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8 Egypt

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This chapter reviews the evolution of Egypt's nuclear program, the major factors that influenced the successive series of nuclear decisions, and the public debate in Egypt over the far-reaching nuclear program that the late President Anwar El-Sadat attempted to implement. Egypt's program is important, not only because Egypt was the first Arab country to enter the nuclear age, but also because it is an ambitious nuclear program, which includes the installation of eight nuclear reactors, undertaken at a time when many other countries are reducing their commitment to nuclear power.

The Origins of the Nuclear Energy Option

The first stirrings of the nuclear movement in Egypt began as a response to the 1953 U.S. Atoms for Peace initiatives. Members of the Egyptian Revolutionary Command Council (RCC) showed immediate interest in nuclear energy and, after the passage of the Atomic Energy Act in 1954 (which empowered the U.S. Atomic Energy Commission to cooperate with other countries on the peaceful uses of nuclear energy), negotiations were started immediately between Egypt and the United States. The negotiations resulted in the installation of a radioisotope laboratory in the National Research Center in June 1956 and an arrangement for U.S. nuclear specialists to train Egyptian personnel.[1] During this same period, the Egyptian Atomic Energy Commission was formed in 1955 under the chairmanship of an RCC member, Colonel Kamal El-Din Hussein.

In September 1956, the U.S. ambassador to Egypt (Byroade) presented a collection of references and academic reports on nuclear energy to Colonel Hussein. In his warm presentation speech, Ambassador Byroade told his Egyptian audience that the United States wanted to share nuclear knowledge with other countries in order to improve the countries' quality of life.[2] However, these preliminary steps beyond U.S.-Egyptian nuclear cooperation ceased because the two countries disagreed on other issues (such as Egyptian-Czech arms trade, Egypt's recognition of the People's Republic of China, and the controversy over building the Nile-spanning High Dam).

Concurrently, Egypt approached the Soviet Unon for a nuclear reactor and uranium, and the Soviet Union quickly agreed, in principle, to provide them. In January 1956, a delegation was dispatched to Moscow to negotiate

the terms of the nuclear deal. This mission resulted in the signing of an agreement under which the Soviet Union agreed to build, at a token cost to Egypt, an experimental 4 megawatt (MW) reactor and a nuclear physics laboratory.[3] Hence, Egypt became the first Arab country to enter the nuclear age.

The Soviets took charge of training a generation of Egyptian nuclear scientists and, in 1958, twelve graduate students were sent to study nuclear physics in the Soviet Union and be trained in the operation of the Soviet nuclear reactors.[4] In 1961, a research reactor was installed and activated in Anshas on a 4,000 feddan area (approximately 9,000 acres) especially allocated for the nuclear program. The Soviet reactor, which is still in operation today, is an experimental Van de Graf type 4 megawatt reactor with a multiplier of 3 million volt pressure power and a thermal capacity of 2,000 kilowatts.[5] Although the reactor's basic function is to produce radioisotopes for various scientific research projects and medical purposes, it has no known capacity to produce plutonium.[6]

Several structural features evident at the birth of Egypt's nuclear program have continued to influence strongly its evolution. The prime factor was, of course, the fact that Egypt's program was undertaken in response to the initiatives of foreign governments and external factors rather than as part of an overall economic development plan. The U.S. Atoms for Peace proposals immediately drew the attention of the RCC "Free Officers" to the importance of nuclear technology, which they deemed highly desirable and which they began to adopt, despite the almost complete lack of Egyptian nuclear scientific manpower and facilities. Furthermore, there was no public debate whatsoever over the decision to enter into the nuclear age. Thus, motivated basically by the United States, all major decisions were made by the Free Officers at the highest governmental levels.

From its beginning, the Egyptian nuclear program was deeply enmeshed in the Cold War, which predominated the politics of the Middle East in the 1950s. The collapse of the U.S.-Egyptian negotiations was due mainly to the incompatibility of the two countries' politico-strategic views at that time. By the same token, the Soviet decision to supply Egypt with a nuclear reactor was part of a concerted Soviet effort to gain a foothold in the Middle East. It is doubtful that Egypt would have been able to initiate a nuclear program had it not been for the U.S.-Soviet rivalry in the 1950s.

As a corollary of the external influences, the Egyptian nuclear program did not start as an indigenous program. When Egypt embarked on the program, it lacked the scientific base needed to develop nuclear technology and run a nuclear program. Consequently, Egypt imported nuclear technology on a purely turn-key basis. Furthermore, the Egyptian nuclear program was characterized by dependency on a single foreign power (the Soviet Union) as a source of nuclear technology and uranium. However, from the program's outset, Egypt's military junta mounted a concerted effort to reduce external

dependency by diversifying sources of nuclear technology. A first step in this direction was to turn the Egyptian Atomic Energy Commission into a state corporation under the chairmanship of President Nasser himself. The new corporation was empowered to lay down the basic guidelines of Egypt's nuclear policy and to promote its actualization.[7] A second step was to create a cadre of Egyptian nuclear physicists, and hence the Faculty of Science at Cairo University started a nuclear-physics program in 1953, which was expanded later to include graduate studies. The third step was to seek indigenous sources of uranium. A comprehensive aerial and geological surveying program was launched to locate uranium and, in 1959, it was reported that deposits had been found in the northern coast, near Rosetta and Demietta.[8] Finally, a diversification of foreign nuclear technology sources proceeded concurrently with the Soviet-Egyptian program. In December 1959, an agreement was signed with Norway for the building of a radioisotope center in Egypt,[9] and, in April 1961, an agreement was signed with Yugoslavia for its assistance in the search for nuclear materials in Egypt. (Through the Yugoslav-Egyptian program, Egypt was able to produce locally a beta x-ray measuring device for the analysis of radioactive materials.[10]) Help was forthcoming also from international organizations in the late 1950s; the International Atomic Energy Agency (IAEA) helped to build a cobalt unit of the new nuclear plant in Anshas.[11]

Despite these efforts to develop internal expertise and external diversity, the purchase of the Soviet-made reactor was based on considerations of availability rather than suitability. The decision was not preceded by any feasibility studies because the Soviet technology was the only technology available to the Free Officers.

The Evolution of the Nuclear Program under Nasser

Beyond the installation of the Anshas reactor, the nuclear program did not show any signs of substantial progress in the 1950s, although nuclear research and manpower development continued at a modest pace. In the early 1960s, however, Egyptian decision makers began to realize the crucial role atomic energy could play in solving growing economic and security problems. Unlike some of its neighbors, Egypt had failed to uncover large new sources of oil, and this prompted Egyptian decision makers to think of atomic energy as an alternative energy source. There was concern also that Israel was developing a nuclear capability in order to deter Arab aggression. As a result, some influential Egyptians contemplated the development of their own nuclear capability.[12]

The confluence of these factors prompted Egypt's leaders to pursue an aggressive course of nuclear development. As a result of the Egyptian deci-

sion makers' renewed interest in atomic energy, the Egyptian Atomic Energy Corporation (EAEC) was instructed to explore available energy alternatives in light of carefully planned feasibility studies. On April 30, 1963, Egypt's minister of scientific research, in his capacity as the minister responsible for the EAEC, signed an agreement with a British consulting group to assess the economics and siting of a potential nuclear power plant.[13] Meanwhile, a commission, headed by the minister himself, was formed in order to study the available alternatives.[14] The commission focused on two major factors influencing the anticipated nuclear expansion: the availability of thorium and of foreign exchange. A concerted effort was staged to produce thorium locally, and it is now feasible for Egyptian scientists to produce thorium from local monazite on a commercial scale.[15]

It is not clear whether the Soviets were approached to subsidize the new program. What is certain is that the Soviets, because of their already heavy investment in Egypt (both in the High Dam project and in assorted military hardware), did not show any interest in the program. Consequently, Nasser decided to rely on Western finance and technology almost exclusively, a choice that has continued to shape the Egyptian nuclear program since the mid-1960s.

