Katz, J.E. and Marwah, O.S. (eds.) Nuclear Power in Developing Countries, Lexington: Lexington Books, 1982

# 17 Turkey

*Tolga Yarman*

Turkey's first movement toward nuclear energy occurred in 1956 with the passing of legislation to establish an Atomic Energy Commission (TAEC) under the Prime Ministry. In 1961, the TAEC founded near Istanbul the Cekemece Nuclear Research Training Center (CNRTC), which was equipped with a swimming-pool type research reactor of 11 megawatt (MW) and was provided by the United States.

These initial steps were taken in recognition of the fact that nuclear power deployment seemed to be the only means of satisfying Turkey's potential energy deficiency. According to the country's anticipated economic development rate, the electrical energy generation of 10 × 10 kilowatt hours (kWh) per year in 1960 was supposed to reach 100 × 10 kWh per year by the early 1990s. The total hydroelectric capacity was estimated to be 70 × 10 kWh per year. Lignite resources could contribute an additonal 50 × 10 kWh per year. Local petroleum production was incapable of filling even the needs outside the electricity production sector. Turkey's known energy resources thus seemed unable to satisfy its projected demands.

A preliminary detailed investigation into the possibility of a nuclear plant in Turkey was carried out in 1965 by an International Atomic Energy Agency (IAEA) mission, which had been invited by the Ministry of Energy and National Resources to assess a 300 MWe plant in Turkey. The mission's conclusion was positive and resulted in reports that included specific information about plant construction. In 1968-1969, a foreign consultant engineering consortium was asked to prepare a feasibility study in the name of the Ministry of Energy and Natural Resources for a 300 MWe nuclear power plant to be in operation by 1977. The project had to be dropped in the early 1970s, however, due to political and economic difficulties resulting primarily from a lack of definition in the responsibilities of the involved organizations. The creation, in 1969, of the Ankara Nuclear Research and Training Center (ANTRC), sister of the CNTRC, marked the beginning of activities in preparation for Turkey's first nuclear plant project.

In 1970, the Turkish Electricity Authority (TEA) was founded by gathering the previous governmental institutions into one single organization responsible for the planning, construction, and operations

I thank Professors J.E. Katz and T. Erben for their helpful comments. Mrs. Selma Ismanur carefully typed the manuscript, and Mrs. Sabahat Avci assisted with the figures.

of all thermal, hydro, and nuclear plants and the related network. TEA had been preceded by the Electrical Study Affairs Institution, which had proved too small to cope with the proliferating complex problems related to Turkey's rapidly developing electrical-generation network. The Nuclear Energy Division (NED) of the TEA started its activities in 1971. These two major nuclear authorities, TAEC and NED-TEA, continued for several years without adequate coordination or clear definitions of mutual duties, until the idea of licensing was introduced into the TAEC in 1975 and the Nuclear Regulatory Committee (NRC) was established under the TAEC. Though some confusion about the respective responsibilities of the organizations still exists, briefly, TEA purchases nuclear plants but must license the sites, the construction, and the operation through the NRC-TAEC, which directs two nuclear research centers, one in Istanbul, CNRTC, and the other, ANRTC, in Ankara. NEC-TEA is incorporated within the Ministry of Energy and Natural Resources, while NRC is part of the TAE, which is related to the prime minister's office.

Finally, plans for the construction of a 600 MWe nuclear power plant, to be in operation by 1986, were undertaken by the NED-TEA. Revised feasibility studies for the plant were completed at the end of 1973 and in 1975 a contract was signed between the TEA and an engineering consortium to carry out consulting engineering services. The Akkuyu site on the Mediterranean coast was selected by TEA on the basis of several investigations.

Bid evaluations led, in 1977, to negotiations with the Swedish ASEA-ATOM and STAL-LAVAL for the nuclear and turbine islands, respectively. As a major bidding condition, these firms proposed to procure credits for a 600 MWe boiling-water reactor. Although the Swedish government presumably will procure the credits, negotiations are still being carried on concerning the total amount of credits that will be brought in, along with many technical and economic details of the plant construction.

Despite the studies and negotiations, Turkey has no clear plans in the areas of nuclear power development, nuclear research, or nuclear fuel supply for anticipated plants, nor is there a general overall energy plan. Neither the TAEC nor the nuclear research centers under its direction have been able to help develop plans with detailed studies or submit proposals for solutions to the many problems posed by the nation's energy needs. The situation that keeps Turkey still well below criticality is essentially a lack of scientific and administrative expertise.

