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CENTRALIZATION, TECHNICIZATION AND DEVELOPMENT ON THE SEMI-PERIPHERY

A Study of South Korea's Commitment to Nuclear Power

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Nuclear power has been promoted as a limitless energy resource for all, but especially for the resource-poor countries of the periphery and semi-periphery. Recently, the promotional message has been elaborated to define developing countries as a new market for the moribund nuclear power industry of technically advanced countries. The rapidly industrializing countries of the Pacific Rim, especially Taiwan and South Korea(1) have been a primary target for Western technology and currently represent some of the most intensive users of nuclear power technology in the world. An architect of the U.S. nuclear industry, Alvin M. Weinberg had earlier emphasized the promise of "cheap, inexhaustible" nuclear energy to eliminate world poverty and to free nations of their historic dependence on scarce raw materials (Weinberg, 1971, p. 416).

> The amount of [nuclear] energy ... is truly enormous: enough to last mankind on any reasonable energy budget for many millions of years! Thus the development of the breeder would provide man with ... reasonably cheap energy, essentially forever. What emerges is the outline of an autarkic world ... in which the primary energy source, based on the breeder reactor ... is available to all countries, not only to countries that possess indigenous fossil fuel, or are rich enough to import such fuel from others.

To reap the benefit of nuclear power, Weinberg recognized that social institutions would have to be restructured to support the development of nuclear energy and its associated technologies (1972, pp. 33-34):

> We nuclear people have made a Faustian bargain with society. On the one hand, we offer -- in the catalystic nuclear burner -- an inexhaustible source of energy ... But the price that we demand of society for this magical energy source is both a vigilance and a longevity of our social institutions ... [W]e have established a military priesthood which guards against inadvertent use of nuclear weapons .. [P]eaceful nuclear energy probably will make demands of the same sort on our society, and possibly of even longer duration ... [T]he knowledge and care that goes into the proper building and operation of nuclear power plants and their subsystems is something that we are committed to forever, so long as we find no other practical energy source of infinite extent.

While a large body of research has developed on the social implications of the use of nuclear power, most of this work has focused on Western programs and policies. Little analysis has been done on the nuclear aspiration of the developing countries. Research on these countries' political and social interests in nuclear power should not be neglected any longer. This paper attempts to explain and critique South Korea's affection for nuclear power. After a brief overview of South Korean nuclear policy, the evolution of this technology's development and use within a highly centralized, technocratic social system is documented. Attention is given to the role of an ideology of progress and the state-directed cooperation of South Korean universities and corporations in fostering energy autonomy through rapid development of nuclear power. In the concluding section of the paper, the social

consequences of what is characterized as the nuclearization of the power complex are discussed. Growing social opposition to nuclear power is traced to the centralist and technocratic underpinnings of the social structure supporting the development and use of this technology.

I. Overview

Since the Korean War (1950-1953), South Korea has envisioned nuclear power as a way to escape from poverty as well as to preempt the military threat from North Korea. An institutional complex was organized in South Korea consisting of an ensemble of technical and military specialists functioning within a technocratic stable social environment to meet the social and political challenges of the atomic adventure. Nuclear power was and is seen as virtually the only significant energy choice in the long run by the government, science and utility complex. Indeed, a recent report issued by many of the country's leading scientists has proposed the construction of 50 more nuclear power plants for the year 2031(KEPCO, 1989).

After the Korean War, South Korea underwent a period of rapid urbanization and industrialization. To meet the energy needs of its growing economy, South Korea created a large-scale, highly centralized system of energy production. A single public utility, the Korea Electric Power Corporation (KEPCO)(2) was organized and given responsibility for the construction of power plants, the generation and distribution of electricity, as well as the planning and finance for future energy needs. Private sector *chaebols*(3) were enlisted to assist in the goal of building a South Korean energy system during the 1960s and 1970s.

Several *chaebols* were able to build engineering and heavy industry companies into their conglomerate structures as a result of their power generation involvements. These conglomerates in turn became the principal sources of work for medium and small scale firms, which over time, have become hierarchically attached to the *chaebols* as suppliers of power plant equipment. Since the 1970s, the state, KEPCO and South Korean conglomerates have been able to set in place a firm technological and social base for the continued centralization of the energy-related sectors of the national economy.