Accordingly, in late 1965, a major decision was made to purchase a Western commercial-scale nuclear power plant at Borg El-Arab, west of Alexandria. The basic purpose of the projected 150 megawatt plant was to desalinate 2,000 cubic meters of sea water (from the Mediterranean) a day, which then could be used in land reclamation.

Because the decision had been made to rely on Western credits, only Western companies were invited to submit bids for the new plant. Bids ranging from $50 to $70 million were received from U.S. and West German companies. However, because of the deteriorating relations between Egypt and the West at this time, Western banks did not grant the sizable credits Egypt needed to build the reactor.[16] Once again, foreign support and technology were crucial to the nuclear program, but, as a result of larger political issues, the program had to be shelved.

The stalemate was not only a result of the lack of foreign exchange, it was also a consequence of the turn-key approach that continued to characterize the Egyptian nuclear program. Egypt was not successful in developing a viable indigenous nuclear scientific establishment that could develop and administer the program. As a result, it relied on foreign expertise and technology, but such assistance was subject to the vicissitudes of international politics. Egypt requested nuclear assistance from West Germany, which sent nuclear physicists to work in Egypt. However, after the severance of West German-Egyptian diplomatic relations and the withdrawal of West German scientists in 1965, the Egyptian nuclear program was hindered severely. As a result, Egypt turned to the People's Republic of China (PRC), especially after the PRC detonated an atomic bomb.[17] Although Sino-Egyptian contacts

did not result in any substantial progress initially, after the Arab-Israeli War in 1967, Egypt placed renewed emphasis on its contacts with China. Egypt's purpose was to obtain atomic technology, and the major reason for this shift was the belief that Israel might develop an atomic bomb and use it against the Arabs if they did not accept Israel's demands. This prompted Nasser to write to Chou En-Lai, reminding him of his promise (made to Nasser after the explosion of the first Chinese nuclear bomb in 1964) that China would share its nuclear knowledge with Afro-Asian countries. Nasser also sent a delegation from the Atomic Energy Corporation to China to ask for help in making a breakthrough in nuclear techniques. Chou, however, advised the Egyptians to be self-reliant: "If the Egyptians want to step into the atomic field, they would have to do it themselves."[18]

Despite the marked lack of progress in the construction of Egyptian nuclear facilities, the Nasser era did bring progress in terms of planning and goal setting, including the planning of an integrated nuclear energy program until the year 2000. Experts of the Atomic Energy Corporation estimated that demand for electricity would increase rapidly, exceeding 100 billion kilowatt hours by the year 2000. They also estimated that thermal units, whether oil-fired or nuclear, are the only two economically feasible alternative sources of energy. Commercially exploitable geothermal resources are virtually nonexistent in Egypt, and the prospects for expanded coal, natural gas, or even hydroelectric power production are very limited.[19]

By contrast, one comparative analysis of the economics of 600 MW plants estimated that, over a twelve-year period of operation, the cumulative savings in the operating costs of a nuclear plant over those of an oil-fired plant would equal the difference between the nuclear plant's and the oil-fired plant's costs after approximately four-and-a-half years of operation. Furthermore, the cumulative savings would equal the total capital cost of the nuclear plant after ten years of operation.[20] These findings indicate that nuclear plants should play an important role in meeting further load growth, probably starting with unit sizes of 600 MW and ultimately reaching unit sizes of 1,000 MW. Table 8-1 shows the role of nuclear power in Egypt from 1977 until the year 2000 as projected by an Egyptian scientist. As the table indicates, the scientist envisaged that Egypt would have eight nuclear power plants with a total capacity of 5,400 megawatts operating by the year 2000.

However, due to the shortage of foreign exchange and the lack of a solid scientific infrastructure to administer the new venture, the envisioned program has not yet gotten underway.[21]

The Egyptian Nuclear Program

After Sadat's accession to power in 1970, Egyptian authorities began to reapproach private U.S. companies concerning the sale and finance of nuclear

Table 8-1
Egypt's Proposed Generating Installations, 1977

Year	Site Location	Type[a]	Number of Units and Megawatt Rating	Total Megawatts Nuclear	Total Megawatts Thermal
1977	Helwan	GT	6 × 20		120
1977	Kafr El Dawar	T	2 × 110		220
1978	Talkha	GT	9 × 20		180
1979	Cairo West, Unit No. 4	T	1 × 87		87
1980	Abu Kir	T	4 × 150		600
1981	Ismailia	T	2 × 150		300
1981	Suez (I)	T	2 × 150		300
1982	Suez (II)	T	2 × 150		300
1983	Sidi-Kreir, Unit No. 1	N	1 × 600	600	
Total added generation for short- and long-term plans				2,707	
1985	Sidi-Kreir, Unit No. 2	N	1 × 600	600	
1986	Cairo, North, Unit No. 6	T	1 × 600		600
1987	Cairo Zone/Qattara I	N/H	1 × 600		600
1988	Lower Egypt Zone	T	1 × 800		800
1989	Upper Egypt Zone	N	1 × 600	600	
1990	El Arish No. 1	N	1 × 600	600	
1991	El Arish No. 2	N	1 × 600	600	
1992	Cairo Zone	T	1 × 600		600
1993	Cairo Zone/Qattara II	N/H	1 × 600	600	
1994	Upper Egypt Zone	T	1 × 800		800
1995	Cairo Zone	N	1 × 1,000	1,000	
1996	Cairo Zone	T	1 × 1,000		1,000
1997	Upper Egypt Zone	N	1 × 1,000	1,000	
1998	Upper Egypt/Lower Egypt Zones	T	2 × 800		1,600
1999	Cairo Zone	N	1 × 1,000	1,000	
Total added generation for short- and long-term plans				14,707	

Source: K.W.A. Effat et al., "Projected Role of Nuclear Power in Egypt and Problems Encountered in Implementing the First Nuclear Power Plant," in *Nuclear Power and Its Fuel Cycle*, 8 vols. (Vienna: International Atomic Energy Agency, 1977), 6:152.

[a]GT = gas-turbine, H = hydro, N = nuclear, T = oil or gas-fired conventional steam plant.

reactors. However, because of the negative context of U.S.-Egyptian relations at the time, the United States never considered the matter seriously.