Professor Nejat Aybers, director of the Institute for Nuclear Energy at the Technical University of Istanbul, and the NED-TEA, led from the beginning by Dr. Ahmet Kutukeuoglu, have played key roles in the achievement of the first nuclear steps. In fact, the decisions in favor of nuclear power have come from five to ten highly educated and primarily nuclear-oriented people, only a nucleus of scientists and engineers from the Turkish



Electrical Authority, the Atomic Energy Commission, and the universities. Supported by the main political parties, they managed to prevail over any opposition. What appears to be the principal determinant of their victory was the foundation of the Nuclear Division of the TEA, which had been given charge of purchasing nuclear plants to avoid a second rejection of nuclear power for the lack of a fully responsible national authority.

Although the people who actively supported nuclear energy were few, they were able to prevail through the dissemination of their views by means of the mass media, conferences, and panel meetings. They also published numerous studies, communications, bulletins, and articles dealing with the many aspects of nuclear energy implementation in Turkey. Important political leaders as well as the principal political parties have supported nuclear power. Ecevit, Demirel, Erbakan, Turkes, Feyzioglu, and Sukan declared themselves behind the nuclear movement, as did some other leaders whose parties were not represented in the National Assembly. The assembly itself has endorsed the nonproliferation treaty (NPT) and this year will endorse a budget that perhaps will include expenditures for the Akkuyu plant. By the time negotiations with ASEA-ATOM had gained momentum, Ecevit was prime minister and the Ministry of Energy and Natural Resources was supporting him in his defense of nuclear energy.

Opposition to the adoption of nuclear energy, chiefly led by the extra-governmental chambers of engineers in Ankara, was weak until 1978, when suddenly, before the final stage prior to the erection of the first nuclear plant, the antinuclear movement gained momentum. Debates, however, only crystallized a rationale for the adoption of nuclear energy. At present, with the site preparation at Akkuyu having been in progress for a few years, the opposition has been almost completely overcome.

**Manpower and Training**

The supporters of nuclear energy have worked for successful nuclear power implementation with a satisfactory degree of national contribution. Indeed, from the beginning, the NED-TEA did its best not to accept a plant on a turn-key basis. Nevertheless, there is apparently no well-established training program yet in Turkey, although students and others are sent abroad to international courses and conferences and to universities.

Also, although the first nuclear-research center was founded in 1960, it was not clear what direction this center would follow, or even whether such a center should follow a direction. Several years had to elapse before people realized that perhaps a general research policy should be adopted to guide the scientists, highly qualified professionals, some of whom had been educated in the most well-known universities in the West. Although they were expert in the handling of specific problems within their own areas of specialization, they lacked an overall understanding of their role in the nuclear research center, which was therefore often thrown into chaos. Confusion about mutual responsibilities and disorder in work distribution and acceptance were experienced even by those who claimed to work in basic fields. As a result of its lack of direction, the nuclear research center became an isotope production center for nuclear medicine. Although such a function did not fulfill the entire raison d'etre of the center, it was naturally adopted because of the center's one MW research and training reactor.

The lack of direction that characterized the nuclear research center from the beginning was due in part to the fact that there was no specific demand for the work of a nontraditional unspecialized nature that some of the scientists proposed to pursue. In addtion, the immediate and concrete need for the transfer and implementation of nuclear power and technology was not thoroughly realized by most of the people, since doctorate degrees in the field of nuclear energy implementation were not yet offered anywhere in the world. Neither could Turkey's scientists turn to the developed countries for answers because, although they were knowledgable about the development and exportation of nuclear plants, these countries had not, of course, experienced the problems related to the importation of an externally developed technology or implementing a complex and massive project with an undeveloped infrastructure.

As a result, the scientists who continued to work in Turkey's nuclear research centers were forced to content themselves with merely playing with a couple of neutrons or integro-differential equations. It was not until 1975 that concepts such as safety, regulatory body, and licensing were discovered and transplanted finally to give at least one clear direction to the TAEC, which is generally, however, still adrift.

The major and oldest nuclear training school in Turkey is the Institute for Nuclear Energy of the Technical University of Istanbul, now equipped with a TRIGA Mark-II research and training reactor. The institute trains nuclear engineers or nuclear licensees at the graduate level. There are other similar schools in the Bogazici University in Istanbul, the Middle East University in Ankara, and Ege University in Ismir.

