sufficiently encouraging to suggest that States would be well-advised to consider the RFCC concept in light of their respective national nuclear power programmes and needs. The Study Project has developed tools to assist Member States in evaluating the basic alternative strategies from the multinational point of view.

As a number of Member States need to plan their fuel cycle requirements at an early stage, it would be useful for them to consider the possibility of participating in a joint study with some other Member States with a view to planning and establishing the necessary fuel cycle facilities on a multinational basis.

As I have said, the report on the regional fuel centre concept will be presented at our Conference in Salzburg from 2 to 13 May. It reaches interesting conclusions about the economic threshold for reprocessing plants - in other words, the size below which reprocessing is likely to be quite uneconomic under any reasonable circumstances. It also reaches interesting conclusions about the economics of reprocessing as against long-term storage of irradiated fuel. These, too, will be reported at Salzburg.

The Agency is also making a much smaller parallel study on all relevant aspects of an international plutonium management system for which there is a base in the IAEA Statute. This considers the pros and cons of centralized storage of plutonium, at existing reprocessing plants in nuclear-weapon States, in countries where no reprocessing is being done and in non-nuclear-weapon States which have plans for reprocessing. The chief interest of this study is, of course, to prevent any stock-piling of surplus plutonium. The study also looks at the possibilities of an international spent fuel management system.

Both the Regional Fuel Cycle Centre Study and the Plutonium Management Study were triggered by concerns about the dangers of proliferation, a concern which we in the IAEA profoundly share.

However, neither of these ideas may have much relevance unless we can reach some consensus about the development of the fast breeder, the use of MOX fuel and, hence, the need for large scale commercial reprocessing.

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Japan Atomic Industrial Forum, Inc.
10th Annual Conference, Tokyo, 9-11 March 1977 (12)

International Co-Operation in the Nuclear Fuel Cycle - The German View

Dr. Werner Boulanger*)

After the end of the second world war, activities of any kind in the nuclear field were prohibited in Germany. When the ban was lifted in 1955, the Government of the Federal Republic began to promote studies, training and research. They concluded Co-operation Agreements with the United States of America and the United Kingdom of Great Britain and Northern Ireland. Several research reactors were bought in the USA and UK and, in co-operation with Länder Governments and partly with industry, nuclear research centres were founded (Garching, Geesthacht, Jülich, Karlsruhe). Also in 1955, the Federal Republic waived any claim for research for or acquisition, possession or use of nuclear weapons.

*) The author expresses his own personal views; they must not necessarily coincide with those of his present or former employers.

The Federal Republic became a founding member of the European Atomic Energy Community (Euratom). This means that all her nuclear activities have, since 1 January 1958, been under strict safeguards implemented by that multinational, supranational authority. It also means that she has to conclude her international agreements in the nuclear field either through or with the concurrence of the European Commission.

The Federal Republic is also a member of the International Atomic Energy Agency (IAEA), the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), the Agreement concluded between Euratom and its Non-Nuclear Weapon States members in execution of Article III para. 1 and 4 of NPT (Verification Agreement). She belongs to the group of countries represented on the Zangger Committee (IAEA document INF/CIRC/209) and in the so-called "London Suppliers' Club". Within this legal and political frame, the Federal Republic of Germany conducts her international co-operation in the nuclear field. She is guided therein by the strict desire to prohibit the spreading of nuclear weapons capability.

The Federal Republic has concluded several bilateral agreements for co-operation in the field of nuclear energy. One of these agreements has been much discussed and also criticized, particularly in the United States of America. I shall nevertheless deal with it briefly in this context, because it gives, in my opinion, an excellent example for the possibilities of international co-operation in the nuclear field and at the same time of the problems encountered.

A basic Agreement on Co-operation in scientific research and technological development was concluded between the Federal Republic of Germany and Brazil on 9 July 1969. Within this framewok, five separate agreements were concluded between corresponding German and Brazilian organizations in the fields of nuclear energy, scientific research, air-craft and space research, mathematics and data processing and short time exchange of scientists. In the field of nuclear energy, two Summer Courses and several Working Seminars were held. A joint "study on the development and construction of the fuel cycle and reactor component industries in Brazil" led to a detailed plan for the introduction of nuclear energy in Brazil with increasing participation of Brazilian industry. This plan became part of the Second National Development Plan. After Brazilian attempts to contract for the necessary "hardware" in the US, including guarantees for continuous enriched uranium supply and reprocessing, failed, one turned to the Federal Republic of Germany. In the ensuing negotiations it was made absolutely clear from both sides that the whole deal was to come under strict safeguards provisions to be implemented by the IAEA. The agreement which was signed on 27 June 1975 provides for

co-operation between scientific and technological research institutions and enterprises in the two States, which includes the prospecting, mining and processing of uranium ores as well as the production of uranium compounds, production of nuclear reactors and other nuclear energy facilities as well as their component parts,
uranium enrichment and enrichment services,
production of fuel elements and reprocessing of irradiated fuels.
The above-mentioned co-operation includes the exchange of the necessary technological information.

