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THE CONTRIBUTION OF NUCLEAR ENERGY TO THE MEETING OF ITALY'S ELECTRIC POWER REQUIREMENTS

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The role of nuclear energy should be viewed in relation to the degree of industrialization of a Country and to its overall energy picture. Italy, the sixth industrial country in the Western world, has a heavy energy demand and is poor in indigenous energy resources; under these conditions the nuclear source has in time come to be regarded, because of its cost and availability characteristics, as the positive although partial reply to the Country's energy problems.

Already in the past Italy's industrial growth has been helped by electric power, which has made possible the nearly full utilization of the hydraulic source; today, under different domestic and international conditions, electricity could play a role in many ways similar, as an economically competitive and technically satisfactory way of utilizing the nuclear source.

1. Italy's Energy Availabilities and Requirements

The natural resources available in Italy are very limited and this condition of scarcity has characterized the Country's development in its industrialization process. In fact, Italy's economic-industrial structure is basically one of transformation (in 1974, for instance, Italy's imports of raw materials and fuels accounted for 42% of the value of total imports, as compared with 15% in Canada, a country with a large mining industry, and with 63% in Japan, the extreme case of a transformation economy).

In the general picture of Italian natural resources, energy sources are no exception to the rule of scarcity.

Liquid and gaseous hydrocarbons have been and are the object of extensive prospecting both on land and on the continental shelf, right up to the limits of technology and industrial risk. In spite of the efforts made, discoveries are limited and the proven reserves now amount to 95 million tonnes of oil and 280 billion cubic meters of natural gas, or 220 million tonnes oil equivalent (t. o. e.).

Solid fossil fuels, instead, are almost totally lacking; on the Italian mainland, low-grade lignite deposits (amounting in energy terms to 4-5 million t.o.e.) are utilized for the generation of electric power. There are also marginal coal deposits in Sardinia (150 million t), already utilized in the past; the competitivity of these mines is now being evaluated, in relation to the present higher coal prices.

As regards nuclear energy, proven economic uranium resources amount to 1, 500 t, while supplementary resources are estimated at about 1, 000 t. Their energy content, with the existing reactors, is around 50 million t.o.e.;with the advent of breeder reactors it will exceed 2, 500 million t. o. e. .

Among renewable sources, hydraulic energy is a substantial component of the annual electricity production (29% in 1975) and the average natural producibility of Italian hydroelectric power plants amounts to 45 billion kWh a year. The remaining unused hydraulic resources, however, are limited (about 10 billion kWh a year) and those with favorable economic prospects amount to about 5 billion kWh/year.

The geothermal source, with respect to which Italy has played a well-known pioneering role, yielded in 1975 two and a half billion kWh (sligtly less than half the world's geothermal power production); it is regarded as a renewable source, although in reality the geothermal deposits, when industrially exploited, could have a life limited to a few decades, as evidenced by the decline of the Larderello basin which started in the last ten years and was compensated by new discoveries. Geothermal prospecting, in which ENEL, in cooperation with the Italian National Research Council, has built up an unmatched wealth of experience, is being actively carried out in several promising areas; new sources have been located and additional exploration work is producing encouraging results.

At present, however, it is impossible to predict the size of the new geothermal resources that may be found and developed, but it seems reasonable to assume that the contribution of geothermal energy to meet the total requirements will be, through the end of the century, substantial in absolute value but limited in percentage. This, of course, does not take into account substantial progress in the commercial utilization of hot dry rocks, which could open up unhoped-for prospects.

Table I shows the essential data about Italy's reserves of conventional energy sources; fossil fuel reserves as a whole correspond to less than three years of consumption (the requirement in 1975 amounted to 134 million t. o. e.).

Table I - Proven Economical Reserves of Conventional Energy Sources, Italy, 1975(a)

Fossil fuels	Proven Reserves		Renewable sources	Producibility	
	Quantity	million t.o.e.		10^9kWh/year	10^6t.o.e./year
Lignite	30 10^6 t	5	Hydraulic energy	50	11.0
Crude Oil	95 10^6 t	95			
Natural gas	280 10^9 m^3	230	Geothermal en.	2.5	0.5
Total	-	330	Total	52.5	11.5

(a) Sources: "The oil and gas journal"; World Energy Conference - Survey of Energy Resources - 1974.