The number of engineers, scientists (nuclear and otherwise), and technicians actually employed by TAEC research centers, universities (including those working with radioisotopes, in hospitals, and so forth), the NEDTEA, and the TAEC Regulatory Body is 800 (450 professionals plus 350 technicians). This number may become 1,500 (800 professionals plus 700 technicians) by 1987, 2,400 (1,300 professionals and 1,100 technicians) by 1992, and 3,300 (1,700 professionals plus 1,600 technicians) by the turn of the century.[1]

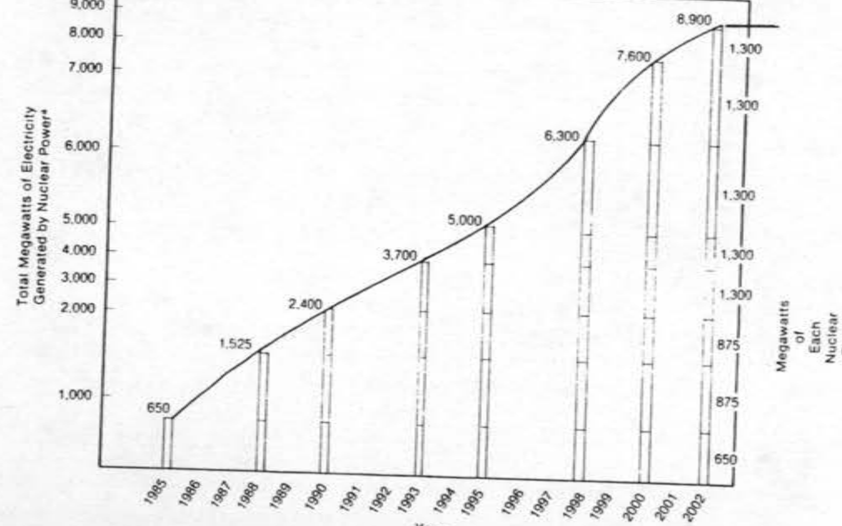


## Nuclear Energy Deployment in Turkey: Siting

Despite Turkey's clear potential energy deficit and the fact that nuclear energy presumably appears to be the only means to meet it,[2] no other nuclear power plant than the one to be constructed in Akkuyu has been planned officially. (A tentative nuclear power growth forecast is shown in figure 17-1; it can be compared with a total installed capacity growth projection shown in figure 17-2. However, in the few years since they were published, these figures already seem optimistic).

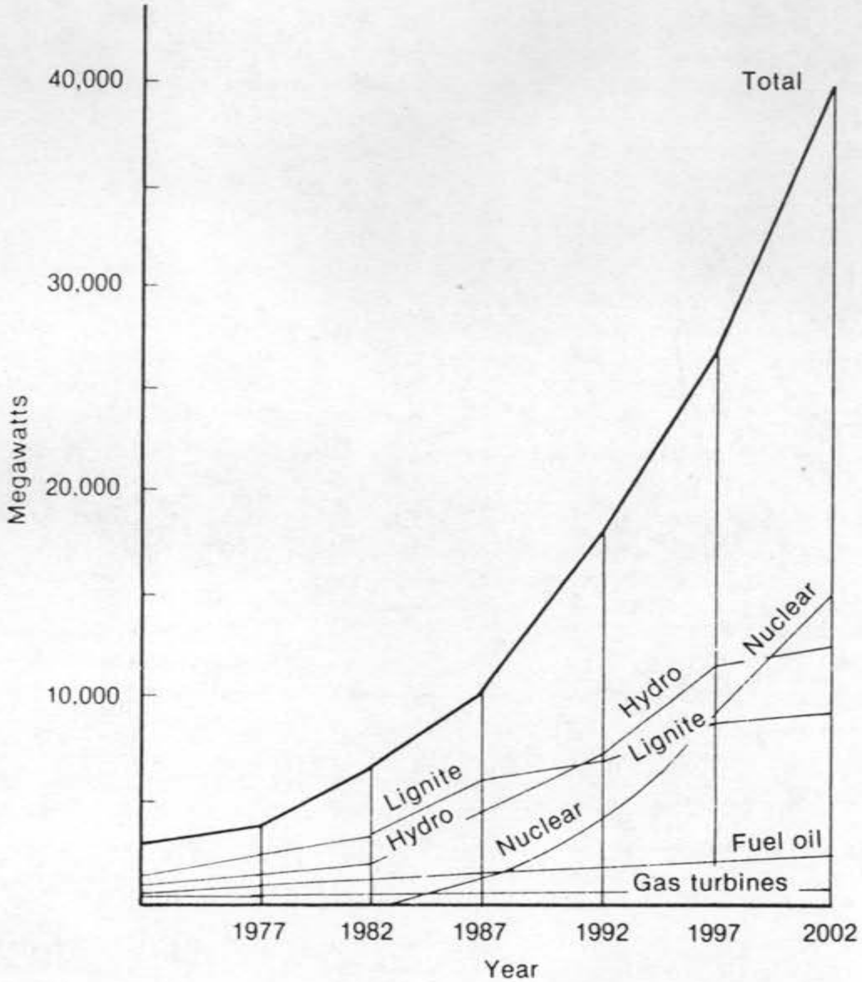
The site of Akkuyu was selected with particular care by the utility (TEA) and the Nuclear Regulatory Committee of the TAEC because Turkey is located on a dangerous seismic belt. Unfortunately, the country's load centers, where nuclear plants should be constructed, are located precisely on that belt, making siting especially problematical. The Marmara region was eliminated because of seismic danger, the Egean region, because it is thickly populated. Finally, the Mediterranean coast—and, specifically, Akkuyu—was chosen because it fulfilled many site requirements, including the possibility of transporting heavy equipment.