Through the combined efforts of these private and public institutions, South Korea achieved rapid technicization in the energy sector. Initially dependent upon foreign capital and technology, the country pursued a strategy of technology transfer with regard to power plant design, constrution, engineering and management, which was quickly indigenized. Ambitious national plans called for full-scale development of an electricity system, including rapid increases in installed generation capacity, the scale of power generation, the unit size of power turbines, and in the efficiency of power generation and distribution, as well as the expansion of the transmission and distribution network.(4) As unit sizes of power plants increased and facilities were clustered at aggregate sites detached from the load centers they serve, electric choices were effectively isolated from the public arena. The alliance of the state, KEPCO and private *chaebols* for all intents and purposes removed economic and political decisions concerning the electricity system from effective community influence. Local communities became dependent on mega-organizations and their decisions, completely preempting community planning of the energy system. Analysts of Western electricity systems have characterized this phenomenon as the institutionalization of "centralized power" (Messing, et al., 1979). In this characterization, electricity functions not only as a technological but political influence on society. The South Korean situation parallels in many ways this pattern, but has the added dimension of the electricity system serving also as a structural force in the organization and development of a technocratic and corporate elite. In this paper, the latter dimension is termed as "technicization," and the two phenomena of centralization and technicization acting together are represented by the concept of "centralized technicization."

The evolution of a highly centralized and technicized power complex built up over four decades prepared South Korea for an extensive nuclear programme involving power reactors, research reactors and nuclear fuel cycle facilities. With its pursuit of nuclear power, South Korea took advantage of the centralized energy system already in place and added military control and secrecy in the electric network. The monopolistic arrangement of nuclear power plant construction and equipment manufacture was rationalized as necessary for the reduction of national dependence on imported oil, the basis for continuous economic and technological development, and the preservation of South Korea's competitive position in the global economy. Technological and economic centralism, aided by the institutional apparatus, is now so pervasive that it represents a determinist force in contemporary energy and development policy.

II. The Evolution of Centralization and Technicization

The electricity network in South Korea has evolved through three development phases. The first phase, covering the period from the 1930s to the 1950s, was a formative stage. Foreign technology and capital were used to construct electric plants for the immediate supply of electricity and contributed to the formation of a corps of domestic engineers and technicians. The second phase (1960s and 1970s) focused on building an electric network and indigenizing the technology. Engineering and technical experiences, especially in hydro-, coal- and oil-fired electric power technology were incorporated into the state utility, industry and research centers. Both the first and second stages of development were a period of institutional preparations for the introduction of nuclear power into the South Korean energy system. In the 1970s, the country entered its nuclear era, in which centralized power and foreign companies collaborated in the construction of nuclear power plants. These three phases of electricity development are described below.

1. Technology Formation: 1930-1960

Electricity was first generated on the Korean peninsula in the late 19th century. However, an electricity system did not significantly evolve until the 1930s. Seeking expansion of its markets, security in its energy supplies, and a military base from which to invade China, the Japanese government and capitalists revised their policies toward colonial *Choson*.(5) No longer content to exploit Korea merely as an agricultural supplier, Japan turned its efforts toward creating a semi-industrial, military production center. Cheap and abundant supplies of electricity were essential to power the new military-industrial complex. "The Master Plan for Electricity in *Choson*" was drawn up by the colonial government in 1931, which specified the location and capacity of each power plant to be built in the river basin; the transmission networks by region to be laid out; and the regional reorganization of companies to operate and manage this electrical network (Kobayasi, 1985, pp. 481-482).

The reorganization and expansion of the electricity network dictated by the master plan significantly shaped the structure of later industry. While electricity generation capacity was rapidly increased, the number of electric companies involved in the generation, transmission and distribution was rather decreased. Small and medium sized enterprises were replaced by monopolistic capital. The transmission system was turned over to two companies -- *Choson* Transmission Company and *Choson* Electricity Company -- and the distribution system which was originally managed by 60 companies, was reduced to only four.(6) Japan's establishment of a concentrated electric system in terms of control and geographical distribution was aimed at serving an equally concentrated industrial structure. Most hydroelectricity was generated in the North where concomitant electric-chemical heavy industries for the military purpose were extremely concentrated.(7) Centralization for the purpose of military and colonial control was a dominant characteristic of electrification during the colonial period.

At liberation in 1945, Korea depended heavily upon hydroelectric systems located in the north to power its industry and urban residential sector. But liberation was almost instantly followed by national partition as the U.S. military forces entered the South, and Soviet troops occupied the North. The peninsula was divided at the 38th parallel, creating two Koreas. Disruption of hydroelectric power by the North in 1948 exposed the South's vulnerability and led to the rapid construction of hydroelectric power stations in the South, as well as coal-fired plants.(8) Faced with the immediate need to compensate for the loss of electricity from the North, South Korea embarked on a plan to construct power plants on a turnkey basis with the aid of foreign finance and engineering companies. Imports from the U.S. provided the technology and capital necessary to create a network of electric power for the industrial development of South Korea.