Table II, instead, shows some significant elements of Italy's 1975 energy balance, and in particular the total requirements and the net imports of sources: evident factors are the very heavy dependence on imports (79% of the total requirement) and the marked predominance of oil, almost all of it imported, which covered more than 70% of the energy demand.

Table II - Energy Sources Used in Italy in 1975(a)

Energy Sources	Total requirements	Net imports	For electricity generation	Gross electricity production
	million t.o.e. (%)		million t.o.e.	billion kWh
Solid fuels	10.0 (7.5%)	9.0	1.7	6.0
Petroleum products	94.6 (70.5%)	89.8	18.2	84.7
Natural gas	18.3 (13.6%)	7.2	1.7	7.6
Hydraulic energy(b)	9.9 (7.4%)	0.5	9.4	42.6
Geothermal energy(b)	0.6 (0.4%)	-	0.6	2.5
Nuclear energy(b)	0.8 (0.6%)	-	0.8	3.8
Total	134.2 (100.0%)	106.5	32.4	147.2

(a) Source: Italian Ministry of Industry's statistics on energy.

(b) Conversions to the values of the year's average specific consumption of thermal power plants, equal to 2,201 kcal/kWh.

Another characteristic feature, which appears from Table II, is the presence in Italy's energy balance of all "commercial" energy sources. In effect, the search for and development of domestic sources has been a constant effort in Italy and the use of the geothermal source since the early part of this century is evidence of it. On the other hand, the industrial utilization of the nuclear source, dating back to 1963, illustrates another policy constantly pursued in Italy: that of the diversification of the energy sources to be utilized.

In the past, also thanks to the liberalization of international trade, energy requirements in Italy have been growing steadily; this evolution has paralleled the development of the economy, which in the last 15 years registered a 4.4% average annual increase in the Gross Domestic Product (at constant prices). Table III summarizes the main elements of the population, economic and energy growth in the 1960-1975 period, during which energy requirements increased at the average annual rate of 6.6%.

Table III - Elements of Economic, Population and Energy Growth in Recent Years in Italy

Year	GDP (constant money)		Population		Gross energy requirement	
	Billion '70 $	Index	Million	Index	Million t.o.e.	Index
1960	53.9	100	50.20	100	51.5	100
1965	69.5	129	51.99	104	80.7	157
1970	92.70	172	53.66	107	121.0	235
1975	103.27	192	55.83	111	134.2	261
Average annual growth rates, %						
1960 - 1965	5.2		0.7		9.4	
1965 - 1970	5.9		0.7		8.5	
1970 - 1975	2.1		0.7		2.1	
1960 - 1975	4.4		0.7		6.6	

The breakdown by five-year periods shows the substantial slow-down that has occurred in the first half of the Seventies. A major contribution to this slow-down, which was particularly marked in 1974-1975, was made by the very heavy increase in the prices of oil, and consequently of the other energy sources, registered since the fall of 1973. The severity of the prob-

lem of petroleum and energy supplies clearly appears from the figures in Table IV, which shows, for the years from 1970 through 1976, the net imports of energy products, the trade balance for goods in general and energy products in particular, the balance of payments and the GDP in current-money; the monetary magnitudes as per cent of the GDP are shown in parentheses.

As it appears from the figures in the table, the soaring of oil prices, which pulled up the prices of the other energy sources, has had a disruptive effect on the balance of payments with profound repercussions on the country's economy, which is still seeking a new equilibrium.

The efforts of the economic system have had to be aimed, in the short term, at balancing the outlay on energy sources, but this is an area in which cutbacks are difficult, because of the vital role of energy as regards industry and business cycles. Thus, increased efforts have been made to contain the imports of goods and to increase exports; it was also necessary to resort to foreign borrowing to finance the energy deficit and the resources available in the Country have inevitably decreased. In any event, the redressing of the balance of payments, which is so adversely affected by the energy deficit, is still one of the most serious problems that the Italian economy must solve. In this connection, a strongly positive effect may be exerted, as we shall see in greater detail further on, by an extensive and timely recourse to the nuclear source.