The Ministry of Tourism opposed the Akkuyu site, based on the uninformed opinion that a plant on the Mediterranean would kill the fish that




Source: General Energy Congress of Turkey, *Energy Statistics* 3 (Ankara: November 1978).
[a]Variable scale.

**Figure 17-1.** A Forecast of Nuclear Power Growth in Turkey




Source: General Energy Congress of Turkey, *Energy Statistics* 3 (Ankara: November 1978).

**Figure 17-2.** An Installed Capacity Forecast for Turkey

attract tourists to the area. This seems an exaggerated concern, considering that only one small and, from the tourist trade standpoint, unimportant bay will be occupied by the plant. Opposition to the site selection, however, has been weakened during the process of debate. Further site investigation are being made along the Black Sea coast.



**Methods of Decision Making concerning Nuclear Technology Transfer**

There are at least six major inputs to decision making about nuclear technology transfer for a developing country like Turkey:

1. Projected growth in energy demand.
2. Potential of the known national resources to meet the energy demand.
3. Availability of those power resources for immediate utilization.
4. The ability to control demand through increased efficiency, better conservation, rationing, or not meeting the public demand.
5. Existence of other possible candidates for partially satisfying the projected energy deficiency, such as unconventional energy sources (solar, wind, geothermal), electricity importation from neighboring countries, or importation of raw primary-energy material.
6. Competition with other developing countries resulting from the economic advantages accompanying the transfer of nuclear technology.

If it is decided, based on these considerations, that nuclear energy is indispensable, other considerations such as safety and technical dependency seem superfluous, and all that really must be decided are the methods of implementation.

Because nuclear plants are expensive and the economic resources of developing countries are limited, decisions about implementation require comprehensive and detailed planning based on knowledge of nuclear and nonnuclear technologies, on the collection of a great amount of data, and on a sense of political and economic world trends. Attaining such knowledge is possible only under the guidance of experts in scientific and political areas and only with skilled manpower under the experts' command. Turkey does not have many such experts. In fact, it may be said to suffer from a lack of sociopolitical, economic, and technological expertise. (Such a deficiency is not, however, inevitable in Third World countries.) This explains why Turkey still has not conceived a general energy plan to guide the implementation of nuclear power production.

Such a plan would have to provide for: (1) financial support; (2) a solution to the nuclear fuel-supply problem, preferably for the lifetime of the projected plants; (3) the establishment of an effective national regulatory and licensing authority; (4) manpower requirements and related educational programs; and (5) the adoption of political and economic measures to decrease dependency on other nations. Only by such a comprehensive planning can the attacks of Turkey's antinuclear movement be countered.

### The Dialectic of Turkey's Nuclear Debate

Opposition to the development of nuclear energy, which has been largely overcome by its supporters, was based on several often repeated objections.

It is argued that Turkey is a rich country in its hydro potential, with a capability of 100 billion kilowatt hours (BkWh) per year, yet not even 10 percent of this potential is currently being used. Turkey also has 5 billion tons of lignites available to feed thermal-power plants to produce 50 BkWh per year, with a consumption of 1,000 tons per year, for at least fifty years. Yet less than 10 percent of this capacity is being tapped. By the time the first nuclear reactor is planned to be in operation (1989), only 25 percent of the hydro and 57 percent of the lignite resources will be in use. Turkey might also have other resources that have not been investigated thoroughly.

The energy-growth projection for Turkey has been called unrealistic, based on the fact that no country has yet achieved such rapid growth in the production of electricity. It is also pointed out that 75 percent of Turkey's electrical energy is consumed by industry, to a great extent for the production of such luxuries as chewing gum. It is argued that, if Turkey would reduce its electricity consumption, it could satisfy its energy needs until well past the turn of the century.

Another point advanced by the opposition is that, by the time Turkey really needs nuclear technology, fast-breeder generation will have made the nuclear reactor obsolete. Moreover, because new technologies such as fusion, solar, wind, and geothermal may change the entire energy picture, Turkey should rely on its potential resources of solar and geothermal energy for the future.