2. Building an Electricity Network: 1961-1976

In the 1960s, the national regime turned its attention toward the establishment of an indigenous power technology base as a part of the country's overall industrial development strategy. To accomplish this, the state sought the aid of domestic industry in restructuring the country's utility operations.

A single-utility electric system was created in 1961 by merging three existing utilities into one public corporation, KEPCO, under the control of the central government.(9) KEPCO was given responsibility for preparing electricity development plans, building and operating the national power system, and establishing and implementing a technology transfer program in electric power.(10) As a result of its mandate, KEPCO engaged in project management and developed power

plant technology through the operation of training programs for its engineers and technicians. Its personnel participated in new power plant projects built by foreign companies as well. KEPCO promoted the use of composite teams consisting of its own staffs and the staffs from participating *chaebols*. Further, KEPCO staffs and engineers were mobilized to inspect power plant equipment for quality assurance and to give advice on technology design and development. A core of engineers, technicians, and project and site managers were mobilized through KEPCO's efforts and its members were later recruited by *chaebols* where they played a key role in the development of power plant companies in the country. In this respect, KEPCO served as a "seed-bed" for the technical and management training of power engineers who were later spread throughout the society as a whole (Lee and Sharan, 1985).(11)

With the aid of the government-sponsored Korea Society for the Advancement of Machinery Industry (KOSAMI), KEPCO was able to control the selection of transferable items and eligible domestic firms into the electric power market, and oversaw inspection and testing of domestically produced equipment. Domestic firms were selected to produce indigenous goods and were usually financed by banks controlled by the central government. In this way, the state laid the groundwork for the development of indigenous technical capacity in energy production. To accomplish indigenization, the government intentionally relied upon large domestic conglomerates to replace foreign suppliers in plant construction and equipment supply to concentrate technology transfer.(12)

The case of the Inchon thermal power plant complex which involved two 250 MW generators, ordered by KEPCO and built in partnership with Mitsui (Japan) in 1970-1974, provides a good example of how *chaebols* organized the transfer of power plant technology. Hyundai Construction Company was given responsibility for the construction of the plants. A team of engineers from Hyundai's construction and shipbuilding companies and from KEPCO designed and managed all activities from the beginning stage of the project. In the same way Daewoo oversaw the Ulsan thermal power plant work (3 units of 400 MW).

The partnership model was routinely used to foster indigenization, with Hyundai and Daewoo singled out by the government to organize engineering companies. These two *chaebols* played major roles in the state's efforts to create domestic manufacture of power plant technology. They have provided technical services to nearly all of the power plant projects in South Korea and acquired knowledge about new power plant techniques through technical collaboration agreements with foreign companies. These agreements facilitated the supply of basic design documentation, technical information, the dispatching of foreign engineers to both companies, and the training of their personnel.(13) With a government policy in 1976 outlawing turnkey power plant projects from foreign companies, South Korean *chaebols* were handed a protected technology market. "Local content ratios" for various types of power plant were used to force the employment of domestic equipment and engineering.(14)

The supply of auxiliary equipment for power plants such as wire and transmitters was also assigned to other large-scale domestic firms such as Hyosung Heavy Industries, Gold Star Instrument and Electric Co., Sinhan Electric, Hyundai Electrical Engineering Co., Ltd., Daemyung Heavy Electric Co. and Leechun Electric Manufacturing Co. Government and foreign collaboration agreements were again used as an important means of technology transfer. The national government played a key organizing role by selecting and partially financing certain *chaebols* for this work. The involved *chaebols* were able to use this production work as a technological learning opportunity. According to one study (Lee and Sharan, 1985), auxiliary equipment requirements of power plants served as an important inducement for the technological build-up efforts of South Korean companies, particularly with respect to quality assurance. Power plant orders accounted for as much as 30% of company sales of auxiliary equipment makers, the engineering and production complexity associated with this equipment demanded relatively high performance and accuracy standards. Through their work in the power plant field, these companies learned and incorporated sophisticated technical capacities into their organizations, that soon spread to other areas of company operations.