2. Nuclear Energy in Italy as an Alternative to Fossil Fuels

Before analyzing the role of nuclear energy in Italy, it may be interesting to make a summary review of the prospects of development in the coming decades of the sources alternative to fossil fuels, which are often incorrectly called "new" sources.

Solar energy is viewed with substantial interest as a substitute for fossil fuels in the heating of water for domestic uses and in space heating, also in relation to the considerable incidence of the energy requirements for these uses (in Italy about 20% of the total). These applications, which are technically established or in an advanced stage of development, have good prospects for cost reductions and therefore good chances of economic success, and thus should become fairly widely established in the coming years.

It is higly questionable, instead, whether solar energy will be used for the generation of large amounts of electric power, due both to its discontinuity, which substantially reduces the value of the power generated, and because it seems very unlikely that, before the end of the century, large-size plants can be developed to convert solar energy into electricity at competitive conditions. And this apart from the problems connected with the occupation of large areas (a solar power plant of 1 million kW capacity would require several tens of square kilometers of land).

The prospects of the development of geothermal energy have been discussed in the preceding section.

Table IV - Gross Domestic Product and Balance of Energy Product Imports, of the Goods Trade and the Balance of Payments in Italy in the '70s

Year	Balance of energy products (imports)	Trade Balance		Balance of economic payments	GDP at market prices
		Energy products (a)	Total Goods		
	million t.o.e.	billion of current Lire (% of GDP)			
1970	98.2	- 900 (1.55)	-1,102 (1.90)	+ 475.6 (0.82)	57,937
1971	102.4	-1,141 (1.81)	- 539 (0.85)	+1,189.0 (1.89)	63,056
1972	107.1	-1,209 (1.75)	- 416 (0.60)	+1,168.5 (1.69)	69,080
1973	114.5	-1,595 (1.94)	-3,354 (4.08)	-1,573.9 (1.92)	82,143
1974	114.7	-5,518 (5.56)	-6,889 (6.94)	-5,178.8 (5.22)	99,239
1975	106.0	-5,322 (5.36)	-2,329 (2.07)	- 343.5 (0.31)	112,358
1975 - 1st half	49.6	-2,406 (4.43)	-1,062 (1.96)	-	54,202
1976 - 1st half	52.9	-3,467 (6.40)	-3,070 (4.73)	-	64,897

(a) excluding electricity.

Wind energy is even more discontinuous than solar energy and the economic problems involved in its conversion into electric power are equally very serious; it may be justified in rural areas in those cases where the cost of electrification has a heavy incidence on the cost of the kWh delivered to the user, and ENEL is studying solutions of this kind. This is obviously a wholly marginal aspect in the overall energy picture.

An economical use of tidal and wave energy appears doubtful even in the countries where tides and waves are substantial. In the Mediterranean the magnitude of such phenomena is very limited, and therefore as far as Italy is concerned the prospects offered by these energy sources are practically non-existent.

As for light-nucleus fusion energy, it is well known that it would yield virtually unlimited amounts of energy. This source, however, is still forming the object of intensive but preliminary research efforts, on the success of which depend the further developments towards the first prototypes; as a commercial source, it seems that its introduction will not take place in this century.

To sum up, new sources and conventional sources are offering in Italy for the coming decades very limited margins of action to reduce the burden of energy imports on the economic system and to increase supply security. It is instead the nuclear fission source that offers a sound alternative to fossil fuels and is available in large quantities.

The desirability of and need for nuclear energy exist in many industrialized countries, in the European Community and even more in Italy.

In the first place, the competitiveness of nuclear energy for electricity generation is widely established; the nuclear kWh, as compared with the kWh from oil, was already competitive for high load factors before the October 1973 crisis. The very substantial rise in the price of crude oil increased the economic advantage of nuclear power, in spite of the generalized increase in the prices of industrial products and in the cost of money that followed the rise in the prices of oil and other raw materials and have a heavier effect on capital intensive nuclear power plants.