An important argument against nuclear energy is that it is still not safe and dangers such as the vulnerability of plants to accident and the accumulation of radioactive wastes are multiplied by incompetent handling in developing countries.

Because Turkey's known uranium resources barely suffice for operating one plant throughout its lifetime, nuclear energy will mean a dependence on other countries similar to the dependency that resulted when Turkey adopted fuel-oil plants without an indigenous supply of petroleum. Furthermore, the world's uranium resources are limited.

Finally, it is argued that Turkey cannot afford to pay for the transfer of nuclear technology at the country's present stage of development and should first develop its own, less expensive resources. In place of Akkuyu, three thermal plants or five hydro plants could be built.

These objections, however, were overcome by the arguments of nuclear energy supporters, especially by the rationale presented to political leaders by the small group of engineers who were responsible for the nuclear decisions. Their logic was based on economic and resource considerations



rather than on political and military concerns. They pointed out that the claim that Turkey's conventional resources are rich must be clarified and quantitied. Not only will Turkey's rich national resources soon be unable to satisfy the anticipated demand, but how rich are these resources when compared with those of other countries? Although Turkey's potential hydropower is 17,000 MW, Sweden's is 80,000 MW, Norway's is 30,000 MW, Pakistan's is 20,000, Japan's is 50,000, and that of India, Colombia, Brazil, the United States, the Soviet Union, and the Republic of China are 70,000, 50,000, 90,000, 185,000, 270,000, and 330,000 MW, respectively.

Compared with Turkey's solid fossil fuels of one billion tons of coal and 5 billion tons of lignite, Czechoslavakia has roughly 12 billion tons of coal, England has 15, Poland has 46, Australia has 16, India has 100, Japan has 19, the United States has 1,000, the Soviet Union has 4,000, and the Republic of China has 1,000. Czechoslavakia has roughly 10 billion tons of lignite, Poland has 15, Yugoslavia has 27, the Democratic Republic of Germany has 30, the Federal Republic of Germany has 62, Australia has 96, the United States has 400, and the Soviet Union has 1,500.

To the opposition's claim that a thorough investigation of Turkey's natural-energy resources has not been undertaken yet, the engineers countered that, although such an investigation might uncover unrealized resources, it would entail a massive outlay of money, equipment, personnel, work, and especially time, the crucial factor in making a decision about nuclear energy. They argued that, in addition, Turkey cannot possibly afford to waste the equally extensive expenditures of time and money that was required for the gathering of present data and reconcile itself to a state of chaos while it makes further expenditures for a corrected and more complete set of data. In the resulting confusion, any healthy decision would be impossible. Whatever the quality of the available data, therefore, the maximum use should be made of it.

The argument that the demand-growth forecast is unrealistic is probably the most defensible objection to nuclear energy, because supporters simply assume that Turkey's conventional resources will be unable to meet future energy shortages. However, the critics of nuclear energy maintain that, even supposing a realistic reduction in demand growth and a severe demand control, shortages could not be held off more than a couple of years, whereas a successful nuclear implementation requires at least twenty years.

It was also claimed that the decision for nuclear power was based on the energy needs of capitalistic industries that produce luxury products by the exploitation of labor, an exploitation that nuclear technology transfer will promote with multinational capitalistic institutions. This objection may be valid, but it is also misleading because it can be applied to the importation of any technology, including that required for the constructionn of a dam or a thermal plant fired by coal, lignite, or petroleum.

The argument was advanced that, because fusion will soon offer a definitive and easy solution to the energy problem, the complex and questionable development of nuclear energy should be abandoned. Many scientists believe, however, that fusion will not be available as an energy source until the turn of the century and it is not known which form, toroidal, magnetic mirror, or laser, will be achieved then. Moreover, after fusion has become scientifically feasible, economic feasibility and the development of industrial components must be accomplished, all of which involve a considerable period of time.

To the objection that the world's uranium sources are limited, it was countered that the known resources of natural uranium would meet the total world energy demand for three to thirteen years, if all of it were satisfied with nuclear energy. However, only some 2 percent of the world energy demand (and 5 percent of the world electricity demand) is met by nuclear energy. By 2000, this ratio could be raised to 20 percent (50 percent of the world electricity demand would then be supplied by nuclear energy). Using fast breeders, the span of three to thirteen years would become 180-780 years, if all of the world energy demand were being met by nuclear energy. Thus, a lack of nuclear fuel is not a valid reason to reject nuclear energy.

Another antinuclear argument was defeated by the rationale that waste disposal does not constitute a problem for developing countries where fuels go to reprocessing factories.