As a result of this experience and close interaction with overseas contractors, *chaebols* gradually became independent power plant engineering and equipment companies. Their engineering, construction and manufacturing companies and subsidiaries expanded into the international market, filling export orders for turnkey power stations and other industrial plants in countries such as Saudi Arabia, the Libyan Arab Jamahiriya and Malaysia. By the end of 1981, Hundai and Daewoo accounted for more than 95 percent of the country's plant exports (Westphal, et al., 1984, p. 32).

By the close of the 1970s, South Korea had achieved an "energy regime" (Winner, 1982) characterized by "centralized technicization." The close collaboration of the state, private conglomerates and science had created a sophisticated technical capacity for designing and producing technology. Through learning in collaborative production settings, the state and domestic conglomerates were able to acquire the necessary expertise and knowledge to become independent producers. In this process, public and private organizations such as KEPCO, Hyundai and Daewoo were able to install a highly centralized and technicized system of production. Centralized technicization had transformed not only the electricity system but the very meaning of the social need for energy. Henceforth, "social need" would be a technical matter best decided by government planners, corporate managers and engineers.

While these institutions indigenized a considerable amount of power plant engineering, consultant and management capability, the importance of their efforts lay in the influence on the entire structure of South Korean economic development. A stamp of centralization and technicization was left not only on the electricity regime but on the wider economy as well. With the help of KEPCO and KOSAMI, state designation of large enterprises such as Hyundai and Daewoo as the only "eligible" participants in power plant construction and equipment manufacture, enabled these firms to have preferential access to a variety of promotional schemes such as special credits, investment support, R&D subsidies, technical manpower allocation, and established their monopolistic or oligopolistic position in these markets. A direct consequence of this development pattern was the narrowing of energy and development choices to those which were dependent upon large-scale, capital-intensive technological organizations. The technological reality of energy and industrial production had overtaken the social reality of community life. The arrival of nuclear power in South Korea was a logical outgrowth of the system of centralized technicization.

III. Nuclearization of the Power Complex

The evolution of a centralized energy sector prepared South Korean society for extensive technological development, but it is with the arrival of nuclear technology that an integrated institutional, ideological and political structure appears. The South Korean nuclear project has provided the practical setting in which a technocratic order could be designed and realized. The formation of the nuclear technocracy and network was based on three factors: the forging of an institutional alliance among the state, the military, the *chaebol* sector and domestic science; the spread of an ideology of economic necessity and national security; and the establishment of a client relation between South Korea and the U.S.

1. Formation of the Nuclear Technocracy and Network

President Eisenhower announced the "Atoms for Peace" programme in 1953, proposing that humanity ought to utilize the destructive power of the atom to serve the "peaceful pursuits" of mankind, and to provide "abundant electrical energy" (Hilgartner et al., 1983, pp. 41-42). This message appealed to developing countries seeking a level of technological and electricity independence, as well as to technically developed countries whose military-based nuclear "technostructures" were searching for a peaceful nuclear mission and a market for their inventions (Winner, 1977). However, nuclear power technology could not be exported overseas unless developing countries acquired the knowledge and appreciation of nuclear technology. It was in this global political economy of nuclear technology promotion that the U.S. and the International Atomic Energy Agency (IAEA) introduced basic nuclear information in South Korea, leading to the formation of the first corps of domestic nuclear scientists and experts in the 1950s. With the assistance of these experts, the government contracted with the General Dynamics Corporation in 1958 for the purchase of a TRIGA Mark-II(100kw) research reactor. The Korean Atomic Energy Research Institute (KAERI) was then established in 1959 for the construction and operation of the purchased research reactor.(15) KAERI mobilized the country's pool of nuclear scientists for the development of the Korean nuclear programme (Ha, 1982, pp. 221-223).

KAERI and KEPCO established the Survey Committee on Nuclear Power Generation in 1962 and "A Plan for the Promotion of Nuclear Power Generation" was drawn up which recommended and rationalized nuclear power as the most promising power source to meet the "urgent" energy needs of "rapid" economic development for the near future. The plan cited the limits of anthracite coal, the major energy source at the time, for future power needs (KEPCO, 1965, p. 334). Based on the committee's preliminary studies, South Korea established the Council on the Nuclear Power Generation Plan in 1965, with members

from KEPCO, KAERI, the Ministry of Commerce and Industry, the Ministry of Construction, the Daehan Coal Corporation, the Korea Oil Company, and representatives from universities (Kim, 1967, p. 30). After conducting a comprehensive study of energy supply technology, the Council recommended the construction of two 500 MW nuclear power plants in the 1970s. In their report, the Council stressed the urgent need to add new electricity capacity and cited nuclear's projected decreasing costs and improving reactor safety.