Instruments regulating details of the co-operation were signed by the Ministries concerned. In the meantime, joint subsidiaries were founded by German and Brazilian firms to take up the work in the different fields.

An agreement was concluded between the International Atomic Energy Agency, Brazil and the Federal Republic of Germany for the application of safeguards to all nuclear activities coming under or evolving out of the bilateral agreement of 27 June 1975. A new feature of this Safeguards Agreement, which goes beyond requirements of the NPT and earlier IAEA safeguards agreements, is that this one also covers technology transfer. This means that not only "hardware" such as nuclear installations and fissionable material will be controlled, but also "software", i.e. information and know how.

This Safeguards Agreement, which is the tightest ever concluded by IAEA, was approved by the Board of Governors in February 1976.

What now will be the benefits for the two States Parties to the bilateral agreement? For the Federal Republic of Germany it holds the hope for finding and developing, together with Brazil, new uranium deposits and for in this way ensuring a continuous uranium supply. It also means a big export volume for nuclear power stations and components thereof. For the Brazilian side the agreement means not only being supplied with new sources of needed electrical energy, but above all acquiring industrial capacity, to in the end-run, constructing nuclear power installations of Brazilian origine. It also means an independent, complete nuclear fuel cycle. For the Federal Republic the fact that she assists a big nation in getting on its own feet in an important field of nuclear technology is a political side effect not to be overlooked.

In spite of its international acceptance by the IAEA Board of Governors, the German/Brazilian agreement continues being under verbal fire from various sides. Some criticize the whole deal, others, seeming to be more knowledgeable, turn against the sale of an enrichment plant and, foremost, a reprocessing plant. They feel that it would be dangerous to give a Non-Nuclear Weapon State the possibility by reprocessing irradiated nuclear fuel elements to get into the possession of plutonium which might be used for making nuclear weapons. Those who hold a different opinion argue that the plutonium should and would be used as fuel for power reactors ("recycling"), thus making full use of the scarce fuel material available. They point to the fact that under the bilateral and trilateral agreements also the reprocessing plant and the nuclear material in it will come under safeguards, as will the enrichment plant, which in this case, because of its technical features (nozzle enrichment) does not lend itself to high enrichment necessary for weapons grade material.

The short ten minutes at my disposal forbid to go into further details of the pro and con. They will most probably come up in the discussion. But I should certainly sum up the German point of view like this: We are fully supporting not only the letter but the spirit of the Non-Proliferation Treaty. It has unfortunately proven not to be quite adequate in every respect. That is why the "London Suppliers' Club" tries to find generally acceptable ways to go beyond the Treaty when necessary. But it should also be seen that the safeguards provided under Article III of the Treaty will not be accepted by nations without the possibilities of Article IV, which stresses the inalienable right of all the Parties to the Treaty to develop research, production and use of nuclear energy for peaceful purposes without discrimination.

Revised

Japan Atomic Industrial Forum, Inc.
10th Annual Conference, Tokyo, 9 - 11 March 1977

International Co-Operation in the Nuclear Fuel Cycle - A German View

Dr. Werner Boulanger *)

After ~~the end of the second world war~~ 1945, activities of any kind in the nuclear field were prohibited in Germany. When the ban was lifted in 1955, the Federal Republic of Germany ~~the Federal Republic~~ renounced irrevocably any research for, or any acquisition, possession or use of, nuclear weapons. At the same time, we began to promote studies, training and research. We concluded Co-operation Agreements with the United States of America, Canada, and the United Kingdom ~~of Great Britain and Northern Ireland~~. Several research reactors were bought in the USA and UK and, in co-operation with Länder Governments and partly with industry, nuclear research centres were founded (Garching, Geesthacht, Jülich, Karlsruhe).