Nuclear energy has a definitely positive influence on the balance of payments. Under the present conditions, Italy's nuclear power production of 3 to 4 billion kWh a year results in the annual saving of one million t of oil products, which would add some 50 billion Lire to the burden on the balance of payments. Much greater will be the impact of the nuclear units under construction or on order in Italy. For each kWh generated in a nuclear power plant the cost of natural uranium and of the enrichment service at current prices amounts to 3-3.5 Lire, while the cost of fuel oil for each kWh is about 15 Lire. Thus, for each 1,000-MW nuclear power plant the annual foreign-currency saving will be around 70 to 80 billion Lire. In ten years' time, assuming a nuclear power production in the order of 120 to 140 billion kWh, the reduction of the balance of payments burden would amount to around 1,400-1,600 billion Lire a year.

As regards the construction of plants, it should be borne in mind that today the Italian industry is capable of producing more than 80% in value of nuclear power plant structures and components. The balance-of-payment incidence of the components to be purchased abroad is thus limited and bound to decrease in the future; nor should it be forgotten that the exports of Italian-built nuclear equipment and components, now already in progress, may increase with construction experience and with the expansion of the domestic market.

Finally, the supply security of nuclear energy should be greater than that of imported fossil fuels, for:

-- uranium is quite abundant in the Earth's crust and the main deposits are located in politically stable countries; in this connection, however, it is to be hoped that the tendencies to restrict the freedom of trade that have developed in some producing countries will give way to a policy of greater opening to international trade;

-- so far, uranium prospecting has covered fairly limited areas of the Earth and an intensification of these activities should result in a considerable increase in proven reserves;

-- the incidence of natural uranium on the cost of power generation is low (at present prices 2 to 2.50 Lire per kWh) and might justify the working of low-grade uranium ore deposits, which are fairly common;

-- the enrichment service, required to obtain fuel for light-water nuclear reactors, should prove adequate in Europe, where the Eurodif and Urenco projects are underway and the Coredif project is under consideration.

These elements combine with some positive characteristics of nuclear power plants, as indicated below:

-- Their industrial maturity is such as to ensure the performance required for large-scale applications. It should be noted that the average availability of the nuclear power plants in operation in the world has not yet reached the levels anticipated and already obtained in a considerable number of plants; the average capacity factor is only about 60%; this value is nevertheless more than sufficient to make nuclear power competitive; a major effort has been undertaken to improve the quality of nuclear power plants in order to achieve higher availability factors in the near future.

-- The environmental compatibility of nuclear power plants represents, in the experts' opinion, a substantial progress over fossil-fuel plants. Indeed, conventional pollution is absent and radioactive releases are limited to such low levels as to involve for the most exposed population radiation doses that are negligible as compared with natural radiation and even its usual variations; safety is ensured by a highly sophisticated set of protective measures and systems based on an accident-prevention approach that, by novelty of concept and strictness of application, has no precedents in engineering. The result is that there have been no radioactivity accidents causing major damage to the operating personnel or to the popula-

tion around plants in the more than 1,000 reactor-years of operation (equivalent to 20-25 years of operation of 50 stations) so far reached in the world.

-- The high value added of nuclear power plants can produce positive results for employment and the national economy since, as indicated above, the Italian industry can turn out almost all of the equipment required by nuclear power plants.

Therefore, for a country like Italy, while the construction of nuclear power plants appears to be well compatible with the industrial structures, the nuclear source, from the technical, economic, foreign currency and ecologic viewpoints, appears capable of making a major contribution to the meeting of energy requirements. The use of this source would thus achieve the result, desirable from many viewpoints, of reserving fossil fuels and above all hydrocarbons for priority uses, as raw materials for industry, and as energy sources for the uses in which they are hard to replace. It would also result in a greater diversification of sources and consequently, for an importing country like Italy, in a greater overall security in energy supplies.

3. The Role of Nuclear Energy

As is known, nuclear energy can now be converted, by technically proven and economically competitive processes, only into electric power. It is therefore from a review of the main lines of the past record and of the predictable developments of this form of energy that we can draw elements for a definition of the role that nuclear energy can play in Italy.

Over the last fifty years Italy's electric power demand has been growing at an average annual rate of 6.2%, doubling every 11-12 years; in the last twenty years, as it appears from Table V, the growth rate was about 7%, with the demand doubling in one decade. In other words, over the two periods of 1955-1965 and 1965-1975, plants and facilities have been built and put into service whose generation, transmission and distribution capacity has equaled and even exceeded that made available from the early days to the beginning of each period.