Experts at the EAEC concentrated their efforts on refining their estimates of Egypt's needs for nuclear energy. They estimated that, by the year 2000, Egypt would have to generate 6,600 MW of electricity (almost 40 percent of Egypt's total electricity needs) through nuclear power.[22] By early 1974, they had decided that a 600 MW block would be required by the year 1984 and that such a block should be built in Sidi-Kreir, west of Alexandria.[23]

The Egyptian decision coincided with the U.S.-Egyptian rapprochement that took place in the aftermath of the October 1973 Yom Kippur War. The United States wanted to symbolize the new relationship by promising nuclear aid to Egypt, so, on June 14, 1974, President Nixon announced from Cairo that the United States would negotiate an agreement for cooperation to provide Egypt with nuclear reactors and fuel. In an attempt to maintain a balanced posture, three days later, the United States announced a similar agreement with Israel. Despite the initial euphoria that accompanied the U.S. announcement, U.S.-Egyptian negotiations floundered because of Israeli objections to the stringent U.S.-imposed inspection procedures, which were required for all Egyptian and Israeli reactors and which were intended to prevent the development of nuclear explosives. Although Egypt was willing to abide by such inspection procedures—provided the Israelis would—the Israelis expressed little interest in going ahead with the proposed deal. By declining the U.S. offer, the Israelis simultaneously avoided the inspection of their nuclear installations and disrupted the U.S.-Egyptian deal. Because the U.S. offer to Egypt was conditional, depending on Israeli acceptance of a similar deal, and because the proposed U.S.-Egyptian deal encountered overwhelming opposition in Congress, the U.S.-Egyptian negotiations were terminated.[24] The only substantive and immediate result of Nixon's expansive promise was a June 26, 1974, fuel-enrichment agreement under which the United States promised to provide Egypt with eight shipments of uranium-235 valued at $39 million.[25]

Meanwhile, Egypt resorted to Cold War politics to expedite the U.S.-Egyptian deal. In November 1974, Foreign Minister Fahmi announced that he had asked the Soviet Union to provide Egypt with a nuclear reactor and that the Soviets had agreed to supply Egypt with a 460 MW reactor. This agreement was to be signed during the forthcoming Brezhenev visit to Cairo, scheduled for January 1975.[26]

The United States seemed to get the message, and they dropped their original far-reaching proposal for inspecting all reactors in favor of inspecting only U.S.-supplied reactors. After renewed negotiations, in November 1975, Egypt and the United States signed a joint statement detailing the conditions under which Egypt would buy nuclear reactors from the United States. The statement provided that:

None of the assistance provided will be employed for any military purposes, including the manufacture of any nuclear explosive device.

The materials and facilities to be supplied as well as the produced plutonium will be subjected to international safeguards, administered by the IAEA, designed to assure their continued uses for peaceful purposes.

Facilities utilizing relevant nuclear technology obtained from the United States will be under effective safeguards.

Egypt guarantees to apply effective physical security measures to the facilities and nuclear material covered by the agreement.

The statement also included an unprecedented condition that obliged Egypt to reprocess, fabricate, and store the plutonium produced by the U.S. reactors or derived from the U.S. fuel supplied for their facilities outside of Egypt.

The statement was supposed to be the forerunner of an agreement by which Egypt would purchase two reactors, with a total electrical capacity of 1,200 MW, at an estimated cost of $1.2 billion. In August 1976, the Egyptian and U.S. governments initialed an agreement on areas of nuclear cooperation. The final agreement was supposed to be signed in 1978. However, in that same year, the United States passed the nonproliferation act, which required any country that purchased U.S. reactors to accept U.S. inspection of all its nuclear activities. Egypt rejected this condition and, as a result, the final agreement was delayed.

Meanwhile, by mid-1975, President Sadat had begun to pay special attention to the nuclear program, and a decision was made to try to accelerate its implementation. The prime motive for this heightened interest was Israeli's hints that it might use a nuclear bomb in future confrontations with the Arab countries. As a result, a Higher Council for Atomic Energy was founded under the chairmanship of President Sadat in 1975. The president instructed all organizations working in the field of nuclear energy to expedite the preliminary procedures for the implementation of the program.[27] The timing of Sadat's decision indicates that Egyptian decision makers saw the potential of somehow producing weapons from the nuclear power program and realized that this would act as a deterrent to Israel.[28]

The desire to move forward with the newly invigorated nuclear plan, which was stymied by the deadlocked U.S.-Egyptian negotiations, motivated Egyptian decision makers to seek alternative suppliers. Egypt approached France,[29] and the Federal Republic of Germany, and Franco-Egyptian negotiations resulted in the initialing of an agreement, according to which Egypt would purchase a 1,000 MW reactor.[30] However, France was reluctant to finalize the deal, mainly because Egypt had not ratified the nuclear nonproliferation treaty (NPT).

Although Egypt had signed the treaty, it delayed ratification until Israel signed it. Both France and the United States demanded Egypt's ratification as a condition for consummating any construction deal. Nevertheless, the Egyptians refrained from complying with their request, fearing that ratification would rule out the option of developing the nuclear bomb, which they believed Israel already possessed. For almost five years, Egyptian decision makers pondered this dilemma, finally concluding that, by not ratifying the NPT, Egypt not only would jeopardize the badly needed nuclear power program, but would also miss the opportunity to obtain the nuclear technology and materials that could enable it, in the long run, to redress the balance of power with Israel.[31] So, in the end, the Egyptians decided to ratify the NPT. The ratification procedures were unusually speedy.[32] Furthermore, once the decision to ratify had been made, Egypt quickly reached a compromise with the United States according to which Egypt accepted IAEA inspection of all its nuclear installations in place of U.S. inspection.

Immediately after the ratification of the NPT, in February 1981, Egypt and France signed a protocol according to which Egypt will purchase two nuclear reactors with a capacity of 1,000 MW each. The first plant will be built in 1989 at Daba'a, on the northern coast, and it will be followed by another plant in 1990, which will be built at Za'fraana, 139 kilometers west of Alexandria. In July 1981, Egypt and the United States signed an agreement according to which Egypt will purchase two nuclear reactors. Finally, according to an agreement initialed in September 1981, the Federal Republic of Germany will sell Egypt two nuclear reactors. The three agreements stipulated that the Western seller will supply the fuel necessary to operate the reactors and also will provide technical expertise and training. It is expected that Britain will be supplying two more nuclear reactors, also.