In 1968, South Korea went forward with the construction of two 500 MW units each to be completed in the mid-1970s. Responsibilities for the construction and operation of the plants were assigned to three governmental agencies: KEPCO for the engineering, construction and operation of the plants; KAERI for the research and development of nuclear power technology, fuel and safety controls, and the training of nuclear engineers and technicians; and the Economic Planning Board (EPB) for coordination of the South Korean nuclear power programme, negotiation of foreign loans and the preparation of feasibility studies (Ha, 1982, pp. 225-226).

With the planning of the first power plant, Kori-1,(16) South Korea aggressively pursued the development of this technology with enthusiastic American support. While the U.S. denied South Korea access to atomic bomb technology,(17) no such restriction was placed on nuclear power generation. After cancellation of the South Korea-French deal on a reprocessing pilot plant, KEPCO signed with Westinghouse and Atomic Energy of Canada, Ltd. (AECL) for two more power plants (Kori-2 and Wolsung-1) in 1977. For South Korea's fourth and fifth nuclear plants (Kori-3 and Kori-4), Westinghouse and the Export-Import Bank the U.S. government collaborated to arrange the sales to South Korea in the increasingly competitive global nuclear market.

In the *chaebol* sector, construction, engineering and equipment technology for power plants was continuously accumulated. Nuclear power projects gave rise to a *chaebol* hierarchy with attached small- and medium-companies that could easily be transformed to nuclear equipment manufacture in the late 1970s. Nuclear power plants were treated as similar to large fossil-fuel fired power plants which the *chebols* had already indigenized.

In sum, during this period (1957-1976), a domestic nuclear technocracy was formed with the assistance of foreign, especially U.S., reactor companies, and through participation in conferences and consultations with IAEA and the U.S. officials. These technocrats played essential roles in the development of a nuclear network including the establishment of university departments, engineering and heavy industries, and research centers. At the same time, engineering and equipment manufacturing technology have coincidentally accumulated by domestic power plant companies.

2. The Ideology of Economic Progress and Nuclear Autonomy

Within this institutional framework, nuclear technology was considered the most promising technology not only for powering the country's future economic development, but also for securing the nation's defense. Propelled by a desire of the people to escape the misery or poverty and war experienced throughout the colonial period and the Korean War, economic and technological development was embraced as the dominant social priority over other social values. The military dictatorship frequently sought to justify its own actions as the necessary price of economic and technological progress.

The development of sophisticated nuclear power technology was specially expected to promote economic growth and security. It was believed that a direct relationship existed between prosperity and energy consumption, with economic growth requiring ever-increasing amounts of energy. Many in the govrenment believed that nuclear power was the only source able to provide an "abundant energy machine" (Byrne and Rich, 1986) to meet the energy needs of rapid industrialization. Particularly since the two oil shocks of the 1970s, South Korea's energy security has been treated as synonymous with nuclear power because of the country's previous dependence on imported oil for electricity generation.

White smoke billowing from a reactor stack was widely recognized in South Korea in the 1970s as a symbol of scientific and economic progress. Poneman has captured developing countries' ambition toward nuclear technology and the attraction of ownership of nuclear power plants:

> Large projects often appeal to developing country governments as a means to demonstrate their ability. Because of its complexity, perhaps even its mystery, the mastery of nuclear technology can instill popular pride as well as enhance the

legitimacy of a central government (Poneman, p. 123).

Nuclear power signalled the transition from underdevelopment to development in the minds of South Korean leaders. The national government expected nuclear power to help in the consolidation and extension of its authority throughout the industrial economy in the same manner that rural electrification had forced the farming populace to rely on state leadership for an essential service. In this respect, nuclear technicism was seen as a complement to the ideologies of economism and political centralism by the leadershp.

The development of nuclear weapons was likewise regarded as a progressive decision, enhancing the security of the country and protecting it from possible invasion by North Korea. The perception of constant threats from North Korea was used to rationalize policies which elevated values of national security over civil society and accelerated the militarization of the country. Military-oriented technical and indusrial development was emphasized and nuclear technology offered a perfect fit promising both the achievement of economic development and the means for military security and autonomy.

From the time that South Korea joined the IAEA in 1957, the government has been interested in developing nuclear weapons technology. Two events -- the fall of South Vietnam in 1975 and President Carter's proposal in 1977 to withdraw American troops from the peninsula -- spurred South Korea to begin a "Manhattan" project of its own as both a deterrent against invasion by North Korea, and as a "bargaining chip" in negotiations over the withdrawal of U.S. forces from South Korea.