In addition to this consideration, which highlights the quantitative aspect of plant development, there are the deep structural changes that have taken place in the electric power industry in the two decades, particularly in the structure of power production. The first period was characterized by a major drive in the utilization of the remaining economically competitive hydraulic resources, by a large-scale thermal power plant construction program and by the appearance of nuclear power. The second period saw an extensive recourse to thermal power plants, standardized by ENEL to take advantage of unified design economies, and the start of a major program of 800-1000 MW nuclear power plants.

In 1975 the electricity demand in Italy amounted to 141.2 billion kWh[1]

(1) In 1976 the electricity demand amounted to 154.1 billion kWh (provisional data) with a 9.1% increase over 1975.

and the winter-peak capacity demand to 26.2 million kW; the average per-capita consumption was 2,304 kWh.

Table V - Production and Capacity of Italian Generation Plants in Selected Years of the 1955-1975 Period

Year	Total production (billion kWh)	Gross capacity (million kW) in: Hydroelectric plants	Thermal plants (a)
1955	38.1	8.7	2.4
1960	56.2	11.5	4.8
1965	83.0	12.8	10.8
1970	117.4	13.4	17.9
1975	147.2	15.1	25.6

(a) Including geothermal and nuclear plants.

Long before the growth rate started rising again in 1976, the author was of the opinion that for the future, although with the uncertainties inherent in forecasting, (which are augmented today by those deriving from the particular economic situation and energy-supply picture prevailing in the world), the short- and medium-term prospect was one of a sustained expansion in the power demand, which would not diverge appreciably from past rates, even though it could be expected that the total energy demand would grow at rates appreciably lower than those anticipated prior to the crisis in late 1973. This is due to many concurrent factors, including:

-- the progressively greater competitiveness of electric power, which already in the past has caused it to take over an increasing share of the world's energy market and which in the future will also benefit from the increasing incidence of the nuclear portion. (In the industrialized countries of the OECD the share of electric power, from 22% in 1955 and 29% in 1974, should rise to 35% in 1985 and to around 50% in 2000);

-- the increasing preference for electric power on the part of household and industrial users, in view of its specific characteristics (flexibility and convenience in use, absolute absence of pollution in the utilization stage, etc.);

-- the possibility of very wide potential markets opening up for electric power (space heating, with heat pumps or combined with solar energy, electric cars, public transportation, etc.).

In Italy these factors combine with the fact that, while the power consumption growth rate in the past was in line with those recorded in the major industrialized countries, per-capita consumption is still considerably

below the levels in the latter, and therefore we should still be very far from a saturation of demand. It is evident, however, that the conditions of the national economy will have a substantial effect on actual future electric power requirements, because of the close dependence of power demand on national-product development.

ENEL's forecasts also take into account the containment of requirements which, hopefully, will derive from an effective energy-conservation policy. Electric power, a particularly valuable form of energy, is already used in a fairly efficient manner; conservation measures, by eliminating wastage and superfluous consumptions and promoting an even more efficient utilization, may contribute to the reduction of requirements to an extent fairly limited in percentage terms but rather substantial in absolute value.

ENEL's electric power demand forecasts, similarly to what is done in other industrialized countries, center on three main stages:

a) that referring to the nearest year that can still be the subject of executive decisions concerning plants to be started immediately; eight years are now regarded by ENEL as necessary to plan and build a large electric power plant; taking into account the serious repercussions which an insufficient electric power supply could have on the national economy, the essential criterion is that of adjusting the operational plans for the new plants to be built to the needs indicated by maximum-development assumptions, among the reasonably likely ones;

b) that concerning the period falling within the eight years of the operational plan; the power demand estimates become more accurate as the deadlines draw closer; limited actions, essentially of an emergency nature, can be taken to correct deficit situations; in the case of a surplus, now unlikely, the construction program can be revised without incurring substantial costs, if the changes are limited;

c) that extending beyond the operational time span and providing an integrated view of the future development, a prospective assessment of the lines adopted and an evalutation of the utilization of the plants decided upon, whose life is 20 to 30 years.