It is estimated that the Egyptian nuclear program will cost between $12 and $15 billion, including the installation and operating costs.[33] The major source of financing will be the profits from the national oil industry. The Egyptian cabinet has already decided to allocate annually $500 million of the profits of the oil industry to finance the program, and the Ministry of Oil has already deposited the 1981 installment with the Central Bank of Egypt, which will administer the financing of the program.[34] The Central Bank of Egypt will issue Alternative Energy Bonds, which will be sold to the general public in foreign-currency denominations, and these bonds will equal the total value of foreign exchange deposited by the oil industry. Foreign loans at generous rates will provide an important additional source of revenue. For example, Sweden has already agreed to provide Egypt with a long-term loan to finance the nuclear program to be repaid over fifty years at an interest rate of less than one percent.[35]

The Egyptian nuclear program, as it evolved during the Sadat era, was characterized by certain major features that distinguish it from its predecessor. Unlike the initial nuclear venture, which received Soviet assistance, the program relies almost exclusively on Western technology. However, this pro-Western technological orientation did in fact begin emerging during the Nasser era. So, since its inception, the modern program was conceived as essentially a Western-supported and -guided operation. Despite overdependence on Western technology in general, the program is highly diversified in terms of the particular sources. No single Western country supplies more than two of the eight reactors in the program. Furthermore, Egypt is deliberately attempting to widen the scope of international cooperation in other areas of nuclear technology to include other countries such as India, Sweden, and Canada. For example, Egypt is cooperating with Canada in testing the economics of extracting uranium from Egyptian phosphate. Unlike the initial venture, which relied on the available Soviet technology (not always the most modern), the present program utilizes advanced Western technology. Throughout negotiations with Western suppliers, the Egyptian planners insisted on purchasing the most sophisticated technology available.[36] It is not yet clear whether Egyptian planners have traded sophistication for appropriateness.

Despite these differences, the current program shares common characteristics with the initial Soviet-Egyptian venture. It is being handled on a purely turn-key basis; the Western suppliers, will provide, as did the Soviets before them, all relevant technological devices and systems, including those for security and waste management.[37] Furthermore, the program is being sponsored, financed, and controlled entirely by the Egyptian government. Despite the issuance of public bonds to finance a portion of the costs, and despite President Sadat's economic open-door policy (*infitah*, which is based on the encouragement of private and foreign investment), only governmental institutions and corporations are involved in the planning, financing, and management of the program.

Nuclear Energy Decision Making

The Egyptian nuclear program, as outlined in the preceding section, so far has consisted mainly of a series of decisions that define the major thrust of the program. Although some are strategic decisions related to the use of nuclear energy as a source of energy and to the reliance on Western technology, others are tactical, because they deal mainly with issues such as the quantity and quality of reactors, sources of uranium supply, and the ratification of international treaties related to nuclear energy. Yet, despite their seeming latitude, these decisions were made within specific structures

and through certain processes that have evolved over the last twenty years and that operate to influence the nature and direction of the decisions.

The analysis of the decision-making structures and processes in the area of nuclear energy in Egypt since 1955 reveals three major characteristics: the decision-making process is highly politicized and centralized; there has been an institutionalization of the decision-making process; and there has been, in organizational terms, a trend toward structural differentiation and functional specificity. These major characteristics and their occasional exceptions illuminate the nuclear decision process.

The Higher Council for Nuclear Energy (HCNE) is the highest decision-making body in the area of nuclear energy in Egypt. The council was established in 1975, and consists of the president, the vice-president, the prime minister, the foreign minister, the minister of defense, the minister of electricity, and the head of the General Intelligence Agency. The composition of the council indicates that it is essentially a political decision-making organ. Apart from the minister of electricity, virtually all members of the council are politicians and have no technical experience in the area of nuclear energy.[38]

The HCNE receives technical advice and recommendations from the Higher Council for Energy (HCE) and the three specialized nuclear corporations. The Higher Council for Energy was established in December 1979 as a purely technical organization. Its role is to establish guidelines for the energy policy and to present technical advice pertaining to nuclear energy to the HCNE. The council consists of the ministers of petroleum, electricity, planning, finance, industry, housing, irrigation, and transportation and communication. The HCNE also receives technical advice from the Egyptian Atomic Energy Corporation (EAEC) and other state corporations whose activities are related to nuclear energy, such as the Nuclear Materials Corporation. However, this advice is usually presented directly by the ministers of electricity and industry in their role as council members.

The politicization of the nuclear energy decision is not restricted to the core decision-making organ. It also extends to embrace the technical echelons of the decision-making system. The case of the EAEC illustrates this point. Since its inception, there has been a noticeable emphasis on placing it under political control. When it was established, President Nasser himself chaired the corporation. In December 1963, the chairmanship was handed to Salah Hedayet, a veteran officer who had become a minister of scientific research. Five months later, however, political control of the EAEC was tightened when it was placed under the supervision of Deputy Premier Kamal El-Din Rifaat, a veteran Free Officer and one of Nasser's close confidants. Subsequently, Field Marshal Amer, the commander of the Armed Forces, was given responsibility to supervise the EAEC. The practice of political control was discontinued in the early seventies when

Professor El-Gebeilay was appointed as a chairman of the Board of Governors of the EAEC in August 1970. Since then, the EAEC has been under the chairmanship of professional nuclear scientists.

The minister of electricity represents the operational link between the Higher Council for Energy and the Higher Council for Nuclear Energy because he is the only common denominator between the two councils. As minister, in cooperation with a selected group of nuclear scientists headed by his nuclear counselor Professor Effat, the former head of the EAEC, he makes major operational decisions about contracts with prospective vendors. The minister also acts as ex-officio political supervisor of the EAEC.

At the technical level of the nuclear energy decision-making system, there also has been a trend toward structural differentiation and functional specificity. Up until 1975, the EAEC performed all nuclear functions, including research, search for nuclear materials, and operating the Anshas reactor. Then the functions were separated and entrusted to independent corporations. In March 1976, the Electricity Generating Nuclear Power Plants Corporation was established. This new corporation was placed under the supervision of the minister of electricity and subsequently was renamed the Nuclear Plants Corporation (NPC). The major function of the corporation is to supervise the establishment of the nuclear power plants envisaged by the Egyptian nuclear program and to manage the plants once they have been established.[39] In 1977, the Department of Geology and Nuclear Materials of the EAEC was turned into a separate corporation and named the Nuclear Materials Corporation (NMC). The NMC was entrusted with geological surveying in search for nuclear materials and the chemical processing of the raw materials.

The decision-making process in the area of nuclear energy is essentially a political process that occurs in an environment characterized by secrecy and lack of public participation. Major decisions are made by the president, in consultation with the Higher Council for Nuclear Energy. For example, it was President Sadat who decided to embark on the nuclear program in 1975, and it was his decision that changed the plan to build the first nuclear power reactor in Sidi-Kreir. Operational decisions are usually made by the minister of electricity in his capacity as the supervisor of the nuclear program. The Parliament plays no discernible role in these processes. For example, the only role the People's Council played in the nuclear energy decision-making process was to endorse the nuclear program already adopted by the HCNE and to appeal to the president to accelerate the implementation of the program. This occurred in 1980, almost five years after the strategic decision to embark upon the program was made.