According to Ha, aside from the problem of securing fissionable material, South Korea would have had little difficulty in mobilizing enough engineers and experts as well as equipment and for making atomic bombs (Ha, 1978, pp. 1139,1141). But, because of the lack of sophisticated fuel-cycle technology, and the high cost associated with the production and fabrication of enriched uranium, the government sought to produce plutonium (Pu, p. 239) by constructing a reprocessing plant in partnership with France. The project was cancelled in 1976 when the U.S. threatened to withhold export licenses and credits necessary to acquire American reactors, and finally threated to terminate U.S. military supplies. (Ha, 1982, p. 237). Despite this decision, however, research and development on nuclear fuel-cycle technology remianed a top priority project of the military government throughout the 1970s. The government recognized that the successful implementation of its ambitious nuclear power program and the future possibility of weapons development depended on a stable domstic supply of nuclear fuel. The Korea Nuclear Fuel Development Institute (KNFDI) was established in 1976 and later merged with KAERI, to promote the development of nuclear fuel-cycle technology. The KNFDI completed a fuel-fabrication pilot plant (10 ton/year) and has developed pilot plants for uranium refining and conversion with financial and technical help from France. Another approach to obtain fissionable material was the construction of a Candu reactor (the Wolsung unit) which began in 1977 and operated in 1983. The low fissile waste from other light water reactors can be recycled in Candu reactors, thereby making reprocessing and plutonium separation unncessary. Furthermore, Candu reactors are themselves well suited to the production of weapon-grade plutonium, presenting a greater possibility of domestic production of nuclear arms (Duderstadt and Kikuchi, 1979, p. 144).

After several experiences with U.S. intervention in its nuclear plans, South Korea attempted to diversify the source of its nuclear reactors and equipment as well as the supply of its nuclear fuel. Thus, South Korea continued its interest in Framatome as a source of technical assistance and fuel supply (including the development of its seventh and eight plants), but was faced again with the U.S. pressure. After president Carter's visit to South Korea in 1979, the country selected Westinghouse as the prime contractor for the seventh and eight plants. The country was forced to accept its status as a client state of the U.S. and bow to restrictions on nuclear development, placing nuclear policy even further beyond the influence of South Korean civil society.

It was in this political and economic climate that increasing demand for self-sufficiency in civilian nuclear power technology arose. The government encouraged *chaebols* like Hyundai and Daewoo Engineering to become involved in the nuclear project. In addition, Korea Power Engineering Company (KOPEC), a KEPCO subsidiary, was established in 1976 to specialize in nuclear engineering services. These efforts reflected the country's single-minded dedication to economic growth through the development of large-scale, centralized technology. Nuclear power epitomized South Korea's belief in economism, centralism and technicism.

3. Institutional Alliance of the State, *Chaebols* and Science

Once the nuclear technocratic and institutional network was formed in the 1970s, a deliberate plan was made to transfer nuclear technology, as had been done in the case of fossil-fuel power plants. The establishment of KOPEC completed the institutional alliance between a public utility (KEPCO), the state (MOST and MOER), science centers (KAERI) and selected conglomerates (Hyundai, Daewoo). KEPCO was given sole responsibility for the construction and operation of all nuclear power plants and it used its monopoly status to force inclusion in collaboration agreements with foreign vendors such things as the sale of design documents, the participation of domestic firms in the production of specific equipment, and foreign technical assistance or training of South Korean engineers and workers. Central services such as project management, design and construction engineering were identified with specific foreign companies by KEPCO and then on-the-job training overseas was arranged. Foreign engineering companies such as Westinghouse, Bechtel and Framatome agreed to provide not only the basic technical documentation and information but also offered personnel training at home facilities. For example, the collaboration agreements with Westinghouse for nuclear power projects Nos. 10 and 11 called for training of KOPEC engineers in project management, engineering design and the operation of safety systems. KEPCO designated KOPEC as the prime architect-engineerng contractor for these works which in effect served to promote and concentrate domestic capacity in nuclear power enginereing. KOPEC conducted feasibility studies, engaged in nuclear power planning and engineering, and provided basic training of technical personnel for all units from 1976. Principally through the mechanism of collaboration agreements, KOPEC has sought to lower learning costs and shorten learning times. While South Korea still depends on foreign contractors and consultancy firms in the areas of design, safety and system engineering, these areas too will soon be indigenized.(18)

Domestic scientific and technical support to KOPEC has continuously come from KAERI.(19) This institute undertook research and development on fuel technology, reactor technology and safety aspects of nuclear power plants. KAERI's Nuclear Safety Centre (NSC) provides support to the government in the area of regulation and licensing and prepares safety analysis reports from inspections of nuclear power plants. NSC is also charged with setting nuclear safety standards. In addition to KAERI, the Korea Institute of Science and Technology (KIST), the Korean Advnced Institute of Science (KAIS), and four university departments of nuclear engineering, the Defense Development Agency and the Korea Nuclear Development Corporation support the nuclearization effort.