ENEL's forecasts, and consequently programs, "slide" as they are revised from year to year in relation to the development of the demand and of the economic conditions; they concern two hypotheses, the maximum one, on which executive decisions are based and the minimum one, which serves with the preceding one to delimit the range in which the real demand will presumably fall. Under many aspects similar to those of other industrial sectors, these forecasts and programs differ because of the long term involved, the cost of the plants decided upon and the need for ensuring, sufficiently in advance and with a high reliability, the future power service.

Without going here into the merit of the methods followed, we shall merely point out that, according to these forecasts, by 1985 the electric power demand in Italy should amount to between 260 and 300 billion kWh; the demand should therefore pratically increase twofold over the decade (1975: 141.2 billion kWh); already in 1976, which according to the partial final

figures now available shows an increase of over 9%, the demand growth rate is likely to be higher than that resulting in a ten-year doubling. In the Eighties, if the current economic difficulties are over, the penetration of electric power should be influenced by the factors mentioned above, which might bring about a development at rates even higher than the present ones; according to the forecasts, by 1990 the power demand could be in the range of 370 to 460 billion kWh, levels which correspond to per-capita consumptions comparable to the present ones in the United States. Forecasts for the last decade of this century are harder to make and their reliability is very limited; however, based on present knowledge, it seems logical to predict a slowing down of the electric power demand in that decade.

The new plants required to meet the demand--except for the completion of conventional thermal plants now under construction, the development of geothermal plants (which will depend on the size of the new deposits discovered), the program of pumped-storage plants, whose basic role will be dwelt upon further on, and few conventional plants to meet special requirements of the network in the Islands--will be exclusively of the nuclear type. ENEL has made the nuclear choice some time ago; actually, it was announced at the last Geneva Conference in 1971 and the forecasts of nuclear energy development then made are not substantially different to-day. ENEL's line has been adopted by the Government and included in the national energy plan which was approved by the Interministerial Economic Planning Committee and will be discussed by Parliament early in 1977.

In round figures it is anticipated that in ten years'time nuclear units will be put into service to a total capacity of about 20,000-MW; this capacity should rise to 45,000-55,000-MW by the early Nineties.

The three plants now in operation at Latina, Garigliano and Trino Vercellese(total capacity about 600-MW), the Caorso Plant(850-MW) which will go into service in 1977 and the four 1,000-MW units ordered in 1973-74 will be followed by the units totaling 16,000-MW contemplated in the national energy plan, which, after the Parliamentary debate, will be ordered within very short terms; subsequently, orders will be placed as the demand develops.

Given the destination of nuclear plants to base-load service and assuming that they will be utilized for 6,500 hours a year--an assumption which appears reasonable in relation to the high quality of the design and of the contruction of new plants-- the percentage of electricity from the nuclear source may rise to 40% in ten years and to 70% in the early part of the Nineties; by the year 2000 it could be as high as 85-90 per cent.

In energy terms, these forecasts mean that nuclear power production will replace each year more than 2 million t of fuel oil by 1978, 30 million t in the latter half of the Eighties and 70 million t in the early Nineties; at present prices, the balance-of-payments savings will amount to over 100 billion Lire in 1978, rising to more than 1,500 billion Lire on completion of the 20,000-MW nuclear program and to 3,500-4,500 billion Lire in the Nineties.

Because of the continuing evolution of prices it is harder to translate

into figures the economic advantage of nuclear production, which in any case should be substantial; it can be estimated that at present nuclear power plants are competitive even at utilization rates below 50% (4,400 hours). Their use for 6,500-7,000 hours will supply the additional kWh at a marginal cost, quite lower than that of thermal power plants; this means, for a 1,000-MW nuclear unit, an annual saving in the order of the tens of billions.

The nuclear plants to be built in Italy will be of large size (1,000-1,300-MW) and of industrially proven type.

ENEL is also active in the promotion and development of those reactor types which appear promising both from the economic standpoint and in terms of the utilization of the potential energy content of uranium.

In particular, a joint ENEL-CNEN project is now underway in Italy for the development of CIRENE, a prototype natural-uranium reactor, moderated with heavy water and cooled with boiling light water. CIRENE is an original Italian design, whose technology has been developed in this country and combines an interesting economic potential with a good utilization of natural uranium. If the operation of the 40-MW prototype, now under construction at Latina, meets the expectations, the CIRENE design may constitute in Italy a sound alternative to proven reactor types.