In some rare cases, public opinion was crucial in the decision-making process. This was the case with Sidi-Kreir. A decision was made in 1975, on purely technical grounds, to build the first nuclear power plant in

Sidi-Kreir. The then minister of electricity, Mustafa Sabry, seemed to be quite convinced that Sidi-Kreir was the proper location and refuted publicly allegations that the projected power plant would jeopardize the ecological life of Alexandria.[40] However, in June 1979, the local council of the province of Alexandria approved a motion rejecting the establishment of the nuclear power plant in Sidi-Kreir. The council argued that the plant would cripple the tourist industry in Alexandria. Furthermore, it argued, Alexandria could generate the power needed for the province through alternative sources, especially the Abu-Kir natural-gas project. The governor of Alexandria conveyed the resolution to President Sadat, who then suspended all plans to build the plant.[41]

The three state corporations operating in the nuclear field do not seem to play a discernible role in the decision-making process, except through their presentation of technical advice and recommendations. In some crucial cases, even the technical role of the EAEC has been short-circuited. The decision to store the Austrian nuclear waste in Egypt is a prime example. In 1978, a protocol was initiated with Austria to dispose of the Austrian nuclear wastes in Egypt's Eastern Desert. The terms of the protocol gave Austria full control of the nuclear waste, including the right to withdraw it. Although this protocol turned out to be one of the worst gaffes in the history of nuclear-energy decision making in Egypt, the relevant point is that the EAEC was never consulted during the process that lead to the signing of the protocol.

The Nuclear Power Debate in Egypt

Having outlined the basic features of the Egyptian nuclear program, let us now look at the public debate that the program triggered in Egypt in 1979-1981.

Until very recently, nuclear power was never a subject of public discussion, much less debate, in Egypt.[42] This was mainly because, in the public's mind, nuclear power was never envisaged as a source of energy, but rather was restricted to exotic medical and research purposes. Even in 1975, when the basic features of the nuclear program were announced and outlined to the Egyptian people, there was no public debate. It is quite possible that Egyptian scientists and opinion leaders did not take the plan seriously in the beginning and so did not devote much attention to it. However, when Egypt started to seek the permission of Western governments to purchase nuclear reactors in 1979, critics of the nuclear program promptly began to organize themselves and to articulate publicly their opinions.

Before turning to the content of the debate, two basic features characterizing the Egyptian debate on the merits of nuclear energy should

be noted. First, the debate was initiated after the program was already decided upon and the implementation phase was in progress. Because of this, the debate did not entail meaningful participation in the decision-making process, but basically manifested the concerns of the critics, who felt they were being asked to legitimate a fait accompli. Thus, the critics called for a reversal of the program and the opening of a true public debate on nuclear energy before any final decisions were made.[43] Second, even the critics' debate did not reflect genuine public concern about the nuclear program, because the general Egyptian public remains almost totally apathetic about the program. As it has turned out, critics of the program are mainly university professors and politicians who belong to opposing political parties, especially the Socialist Labor Party. The advocates of the nuclear program are mainly governmental functionaries from the three corporations that supervise the nuclear program and the governmental politicians who make the decisions to embark upon the program. Hence, Egypt's nuclear debate is essentially elitist in character.

The content of the nuclear power debate has revolved around the same major issues as have the debates in the Western industrial countries, although Egypt's need for nuclear energy and the economics of increased reliance on it have been the most important issues so far.

The Economics of Nuclear Power in Egypt

As their two major arguments for nuclear power, proponents of the nuclear program cite the lack of alternative fuel sources and the economic competitiveness of nuclear-generated power as compared with oil and coal-fired power plants. They hold that the elasticity of demand for energy in Egypt is almost 1.7, which means that the demand for energy will increase tenfold by the year 2000[44] and that nonnuclear sources cannot cover the expected increase. Although Egypt will need 105 billion kilowatt hours of electricity by the year 2000, only 16 billion kilowatt hours can be generated from hydraulic sources. Thus, in the year 2000, it would take Egypt's entire production of oil simply to generate the remaining 89 billion kilowatt hours, but obviously this would be an imprudent policy. Furthermore Egypt would require 260 percent of its annual natural-gas production to generate the amount of electricity needed to fill this gap. Solar energy cannot be considered seriously because it could provide only 5 percent of Egypt's electricity needs by the year 2000.[45] The Egyptian advocates argue also that nuclear power is the only viable alternative to a future of energy imports or shortages, either one of which would be disastrous economically. Furthermore, electricity generated from nuclear power is cheaper than that generated from coal or oil.[46] They estimated that the cost of producing one kilowatt hour of electricity from oil-fired, coal-fired, and nuclear power plants is 33.7, 26.1, and 15.2 millimes, respectively[47] (one millime equals $0.00149).

The critics question Egypt's need for nuclear energy in the first place, arguing that Egypt has not yet exhausted other sources of energy, especially hydroelectric power. They also challenge the economic arguments, insisting that the costs of nuclear-generated electricity are equivalent to if not more than the costs of coal-generated electricity. One critic, Professor Ashraf Bayoumi, a nuclear engineer, maintained that Americans who use electricity generated from nuclear energy pay more than do Americans who use electricity generated from other sources.

A second line of argument is that the establishment of nuclear power has specific features that make it inappropriate for developing countries such as Egypt. Egypt lacks the basic infrastructure that is essential for the establishment of a nuclear program, such as adequate transportation, electrical, water, sewage, and telephone systems. The critics maintain that the cost of building such systems should be added to those of the nuclear reactor construction and operation.[48]

On a more fundamental level, it is insufficient to simply posit an electricity growth rate and project a gap that needs to be filled. Much more fundamental questions need to be addressed and the purposes of the electricity must be examined; it is not convincing to argue that Egypt needs electricity as the justification for a nuclear program. The crucial question relates to the uses of such electricity within the framework of an economic development plan that takes into account the basic needs of a developing country. For instance, Professor Bayoumi argued that, if electricity is needed to run a soft-drink plant or similar activities, then the society certainly does not need a nuclear plant and its attendant risks. Ultimately, this is a question of values and is not easily subjected to economic analysis.

Radiation Exposure and Health Issues

A major component of the debate over nuclear power has been the safety of operating nuclear plants and, in particular, the impact of radiation on public health. Critics argue that an average-size nuclear reactor contains a great deal of radioactive materials when in operation, and in and of themselves these present a clear and present danger. Also, varying levels of radioactivity would be present in the nuclear fuel cycle and during fuel processing, and these pose an imminent danger, too.[49] Of particular concern to the critics is the effect of the proposed nuclear plants on the nearby city of Alexandria—a concern that escalated after the Three Mile Island accident.[50]

Proponents of nuclear power, while agreeing that the release of a large quantity of radioactivity could have catastrophic effects on humans, disagree

on the minimum amount of exposure likely to cause damage. They maintain that nuclear reactors are designed to prevent the leakage of radiation in excess of acceptable levels. Professor Hammouda, the head of the EAEC, asserts that the radiation from nuclear power plants is considerably less than that natural radiation to which humans are inevitably exposed.[51] Moreover, nuclear power plants are by far the least damaging type of power-generating plants in terms of environmental pollution.[52]

Radioactive Waste Disposal

The issue of nuclear waste management was triggered by the disclosure, mentioned earlier, of the Austrian-Egyptian protocol calling for the disposal of Austrian nuclear waste in Egypt. Two Egyptian academics published a book in which they disclosed and then excoriated the text of the protocol, stating that it amounted to sheer delusion and that the radioactivity of the nuclear waste would constrain the future settlement of the Eastern Desert indefinitely. It also would destroy the ecological harmony of Egypt and would engender cancer in future generations. They conducted an opinion survey of Egyptian specialists in nuclear energy and found that all of them opposed the storage of the Austrian waste in Egypt.[53]