Although generally it is conceded that opposition to nuclear development legitimately concerns itself with the issues of the safe operation of plants, nuclear fuel provision, and national dependency on imported technology, the decision for nuclear power was made by the Turkish government on the basis that nuclear power will become indispensable to Turkey.

### The Energy Outlook for Turkey

Energy resources produce a total of 23 BkWh per year for a population of 41 million. The respective share of various sources from which the energy is derived is shown in table 17-1.

Petroleum, lignite, and coal form the major portion of the energy supplies[3] and, as is indicated in table 17-2, Turkey depends heavily on imported sources, especially on petroleum. The difference between production and consumption must be made up by increasingly expensive imports.

Turkey's electricity production capacity is approximately one-tenth of the general energy consumption. It is notable that a greater proportion of the overall energy need is met through cow-dung pyrolization than through electricity. The electricity production is broken down by sources in table 17-3 and estimated lignite and coal reserves are given in table 17-4.



**Table 17-1**
**Percentage of Various Sources in Turkey's Overall Energy Consumption**

| *Sources* | *Percentage* |
|---|---|
| Petroleum[a] | 51 |
| Lignites | 17 |
| Coal | 11 |
| Hydro | 5 |
| Manure | 16 |

[a]Almost 90 percent of this petroleum is imported.

Based on their understanding of Turkey's energy picture, the decision makers felt they had little option than to proceed with the development of nuclear energy. Turkey is only able to produce 123 BkWh per year of electricity by installing 26,000 MW of hydro- and lignite-fired capacities. This would barely satisfy Turkey's needs alone by 1995.

The part played by less conventional sources of energy in the entire energy picture was also considered. Although Turkey is wealthy in solar and geothermal energies, solar-electricity generation is not yet feasible economically. When generated through thermodynamic means, solar energy is still five to ten times more expensive than that acquired through conventional means. Solar photovoltaic-electricity generation is even more expensive by a factor of 100.

Solar rural application seems, on the other hand, promising. In any case, solar energy could not possibly make a considerable contribution (1,000 MW per year) before the end of the century.

Studies of geothermal energy are being conducted[4] and a pilot plant of 0.5 MW is now in operation in Kisildere in the western part of Turkey, although a potential production of only 100 to 200 MW is anticipated until the 1990s.

Although geothermal energy is relatively inexpensive, it requires long periods (ten years) for plant construction and its exploitation technology needs refinement.

**Table 17-2**
**Turkey's Fossil-Fuel Production and Consumption**
*(in million tons of coal equivalent)*

| *Resources* | *Domestic Production* | *Imported* | *Total Consumption* |
|---|---|---|---|
| Petroleum | 5.3 | 14.7 | 20.0 |
| Lignites | 8.1 | 0.4 | 8.5 |
| Coal | 5.8 | 1.2 | 7.0 |

**Table 17-3**
**Turkey's Current Electricity-Production Capacities**

| *Installed Power* | *Megawatts* |
|---|---|
| Hydro | 1,780 |
| Motorin[a] | 468 |
| Fuel oil | 956 |
| Lignite | 609 |
| Coal | 350 |
| Others | 12 |
| Total | 4,175 |

[a]Diesel driven.

On the basis of these considerations it may be concluded that Turkey should accept imported energy costs and save some of its fossil-fuel potential for future industrial use, rather than gamble on an early appearance of some unconventional energy-resource miracle.

What, then, are Turkey's options for energy importation? It cannot afford to import petroleum or natural gas to burn in power plants because it is already paying $3 billion per year to import petroleum, approximately the same amount earned through exports. Importation of coal is an equally impractical solution, due to the country's undeveloped transportation network. Importing electricity from neighbors seem unlikely if the current does not circulate both ways and equally. (In any event, international electricity networks can be sabotaged or disrupted easily.)

Therefore, it should be decided that the development of nuclear energy is the only realistic solution to Turkey's potential energy shortage and that the development of it should be begun immediately. The first problem is financing such an expensive project. Because Turkey is already repaying foreign loans of $21 billion, it would be ready to accept financial assistance whenever it were offered.

The time required for the deployment of nuclear energy was another consideration for Turkey. Since 1972, the NED-TEA staff has been working toward the plant projected for 1986-1989, and eventually Turkey will need several such plants. As the world moves toward the energy crisis projected for the 1990s and uranium supplies dwindle, nuclear fuel provision could also become a problem. However, the fast-breeder reactors, which will be available long before fusion and solar plants are on-line, may alleviate the shortage. Plutonium, the fuel source, must be produced domestically in conventional reactors, because it will probably become unavailable on world markets, and thus nuclear technology must be transferred and assimilated rapidly so that Turkey can meet successfully the challenges of supplying energy to a growing economy.