In a longer-term prospect, ENEL together with Electricité de France and Rheinisch-Westfälisches Elektrizitätswerk has promoted the construction in Europe of large demonstration plants equipped with sodium-cooled fast breeder reactors. The agreement entered into by the three power utilities, now extended to other producers in the Community, calls for an initial stage which, started three years ago, is now materializing with the construction of the 1,200-MW plant at Creys-Malville, in which ENEL has a one-third participation. In the design and construction of this plant, derived from the French prototype Phénix, an active role is played by the Italian industry, which will supply one-third of the components and systems for both the conventional and the nuclear part of the plant.

In addition to the nuclear program, ENEL has underway a major and engaging program of pumped-storage plants. In a predominantly nuclear electrical economy, pumped-storage plants combine excellent technical characteristics in regulation and reserve services with substantial financial and economic advantages. In the areas offering favorable conditions, the capital cost of pumped-storage plants is low; in addition, in low-demand hours, they store electric power at a rather low cost, if generated by nuclear power plants. The result is an appreciable economic advantage deriving from a greater utilization of nuclear power plant and, through pumping, from the generation of high-value power in peak hours.

The development of pumped-storage plants also reduces the capacity and number of nuclear power plants, since their capacity replaces an equal amount of nuclear capacity; from the financial viewpoint, truly substantial savings can be achieved since, under favorable orographic conditions, the capital cost per kW of a pumped-storage plant can be as low as half of that of a nuclear plant.

ENEL, taking advantage of the particularly favorable Italian orographic conditions, has put into service in the 1963-75 period pumped-storage plants totaling 2.3 million kW, including Europe's largest plant, the 1,000-MW Lake Delio; 1.5 million kW are under construction and an additional 3.5 million kW are included in the operational plan.

ENEL has also ascertained that the potential capacity of economically feasible pumped-storage plants in Italy is in the order of 15 million kW, a true natural resource which can be gradually developed as nuclear capacity increases and which can be utilized for deep regulation of power on a European scale.

4. The Problems Posed by Nuclear Development

In recent years the implementation of the Italian nuclear power program encountered very serious difficulties, foremost among them the unavailability of sites, which have delayed its start.

Of the four 1,000-MW nuclear units ordered in 1973 and 1974, two were to be sited on the Tyrrhenian Sea in the Upper Lazio Region and two on the Adriatic Sea in the Molise Region. It should be noted that ENEL's identification of a site for a nuclear or conventional plant is the result of a systematical nation-wide survey, in which are weighed, alongside the technical specifications, the relevant population, tourist, industrial, social and environmental factors, with a view to locating the sites that best reconcile the technical and economic requirements of the plants with the social and environment-conservation requirements.

This systematical work, which ENEL has been pursuing for years and in the framework of which major ecologic research programs are conducted, has resulted and is resulting, among other things, in some unique publications, such as for instance the "Atlas of the Primary Land Features of the Italian Coasts", which shows, kilometer by kilometer, the main population, tourist, orographic, batymetric and industrial features of all Italian coasts, together with restrictions and planned land uses, or such as the Italian Neotectonics Map and the Catalog of Italian Earthquakes since the year 1000.

In spite of the efforts made by ENEL for site selection, on a local level very strong oppositions have developed against the installation of power plants, very often prompted by sectorial interests or reasons that have nothing to do with nuclear energy.

The Government and the Parliament have taken into careful consideration this situation, which was seriously jeopardizing ENEL's capacity to meet the demand for electric power in the coming years, and in August 1975 a law was passed which takes local requirements into the fullest account and lays down a strict procedure, but with specific deadlines for the granting by local and central authorities of the permits required for the installation of nuclear power plants.

It is also due to this law that ENEL, in the late fall of 1976 -- and therefore three years since the order--has at last succeeded in obtaining the permits for the Montalto di Castro site in the Upper Lazio Region. For the Molise site, instead, no progress has been made.