The Austrian-Egyptian protocol sparked another debate, this concerning the disposal of the waste from the Egyptian nuclear program. Although critics restated their views, proponents argued that disposal of high-level waste, when viewed in perspective, would not pose a danger substantially different from that which man already experiences.[54] Furthermore, Minister Abaza argued that low-level radioactive waste, resulting from the routine maintenance operations, is not hazardous and dangerous. However, high-level wastes, which consist basically of fission by-products—concrete structures, machines, cleaning rags, and protective clothing—could be safely disposed of in steel canisters stored in concrete trenches at the nuclear plant site. The spent fuel itself would be reexported to the supplying countries because this is one of the conditions they have set for selling uranium to Egypt.[55]

The Site of the Reactor Issue

As soon as it was learned that a nuclear reactor would be built in the north coast west of Alexandria, a public controversy flared up over the reactor's impact on economic development and tourism in the northern coast, especially in the city of Alexandria. Surprisingly, some cabinet ministers joined the critics. The minister of housing argued that building a nuclear

reactor in Sidi-Kreir, which is located 36 miles west of Alexandria, would pollute the Alexandrian water supply because the Mediterranean water moves from west to east. He added that the plant would paralyze the program for building new housing specifically and would end prospects of the economic development of the northern coast in general. General Ezz El-Din Atef suggested that the new plant would endanger Alexandria, especially because of the absence of an evacuation plan in the case of a nuclear emergency.[56]

In April 1981, the critics asked the State Council to impose a court injunction against the establishment of the plant in Sidi-Kreir. The case was submitted by Abdel-Halim Ramadan, an Alexandrian attorney who was joined by the Alexandria Human Rights Association.

The advocates of building the new reactor on the northern coast and especially in Sidi-Kreir were led this time by the then minister of electricity, Mustafa Kamal Sabry. Mr. Sabry argued that the northern coast is probably the only area suitable for building nuclear reactors. He stated that the site must satisfy two criteria: it should not be in an earthquake-prone zone and it must be close to an abundant water supply because the plant needs 30,000-40,000 cubic meter of water per hour for its cooling system. A Red Sea site was rejected because it is in an earthquake zone, (as French experts had assured the minister).[57] On a later occasion, Minister Sabry asserted that the Sidi-Kreir plant would have a positive effect on the Alexandria environment. According to him, the plant would produce a slight increase in the temperature of the Mediterranean waters adjacent to the plant, which would benefit the fishery industry in this area.

The Alexandria Local Council, unconvinced by plant proponents, took the issue to President Sadat, who subsequently ordered a reversal of the decision to build the nuclear plant in Sidi-Kreir. The plants will now be built farther to the west of Alexandria, in Daba'a and Za'fraana.

The Dependency Issue

Critics of the nuclear program have argued that the nuclear program would exacerbate Egypt's political and technological dependence on the West. They also have said that the purchase of eight nuclear reactors on a turn-key basis will result in foreign supervision of the operation of the reactors. Furthermore, Egypt's confirmed reserves of uranium cannot supply more than 10 percent of the required uranium until the year 2000 and, therefore, the country will have to rely on imported uranium. The result of the importation of technology and fuel will be an increased technological and political dependency on the supplying countries and all the attendant consequences of such a dependency.[58] The critics have pleaded for self-reliance in nuclear

technology to reduce overdependency on foreign sources.[59] Whatever their private beliefs, the advocates have simply ignored the criticism, remaining publicly silent on the issue.

Reactor Safety

The reactor safety issue was highlighted dramatically by the Israeli raid on Iraq's nuclear reactor. The Egyptian opposition reminded the government that the eight nuclear reactors included in the nuclear program may face the same fate.[60] To this argument, the minister of electricity replied that Egyptian reactors, unlike the Iraqi reactor, will be protected by a concrete shield that can resist bombing.[61]

Despite the various issues and arguments, apart from the Sidi-Kreir decision, the objections of the critics of the Egyptian nuclear program have not brought about any discernible change in the basic orientation of the program or, for that matter, even in the program's details. However, as the program proceeds further, and various facilities begin functioning, it is likely the criticisms will gain more credibility and the opponents will attain greater visibility.

Conclusion: The Prospects of the Egyptian Nuclear Program

As the Egyptian nuclear program evolved, it became elaborate and ambitious. However, before it reaches fruition, the program faces some major obstacles that will inevitably influence its eventual implementation and functioning. The three factors most problematical are human, organizational, and natural-resource constraints and limitations.

Egypt's Scientific Capability

Egypt does not have the necessary scientific and technical expertise to embark on an elaborate nuclear program.[62] Although it has been estimated that Egypt has almost 1,000 nuclear physicists who hold doctoral and master's degrees in nuclear sciences,[63] the Egyptian nuclear scientific community is neither well-integrated nor supported enough to meet the challenge of the envisaged nuclear program. Suffice it to say that the entire 1977 research budget of the Atomic Energy Corporation was 3.3 million Egyptian pounds (less than $5 million), and only 4.6 percent of this budget was allocated for basic nuclear research. Of this amount, only $800,000 was

available in foreign currency.[64] The lack of research capabilities forced many nuclear scientists to abandon nuclear research and accept teaching positions in Egyptian or other Arab universities. An expert at the Atomic Energy Corporation assessed the research capabilities of the EAEC as follows:

> Egypt's scientific base, which has been evolving over the last twenty years, has not been successful in developing and integrating the required specializations. It does not have the capability to implement a self-reliant national program for nuclear energy. Further, the present scientific base has not been fully utilized yet. As a result of the recession of the scientific activities of the Egyptian corporations operating in the nuclear field, growing numbers of experts have emigrated to national universities and Arab countries.[65]

Although the minister of electricity has appealed to Egyptian immigrant nuclear scientists to return to Egypt and take part in the Egyptian nuclear program, as yet few have responded to his appeal.

The Institutional Instability of Nuclear Organizations

The three state corporations operating in the nuclear field are plagued by bureaucratic uncertainty. This is quite evident in the continuous restructuring of these corporations and periodic changes in their relative administrative ranks. For example, over the last fifteen years, the EAEC was placed under the supervision of the Ministry of Higher Education, the Ministry of Scientific Research, the Academy of Scientific Research and Technology and the Ministry of Electricity. These changes are not purely administrative, because they entail varying the perspectives and views of the role and orientation of the organization, and sometimes changes are to the detriment of either the program's progress or the role and effectiveness of the nuclear scientists themselves. The NMC has suffered from crippling intraorganizational conflicts also; at one point, the minister of industry, who supervises the NMC, threatened to dissolve the NMC's Board of Governors and assume the functions of the board himself. Such bureaucratic uncertainties have demoralized many of the nuclear scientists and geologists working in these organizations and consequently have influenced the scientific efficiency of the Egyptian nuclear program.