**Table 17-4**
**Estimated Lignite and Coal Reserves of Turkey**
*(in billion tons)*

| *Resource*[a] | *Lignite* | *Coal* |
|---|---|---|
| Proven | 2.742 | 0.186 |
| Probable | 1.953 | 0.255 |
| Possible | 0.570 | 0.834 |
| Total | 5.265 | 1.275 |

Source: T. Yarman and M. Sen, "General Report of Division 4," *Unconventional Energy Resources* 3 (Ankara: General Energy Congress of Turkey, November 1978).
[a]The largest basin, with 3.5 billion tons, is in Elbistan. Thus, already a lignite-fired complex of 9,000 MW capacity is projected. The coal reserves are located mostly around the Zonguldak region.

Of course it is always possible to question the validity of energy-demand projections. For instance, comparing figures 17-1 and 17-2 reveals a discrepancy of 20 BkWh per year between what is to be produced and consumed in 1995. Although a great shortage can be expected on the basis of these projections, it is still conceivable that Turkey could actually have a large surplus generating capacity. These issues reflect the problems of projections, especially those based simply on trend extrapolation. These predictions ought to be forbidden because they can mislead easily and, in any event, the future is full of uncertainty.

Turkey's economic structure, however, makes some projection necessary for future planning. An electricity-demand forecast is an essential part of the planning process, even though it might have to be changed frequently as different economic conditions prevail. It is unlikely that the electricity-demand forecast for Turkey is greatly exaggerated, considering that Italy possesses an installed capacity of 40,000 MW, France has 48,000 MW, Great Britain has 72,000 MW, and the Federal Republic of Germany has 77,000 MW. Of course, if demand could be controlled or channeled, the energy planning might have to be reconsidered, but the resulting change would be of minor importance and would not affect decisions about nuclear energy. In any case, the foregoing projections cannot be far wrong, and thus it was decided to proceed with the deployment of nuclear power.

### Uranium Resources of Turkey

Turkey has 4,600 tons of proven $U_3O_8$ reserves, 3,000 tons of which are located in the region of Salihli-Koprubasi. This amount would be able to meet the demand of operating a 600 MW reactor for thirty years. Also, it would be possible to build here a uranium-process plant that would produce

130 tons of $U_3O_8$ per year by 1986. In addition, the phosphoric-acid plants of the manure and nitrogen industry now produce 160 to 170 tons of $U_3O_8$ per year as a by-product. It is expected that this potential will reach 230 to 260 tons with the new phosphoric-acid plants to be built by 1984-1986. It is anticipated that the feasible construction, through mostly national means, of a uranium-process factory near the acid plants would allow the by-product to acquire its anticipated value. In this way, fuel for the full lifetime of a second power plant of 1,000 MW would be provided for solely through national means.[5]

Turkey has other resources with a smaller quantity of uranium. One of these is the Sirnak asphaltite reserve of a million-ton capacity. Sirnak asphaltites contain 100 to 200 grams of uranium per ton of ashes. Thus, it is conjectured that, for every million tons of asphaltite that will be burned in Sirnak, in the southeast of Turkey, 45 tons of uranium can be produced.

It is known that lignites of Yatagan, in the southwest of Turkey, also contain uranium, although it is not homogenously distributed.[6] Sounding investigations are necessary to ascertain the amount of uranium available there.

Uranium has been discovered also in the Black Sea and Lake Van. It is conjectured that the Black Sea bottom contains 10 to 80 grams of uranium per ton of bottom mud, within a layer of 1-2 meters. The Lake Van water is known to contain 80 milligram per ton (mg./ton) of uranium (twenty-five times higher than the usual amount of 3 mg./ton found in the seas). However, the extraction of uranium from these resources appears difficult and still unfeasible economically.

In addition to the uranium reserves, there are large reserves of thorium in Turkey (200,000 tons of $ThO_2$ alone near Eskisehir, with an ore deposit of 0.3-0.4 percent and 1-4 percent rare earth elements) for possible future use in nuclear reactors.

## Recent Developments

Because the new military government in Turkey wants to proceed with the construction of nuclear power plants, an attempt is being made to continue the development of a national nuclear policy. So far, however, although the planning process is continuing actively, nothing definitive has emerged. Simultaneously with this effort, negotiations are still proceeding with the Swedish ASEA-ATOM for the first power plant, to be built in Akkuyu. Although the Swedish government is offering to advance 80 percent of the plant's total cost through credit, the Turkish government is insisting that more generous terms be extended by the Swedes. At this moment, the two governments are at an impasse and prolonged disagreement could derail the entire agreement. If this occurs, it appears likely that the process of soliciting



bids and selecting a contractor could begin anew. Because of the great uncertainty over both the entire nuclear program and Turkey's situation in general, it would be foolhardy to venture a guess about either the specific outcome of the present negotiations or the future of the nuclear program in Turkey.