Chaebols, particularly Hyundai, Daewoo and Samsung, estabslihed heavy industiral companies from their engineering or construction companies in order to participate in the nuclear campaign. But the national government decided in 1978 that the government owned Korean Heavy Industry Company (KHIC) (which was formed by government buyout of Hyundai International and Daewoo Heavy Industries) would have an exclusive monopoly on nuclear construction. KHIC monopolized all nuclear engineering andequipment production, forcing *chaebols* to move to the international nuclear market.(20) Recently, though, the *chaebol* sector has been pressuring the government to reopen the domestic nuclear market. Hyundai and Samsung are presently competing to take over KHIC, and thereby add domestic projects to their export business in nuclear construction. The exclusion of domestic firms from home market power plant orders in the nuclear area initially hurt their ability to acquire expertise in systems engineering and plant design.(21) As a result, domestic firms accelerated their efforts to enter the export market and diversified into other energy technology fields.(22)

The impact of these forces is easily illustrated by the quantitative importance of nuclear technology in the power complex. As of February 1990, the total installed net capacity of nine nuclear power plants was 7,616 MW, contributing 53.1% of the total electricity generated in the country. Five more nuclear power plants of about 1,000 MW each are scheduled for operation in the 1990s. Through the end of this century, 70 percent of new capacity in South Korea will be nuclear, if state plans are followed; over 75 percent of new capital investment in electricity will likewise be nuclear. Soaring electricity demand (increasing at an average of 11 percent per year in the 1980s) and the absence of significant domestic energy reserves ensure that the pressure for expansion of nuclear power will continue.

IV. Conclusion

The development stages of the electricity system in South Korea, including the nuclearization stage, parallel the pattern of national industrial development. Relying initially on foreign capital and knowledge, the South

Korean state and *chaebols* organized a highly cnetralized, technicized industrial order. Adopting an authoritarian planning structure, these same institutions were able to then indigenize technology development and direct the economy along a corporate path of "centralized technicization." In the South Korean experience, public and private conglomerates provided the capital, as well as the engineers and technicians, to secure a monopolistic position in industrial production generally, and in electricity production in particular. Essential to the centralized technicization process has been the strong military state.

The prevailing view of South Korea as a model of successful industrial development in which a "backward" agrarian political economy was transformed into a "modern" capitalist one within four decades disregards most of the realities of this development. Left out of this image is the authoritarian and monopolistic character of centralized technicization. Centralized technicization eliminated competing medium and small power systems and greatly reduced the economic power of the merchant economy. Development by conglomerate groups was essentially dictated by their monopoly of core technology, engineers, capital and experience. Industrialization via these centralized institutions made nuclear power a logical and technical necessity.

At the same time, South Korea's reliance on nuclear technology ineluctably drew it into superpower politics. As South Korea increased efforts to indigenize nuclear technologies and diversify fuel sources, the country was confronted with superpower efforts to restrict its development of this sensitive technology, as shown by the reaction of the U.S. to South Korea's plan to diversify into French nuclear technology in the mid-1970s.

The nuclearization of the South Korean power complex has inspired a nascent anti-nuclear movement. Linked to the democratic movement, anti-nuclear protests are creating, for the first time, a political challenge to centralized technicization. The requirements of the mega-electric nuclear system are in direct conflict with the deep-rooted values of Korean culture and traditions, and with the growing demands by the people for political and economic decentralization.

Notes

(1) Throughout the paper, South Korea is used to refer to the Republic of Korea, North Korea to the People's Democratic Republic of Korea, and Korea to both regimes.

(2) KEPCO (Korea Electric Power Corporation) generates and distributes most of the country's electricity, and the size of its budget is three times as large as Seoul city's budget and equal to one-third of South Korea's national government budget. More than 16 percent of the nation's total debt is traceable to KEPCO, especially nuclear power projects.

(3) This Korean term denotes family-owned conglomerates networking a range of different companies. Hyundai, Samsung, Daewoo, Sunkyong, Goldstar and Ssangyong are representative *chaebols* which are highly rank among the largest companies in the world. (see Fortune, July 1989). As discussed below, several *chaebols* have been active in the development of nuclear power.