The Availability of Uranium

Although it is estimated that the Egyptian nuclear program will require 10,000 tons of uranium between now and the year 2000, according to

Professor El-Shazly, the head of the NMC, Egypt has huge reserves of uranium oxide and will eventually become self-sufficient. The NMC, he asserts, is in the process of extracting 5,000 tons of uranium oxide.[66] However, according to other NMC experts, the corporation has not been successful in developing a well-integrated program for turning Egypt into a self-reliant uranium producer.The NMC, they contend, has never come up with a valid estimation of Egyptian reserves of uranium oxide, neither has it put together a coherent plan for developing the present mines or producing uranium oxide or thorium oxide on a commercial scale. Furthermore, the organization conflicts mentioned earlier have seriously affected the corporation's organizational efficiency.[67] Without dwelling on the NMC's problems, two indicators of its disarray are that its Board of Directors has never met and that it has never conducted an aerial exploration of Egypt. At best, the experts of the NMC add, Egypt could produce only 10 percent of its uranium needs.[68]

Because of the uncertainty about domestic uranium production, the planners of the Egyptian nuclear program have decided to rely almost entirely on imported uranium. They are confident that world supply of uranium exceeds demand and that uranium prices will be moderate. Additional assurances of uranium-supply security are contained in the agreements with France and the United States, which include clauses stating that the supplier will provide the fuel needed for the nuclear reactors.

Although it is always risky to venture predictions about the future, making predictions regarding Egypt's program is even riskier because of the disappearance of President Sadat from the political scene. President Sadat was committed personally to the implementation of the nuclear program, and he exerted a profound influence over it. However, it is not clear whether his successor, President Hosni Mubarak, is equally committed, because he has never spoken publicly about the program, and, given the structural constraints, one may expect the new president to reassess the scope, timing, and magnitude of the program. On the other hand, as yet there has been no backing away from the commitment reiterated to the Egyptian parliament on September 22, 1981, by First Deputy Prime Minister Dr. Fuad Muhyi Al-Din. In a lengthy policy statement, he declared that Egypt would have eight reactors generating 8,000 MW by the year 2000 and that these reactors would supply 40 percent of Egypt's electrical needs.

Notes

1. *Al-Ahram* (Cairo), 4 June 1956; Gobrial Wahba, *Al-Taka Al-Zarriya* [Atomic energy] (Cairo: Lagnat Al-Bayan Al-Arabi Press, 1956), p. 93.

2. *Al-Ahram*, 11 September 1956.

3. *Al-Ahram*, 15 July 1956.

4. *Al-Ahram*, 9 September 1958.

5. For a full description of the Soviet reactor, see *Al-Tak Al-Zarrya fi Al-Gomhouria Al-Arabiya Al-Mouttahida* [Atomic energy in the United Arab Republic] (Cairo: Mu'assat al-Taka Al-Zarrya, 1964).

6. *Al-Ahram*, 5 October 1961.

7. *Al-Ahram*, 28 March 1957.

8. *Al-Ahram*, 26 July 1958, 31 December 1959, and 2 December 1960.

9. *Al-Ahram*, 19 December 1959. In 1963, the center was turned into a regional center for the Arab countries. It was named the Middle Eastern Regional Radio-Isotope Centre for Arab Countries and was placed under the supervision of the International Atomic Energy Agency.

10. *Al-Ahram*, 13 September 1962.

11. *Al-Ahram*, 31 December 1959 and 21 March 1961.

12. For example, Mohammad Heikal advocated that course of action in his weekly column in *Al-Ahram*, 15 October 1965. However, Nasser asserted publicly that Egypt had no intention of developing such capability (*Al-Ahram*, 23 July 1965). For a full review of the impact of Israel's nuclear capability on Egypt's nuclear option, see S. El-Hattab, "The Evolution of the Egyptian Military Doctrine: Some Factors Influencing Strategy and Defense Policy Toward Israel" (Ph.D. diss., Carleton University, Canada, 1976), pp. 99-139.

13. *Al-Ahram*, 1 May 1963.

14. *Al-Ahram*, 6 September 1963.

15. *Al-Ahram*, 9 January 1964. Egyptian scientists found out that the coastal area between Damietta and Port Said is rich in monazite, with a 3 percent level of concentration. They extracted 6 percent oxide thorium and 45 percent oxide uranium from the monazite (*Al-Ahram*, 13 January 1965).

16. *The New York Times*, 4 February 1966; John Cooley, "Cairo Steers Clear of A-Race," *Christian Science Monitor*, 19 June 1969.

17. *Al-Haya'a* (Beirut), 13 June 1965.

18. Mohamed Heikal, *The Cairo Documents* (New York: Doubleday, 1973), p. 313.

19. K.W.A. Effat et al., "Projected Role of Nuclear Power in Egypt and Problems Encountered in Implementing the First Nuclear Power Plant," in *Nuclear Power and Its Fuel Cycle*, 8 vols. Proceedings of an international conference held in Salzburg on 2-13 May 1977 (Vienna: International Atomic Energy Agency, 1977), 6:148.

20. Ibid., p. 149.

21. Mohammad Heikal, "The Bomb," *Al-Ahram*, 23 November 1973.

22. From an address given by the deputy prime minister for production and electricity at the Second Conference of Nuclear Energy held in Cairo (see *Al-Ahram*, 23 April 1978).

23. Effat et al., "Projected Role of Nuclear Power," p. 151.
24. *Washington Post*, 12 July 1974.
25. *Al-Ahram*, 3 October 1974; *The New York Times*, 2 July 1974.
26. *Al-Ahram*, 14 November 1974.
27. *Al-Ahram*, 8 August 1975.
28. When Egypt decided to ratify the NPT in 1981, the decision was justified by the editor-in-chief of *Al-Ahram* as one that "will reinforce the nuclear option for Egypt in the future." He argued that, by ratifying the NPT, Egypt would receive a variety of nuclear technology and that Egypt could always withdraw from the treaty if a credible Israeli threat emerged: See Ibrahim Nafie, "Egypt's Nuclear Option and the Ratification of the NPT," *Al-Ahram*, 20 February 1981.
29. Egypt's decision to approach France in particular was motivated by two major factors: (1) The governmental control of the French nuclear industry. The Egyptian minister of electricity argued that such control makes dealing with the government of France safer than dealing with private companies. (2) The sophistication of the French nuclear technology. The minister also asserted that the United States and France may possess the most advanced nuclear technology, followed by Canada and the Federal Republic of Germany. See interviews with Minister Maher Abaza in *Al-Ahram*, 22 February 1981 and *Akher Sa'a* (Cairo), 1 April 1981.
30. Adel Hammouda, "Egypt's Nuclear Bomb," *Rose Al-Youssef* (Cairo), 2 March 1981, pp. 24-26.
31. From an address given by Deputy Prime Minister Kamal Ali at the Shura Council. See *Al-Gomhouria*, 8 February 1981, and Nafie, "Egypt's Nuclear Option."
32. The decision to ratify the NPT was met by overwhelming opposition in Egypt. The Socialist Labor Party led the opposition. The leader of the party argued during the parliamentary debate that Egypt had no urgent need for nuclear energy. He added that Egypt should ratify the NPT only if Israel did. The foreign minister replied that Israel had already accepted an Egyptian-sponsored resolution during the thirty-fifth session of the General Assembly of the United Nations, which declared the Middle East an area free from nuclear weapons. He added that Egypt could always withdraw from the NPT if a credible threat to its national security emerged. See *Al-Ahram*, 17 February 1981.
33. From a statement made by Minister of Electricity Maher Abaza. See *Rose Al-Youssef*, 2 July 1981, p. 20.
34. *Al-Ahram*, 29 March 1981 and 3 July 1981.
35. *Al-Ahram*, 2 April 1981.
36. From an interview with the minister of electricity in *Akher Sa'a*, 1 April 1981.
37. From an interview with the minister of electricity in *Al-Ahram Al-Iktisadi* (Cairo), 2 March 1981.