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The Federal Republic is also a member of the International Atomic Energy Agency (IAEA), of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), and of the Agreement concluded between Euratom and its Non-Nuclear Weapon States members in execution of Article III para. 1 and 4 of NPT (Verification Agreement). It belongs to the group of countries represented on the Zangger Committee (IAEA document INF/CIRC/209). It participates in the discussions of the so-called "Suppliers". Within this legal and political frame the Federal Republic of Germany conducts its international co-operation in the nuclear field. It is guided therein by the strict desire to prohibit the spreading of nuclear weapons capability.

The Federal Republic has concluded several bilateral agreements for co-operation in the field of nuclear energy. One of these agreements has been much discussed and also criticized, particularly in the United States of America. I shall nevertheless deal with it briefly in this context, because it gives, in my opinion, an [redacted] example for the possibilities of international co-operation in the nuclear field and at the same time of the problems encountered.

A basic Agreement on Co-operation in scientific research and technological development was concluded between the Federal Republic of Germany and Brazil on 9 July 1969. Within this framewok, six separate agreements were concluded between corresponding German and Brazilian organizations in the fields of nuclear energy, scientific research, air-craft and space research, mathematics and data processing and short time exchange of scientists. In the field of nuclear energy, two Summer Courses and several Working Seminars were held. A joint "study on the development and construction of the fuel cycle and reactor component industries in Brazil" led to a detailed plan for the introduction of nuclear energy for peaceful purposes in Braz with increasing participation of Brazilian industry. This plan became part of the Second National Development Plan. After Brazilian attempts to contract for the necessary "hardware" in other countries [redacted], including guarantees for continuous enriched uranium supply and reprocessing, got stuck, it [redacted] turned to the Federal Republic of Germany. In the ensuing negotiations it was made absolutely clear from both sides that the whole cooperation was to come under strict safeguards provisions to be implemented by the IAEA. The agreement which was signed on 27 June 1975 provides for co-operation between scientific and technological research institutions and enterprises in [redacted] both States, which includes the prospecting, mining and processing of uranium [redacted] as well as the [redacted] supply of nuclear reactors and other nuclear [redacted] facilities [redacted] like uranium enrichment and [redacted], [redacted] fabrication of fuel elements and reprocessing of irradiated fuels. The above-mentioned co-operation includes the exchange of the necessary technological information.

Instruments regulating details of the co-operation were signed by the Ministries concerned. In the meantime, joint subsidiaries were founded by German and Brazilian firms to take up the work in the different fields.

An agreement was concluded between the International Atomic Energy Agency, Brazil and the Federal Republic [redacted] for the application of safeguards to all nuclear activities coming under or evolving out of the bilateral agreement of 27 June 1975. A new feature of this Safeguards Agreement, which goes beyond requirements of the NPT and earlier IAEA safeguards agreements, is that this one also covers technology transfer. This means that not only "hardware" such as nuclear installations and fissionable material will be controlled, but also the transfer of "software", i.e. of information and know how, will trigger IAEA safeguards on nuclear material produced, processed of used with the help of such software transferred.

This Safeguards Agreement, which is the tightest ever concluded by IAEA, was approved by the Board of Governors in February 1976.

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that the plutonium should and would be used as fuel for power reactors ("recycling"), thus making full use of the scare fuel material available. They point to the fact that under the bilateral and trilateral agreements also the reprocessing plant and the nuclear material in it will come under safeguards, as will the nozzle enrichment plant which will be designed for the production of low grade enrichment for power reactor fuel.

The short ten minutes at my disposal forbid to go into further details of the pro and con. [redacted]. But I should certainly sum up my point of view like this: We are fully supporting not only the letter but the spirit of the Non-Proliferation Treaty. It has unfortunately proven not to be quite adequate in every respect. That is why the main suppliers in this field try to find generally acceptable ways to go beyond the Treaty provisions on safeguards when necessary. But it should also be seen that the safeguards provided under Article III of the Treaty will not be accepted by nations without the possibilities of Article IV, which stresses the inalienable right of all the Parties to the Treaty to develop research, production and use of nuclear energy for peaceful purposes without discrimination. And this brings me to [redacted] the final point: To my mind, the most effective and at the same time most realistic way, to make countries which are not yet a party to the NPT, share in the global task of preventing further proliferation of nuclear explosive devices, is to cooperate with them in the peaceful utilization of nuclear energy, the benefits of such cooperation to be safeguarded properly. If one does not cooperate with them, one can hardly expect them to share in one's own responsibility for non-proliferation. One would leave them alone, both in using nuclear energy and in making up their minds on how to prevent the abuse of nuclear energy.