## Conclusion

Nuclear-energy decision making is an integral part of the general energy policy, not only in its scientific and technological dimensions, but also through its numerous economic and political inputs. For example, what determined the type of Turkey's first nuclear power plant were simply the credits proposed by the bidder, Swedish ASEA-ATOM. Furthermore, the fact that the political leaders of the two major parties in Turkey, one in power and the other in opposition, agreed in principle to import nuclear power undoubtedly smoothed the conflict over its adoption. A number of psychological factors, by influencing public opinion, also determined nuclear decision making to some extent. Fear of technology, fear of national dependence that results from technology transfer, along with the fear of being left out of the nuclear age, helped form opinions in the public forum.

The decision for nuclear energy in Turkey may have to be reviewed and perhaps modified after further informed opinions on the subjects of technology transfer, the development of a regulatory body, quality assurance and control, the safe operation of plants, nuclear-fuel supply and processing, and so forth have been considered. Such new information will help to clarify Turkey's path to nuclear development and integrate it with Turkey's other paths and undertakings.

## Notes

1. N. Aybers, *Manpower Requirements for Future Nuclear Power Programmes in Turkey,* (Vienna: IAEA-SM-238 15, April 1979).

2. General Energy Congress of Turkey, *Energy Statistics* 3 (Ankara: November 1978); H.H. Isikpinar, *Turkey's Electrical Energy Prospect for the Year of 2000* (Istanbul: Tenth World Energy Conference, September 1977), sec. 1.4-14; G. Turkoglu, O.Z. Demiray, S. Kiciman, *Long-Term Electricity Generation of Turkey* (Istanbul: Tenth World Energy Conference, September 1977), sec. 1.4-10.

3. T. Yarman and M. Sen, "General Report of Division 4," *Unconventional Energy Resources* 3 (Ankara: General Energy Congress of Turkey, November 1978).

4. T. Yarman, "General Report of Division 4," *Unconventional Energy Resources*, Studies of Development (Istanbul: Tenth World Energy Conference, September 1977).

5. T. Hepsen, "Earning of the Uranium from the Lignites of Mugla-Yatagan Region" (Ph.D. diss., Technical University of Istanbul, Institute for Nuclear Energy, 1976).

6. T.H. Evcimen and M. Cetincelik, *The Importance of Radioactive Minerals (Uranium and Thorium) in Turkey for Future Nuclear Energy Production* (Istanbul: Tenth World Energy Conference, September 1977), sec. 3.2-5.

# 18 Venezuela

*Marcel Roche*

The decision to initiate a program in atomic energy may be based on three different reasons: to provide the facilities for research, to use fission as an energy source, or for military purposes. In 1954, when the decision was being made to build a nuclear reactor in Venezuela, neither of the first two reasons carried weight because, on the one hand, the number of active scientists was extremely small and, on the other, hydro and fossil fuels were plentiful.

The third reason has apparently had no influence on Venezuela's nuclear policy. The decision to build a fairly significant (3 megawatt) research reactor was made by a single ambitious individual, backed by a dictatorial, prestige-seeking government, which soon fell (1958) under the pressure of democratic forces. Although the atomic program has been continued under the new regime, it has had only modest success.

This chapter will discuss briefly growth over the last twenty years with special reference to atomic energy. The development of the nuclear energy program will be examined with emphasis on the scientists, engineers, and others who have been instrumental in carrying it forward.

## The Country

Venezuela is situated in the humid tropical zone, bordering on the Caribbean Sea to the north, Brazil to the south, Guyana to the east, and Colombia to the west. Its surface area covers 912,050 square kilometers. In 1954, when the first nuclear decisions were being made, it had approximately 6 million inhabitants with a growth rate of nearly 4 percent per annum.[1] Its present (1981) population is estimated at 14.31 million. The present per capita income, in U.S. dollars, is $2,415, the highest in Latin America, but earnings have always been unevenly distributed.

In the eighteenth century, cocoa was the main export, in the nineteenth, it was coffee; and from the twenties of the present century on, it has been petroleum. In the 1940s, Venezuela was the second largest producer of petroleum in the world, after the United States, and the largest exporter. Since then, although its relative position has dropped, petroleum continues to be the chief export, from which Venezuela derives 65 percent of its budget and 92 percent of its foreign income. In 1980, average production