38. The council held its first meeting in September 1975 under the chairmanship of President Sadat. At this meeting, it was decided to build the first nuclear power plant in Sidi-Kreir. See *Al-Ahram*, 18 September 1975.
39. The corporation was, in fact, an extension of the Higher Commission for the Supervision of Electricity Generating Nuclear Power Plants.
40. *Al-Ahram*, 7 July 1979.
41. *Al-Ahram*, 18 June 1979.
42. In 1956, there was, however, a public appeal by Professors Nouh and Hazzah (of the Faculties of Science of Cairo and Ain Sahms Universities, respectively) to establish a nuclear power reactor to generate electricity. The appeal failed to trigger a public debate. See Mohammad Nouh and I. Hazzah, *Al-Taka Al-Zarrya* [Atomic energy] (Cairo: Dar Al-Fikr Al-Arabi, 1956), pp. 89-90.
43. Some of critics of the program went as far as calling for a referendum on the nuclear program. "The Debates of the Shura Council on the Ratification of the NPT," *Al-Gomhouria*, 8 February 1981.
44. For a review of these arguments, see Ali Nassar, *Badael Mustakbal Al-Taka fi Misr* [Alternatives for the future of energy in Egypt], Monograph no. 9 of EDCAS Project (Cairo: Jihaz Tanzim Al-Osra wal Sukkan); Ragia Abdeen, "Basic Features of the Evolution of the Energy Sectors in Egypt until the Year 2000" (proceedings of the Annual Scientific Conference of Egyptian Economists, March 1980).
45. Professor Ali Fahmi Al-Saidi, the deputy chairman of the NPC, and Minister Abaza as quoted in *Al-Akhbar*, 19 February 1981 and 25 April 1981, and former Minister Sabry as quoted in *Al-Ahram*, 10 October 1979 and 15 January 1980.
46. Professor Fawzy Hammad, the chairman of the Nuclear Physics Department of the AEC, as quoted in Ibtihal Ghaith and M. Afifi, "Sidi-Kreir, The Beginning of Nuclear Energy," *October* (Cairo), 11 June 1978, p. 36.
47. Minister Abaza as quoted in *Al-Akhbar*, 19 February 1981.
48. "Al-Shaab Continues the Dialogue over Nuclear Reactors," *Al-Shaab*, 7 April 1981, p. 15; Ni'maat Fouad, "Today, We Warn about Nuclear Reactors," *Al-Shaab*, 16 June 1981, p. 12; and Professor Abdel-Rassourl of the University of Assuit as cited in *Al-Shaab*, 14 April 1981.
49. This criticism was made in a public lecture given by Professor Ashraf Bayoumi, who specializes in nuclear engineering. See "Al-Shaab Continues the Dialogue," *Al-Shaab*.
50. K. El-Hadidy, "Alexandria is Threatened by Nuclear Radiation," *Al-Shaab*, 12 May 1981, p. 6.
51. Quoted in Essam Allam, "Atomic Energy is a Must for Egypt," *Al-Ahram*, 20 May 1980.
52. From an interview with Maher Abaza in *Al-Akhbar*, 19 February 1981.

53. Hamed Rabie and N. Fouad, *Misr Tadkhul Asr Al-Nifayat Al-Zarrya* [Egypt enters the age of nuclear waste] (Cairo: Dar Al-Fkir Al-Arabi, 1979), pp. 74-80.

54. Ali Fahmi Al-Saidi, "On Radiatory Waste of the Nuclear Plants," *Risalat Al-Younesco* (Cairo), no. 223 (1980).

55. Interviews with Maher Abaza in *Al-Akhbar, Al-Ahram*, and *Rose El-Youssef*.

56. For a full review of these arguments, see "The Alexandria Nuclear Reactor Before the State Council," *Al-Shaab*, 5 May 1981.

57. From a statement by the minister in *Al-Ahram*, 7 July 1979; see also Wagdy Riad, "The Meaning of the Nuclear Plant in Sidi-Kreir," *Al-Ahram*, 15 October 1975.

58. This argument was articulated by Ashraf Al-Nadouri, professor of law at the University of Alexandria, and Professor Abdel Rassoul in *Al-Shaab*, 7 April 1981 and 14 April 1981.

59. Professor Ashraf Bayoumi, as quoted in Hatem Farid, "Nuclear Energy and the Prospects of the Future," *October*, 19 July 1981, p. 14.

60. Ahmad El-Khawage, the then head of the Egyptian Bar Association, in the general congress of the Labor Socialist Party. See *Al-Shaab*, 16 June 1981, p. 4.

61. *Al-Iktisadi*, 15 June 1981, p. 11.

62. For a full review of Egypt's scientific capability, see Adnan Mustafa, "The Reality of Arab Nuclear Capability," *Al-Mustakbal Al-Arabi*, September 1979, pp. 7-28; Antoine Zahlan, *Al-Elm wal Siyasa Al-Elmiya fi Al-Watan Al-Arabi* [Science and scientific policy in the Arab world] (Beirut: Centre for Arab Unity Studies, 1980), pp. 228-229.

63. From a statement made by the minister of electricity; see *Al-Ahram*, 25 April 1981.

64. Zahlan, *Al-Elm wal Siyasa Al-Elmiya fi Al-Wtan Al-Arabi*, pp. 116-117.

65. Abdel-Gawad Sayed, "The Reality of the Arab Nuclear Capability," *Al-Mustakbal Al-Arabi*, January 1980, p. 162 (author's translation).

66. From statements made by Professor El-Shazly in *Akher Sa'a*, 1 April 1981, and in "The Truth About Uranium in Egypt," *Al-Akhbar*, 4 July 1981.

67. These views were articulated by Professors Mamdouh Hassan and Ahmad Hashad of the NMC. See Mamdouh Hassan, "A Nuclear Puzzle: Why Did India Progress and Egypt Retrogress?" *Al-Iktisadi*, 18 May 1981; "Fact and Fiction About Egypt's Uranium," *Al-Iktisadi*, 16 March 1981; and "What Is Happening in the Nuclear Materials Corporation?" *Al-Iktisadi*, 9 February 1981. See also Ahmad Hashad, "The Truth About Egypt's Nuclear Prospects," *Al-Iktisadi*, 26 January 1981, and "Inquiries About Uranium in Egypt," *Al-Iktisadi*, 9 March 1981.

68. Ahmad Hashad, "The Truth About Egypt's Nuclear Prospects," *Al-Iktisadi*, 23 February 1981, and Mamdouh Hassan, "The Nuclear Fuel from Egyptian Sources," *Al-Iktisadi*, 26 January 1981.