The procedures laid down by the Law have been started by ENEL for several other sites, and in this connection discussions have been in progress for some time with central and local authorities and with the control and safety agencies for the siting of nuclear power plants in Piemonte, Lombardia, Tuscany, Puglia and other Regions. It is to be hoped that such discussions will soon lead to an agreement among all parties concerned and to the issuance of the permits. Failing this, the implementation of the Italian nuclear program, of which we have seen the necessity and importance for the economy and the national community, could be seriously threatened.

Even though the opposition to nuclear plants, as we have seen, are often prompted by sectorial interests and considerations that have little or nothing to do with nuclear energy, it is still very important that public opinion be informed as correctly as possible, without the alarmism and factiousness with which the problems of nuclear energy have often been presented. In this connection, a highly important role may be played by qualified national and international bodies whose non-partisan position can give the public opinion guarantees of the utmost objectivity. A stand taken by such bodies with respect to nuclear energy may place its advantages and problems in the correct perspective. Local oppositions too should be tempered by an awareness of the general interest; moreover, a more correct evaluation of the significance of the siting of a nuclear power plant should produce, also on a local level, a favorable cost/benefit balance and eliminate the very cause of the oppositions.

Another major problem posed by the development of nuclear energy in Italy is the financing of nuclear power plants which, as is known, have a unit capital cost about twice as great as that of conventional thermal power plants.

The size of nuclear investment on the 20,000-MW program -- in the order of 10,000 billion Lire based on the value of the currency in early 1976-- is such as to surpass the scope of ENEL's finances and to assume national importance.

Today more than ever, however, the investment in nuclear plants should be given priority because it will make it possible to produce electricity at lower cost, it will substantially reduce the outlay of foreign currency for energy imports, it will decrease Italy's dependence on such imports, and it will create much work for the Italian industry. For such reasons this is an investment which, within a few years, will have highly favorable effects on the national economic development.

On the other hand these investments, even though very large in absolute terms, have an incidence on the gross national product that appears acceptable and do not require an effort greater than that being made in other countries or than that made in Italy for hydroelectric plants in the prewar

period or in the Fifties. According to a very recent EEC study, all energy investments in Italy in the 1968-72 five-year period have absorbed 1.6% of the GDP; those to be made in the 1976-80 period, which includes a substantial portion of the nuclear program (about 3,000 billion Lire), will absorb 1.9%.

The investment scheduled for the 1976-1980 period in Great Britain, which is engaged in a huge effort to exploit the oil fields in the Northern Sea, amounts to 3.2% of the gross domestic product. This figure indicates that, if the investigation is extended to the whole productive cycle from prospection to electricity generation, the investment in the oil sector may be comparable to or even greater than that for the nuclear sector, from mining to generation.

In any event, the problem of financing nuclear plants in Italy involves a considerable effort by all parties concerned and requires the assistance of the Government it is hoped that it can be solved also with the help of the Parliament when, as mentioned above, the national energy plan is discussed in early 1977.

The availability of sites and that of the capital required for plant construction now constitute in Italy the greatest problems to be solved for the concrete implementation of the Italian nuclear program.

Our review, however, would not be complete without mention of other difficulties which fall outside the national framework and could hinder an extensive recourse to the nuclear source.

I am referring in the first place to the problem of the closing of the nuclear fuel cycle, which is of the utmost importance not only for the short- and medium-term development of nuclear energy but also and above all for the successful introduction of breeder reactors, which are the only ones that can increase the duration of the nuclear source from a few decades to many centuries. A solution must be found for the problem of the irradiated fuel reprocessing service, which at present is available in the world in a wholly insufficient amount. This problem is strictly connected to that of the final disposal of radioactive waste, and therefore of the establishment of suitable storage facilities. This last issue has political, social and technical aspects which must be dealt with as soon as possible.

A second consideration concerns the supply of natural uranium. It is necessary to intensify prospection activities, to establish the required mining industries and to give this sector a structure that can cope with the heavy demand expansion, ensuring at the same time the necessary freedom of the international natural uranium market.

It is only through an effective solution of these problems that we will be able to count on nuclear energy, as the only source that can really replace fossil fuels, particularly petroleum, in covering a large portion of the energy requirements which mankind, and especially the less developed countries, need to achieve a higher standard of living.