(4) The installed capacity for electricity generation increased from 367 MW in 1961 to 20,997 MW by February 1990, a 57 fold increase. The past build-up took place mostly through the construction of thermal steam power plants and internal combustion plants. Recently, the share of nuclear power is sharply increasing.

(5) *Choson* was the name of the ruling old dynasty in the Korean peninsula from 1392 to 1910. *Choson* was colonized by Japan in 1910.

(6) For detailed information on the concentration of the electric industry and capital, see Kobayasi, pp. 481-482.

(7) As of 1944, the total hydroelectric power was 5,863 MW, of which 85.8 percent was located in the North. In the South, representative thermal plants which used coal or oil included a facility near Seoul, with a capacity of 22 MWh, one at Pusan with a capacity of 14 MWh and a large generator in the coal fields at Yongwol, with a capacity of 107 MWh (McCune, 1956, pp. 223-224).

(8) In 1953, power supply in the South reached 736 MWh of which 394 MWh were from hydroelectric plants, 131 MWh from thermal plants and 211 MWh from power barges (McCune, 1956, p. 224).

(9) KEPCO was placed under the general supervision of the Ministry of Energy and Resources (MOER) and the Economic Planning Board (EPB); the Ministry of Finance (MOF) oversees the financial

programmes; and the Ministry of Science and Technology (MOST) regulates and licenses KEPCO's nuclear power plants.

(10) Both the Kyongin Energy Company (KEC) and the Industrial Sites and Water Resources Development Corporation (ISWRDC) which respectively have installed generation capacity of 325 MW and of 811 MW, sell their entire output to KEPCO (KEPCO, Financial Statistics, 1989).

(11) Hyundai and Daewoo Engineering had 30 and 10 former KEPCO engineers respectively, as the core staff of their power engineering teams in the mid-1970s (Lee and Sharan, 1985, p. 38).

(12) In 1964, the government decided to entrust the construction of power plants to domestic firms which encouraged some of the larger construction companies to participate in the project and to learn power plant engineering.

(13) Hyundai Engineering, for example, sent ten engineers to Brown & Root to study basic design for the Pyeongtaek project, and Daewoo Engineering had a team of seven engineers from United Engineering (USA) for the Ulsan project and sent 20 engineers from Daewoo to UE for training (Lee and Sharan, 1985, pp. 39-40).

(14) The government annually assigned a ratio of local participation in each type of power plant project.

(15) The original title of KAERI was the Atomic Energy Research Institute (AERI) when it was established as a major division of the Office of Atomic Energy (OAE) under the authority of the president. In 1973, AERI changed its name to KAERI, by incorporating the Radiological Research Institute and the Radiation Research Institute which were under OAE. For convenience, KAERI is consistently used as the name of the organization. With the establishment of MOST in 1967, OAE was reorganized into the Atomic Energy Bureau (AEB) under MOST.

(16) South Korea contracted with Westinghouse Electric International Company (WEICO) in 1970 as a prime contractor for the turnkey-based construction of the first nuclear power plant.

(17) The U.S. blocked the Export-Import Bank credit (a $79 million loan and $157 million loan guarantee) for the construction of the second nuclear power plant, until South Korea ratified the Treaty on Nonproliferation of Nuclear Weapons with IAEA in 1975 (Ha, 1982, p. 227).

(18) At the end of 1984, 60% of the materials and 70% of the planning and engineering of nuclear plant works were conducted by the country's own technology while 97% of the construction itself was conducted by domestic companies (Kim and Jeong, 1986, p. 57).

(19) There are close ties between two organizations with the president of KEPCO which owns KOPEC serving as chairman of the board of KAERI.

(20) Recently, KEPCO announced plans to hire KHIC as a prime contractor of engineering and main equipment production for subsequent nuclear plant works (nos. 12 and 13).

(21) Under current national energy policy, KOPEC has a monopoly over all the domestic power plants, including those in the thermal and hydro-power field. In the domestic nuclear power plant field, KOPEC and KAERI (the Korea Atomic Energy Research Institute) have monnpolized personnel training, rector technology and safety inspection of nuclear power plants.

(22) KHIC has a long-term training collaboration agreement with Combustion Engineering (USA) for boiler design technology, and seeks similar arrangements with foreign manufacturers of turbines and generators. Hyundai Heavy Industrial Co. is also accelerating the buildup of design capacity through expanded overseas training programmes for its design engineers.

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