DRAFT

The Republic of Korea

Nuclear Power Plant Program

Nuclear Annex
to the
Report of

The Korean/U.S. Joint Energy Assessment

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1980

INTRODUCTION

The Republic of Korea's nuclear power plant program began with the creation of the Office of Atomic Energy in 1959. The Office was chartered to carry out research and development of nuclear energy for peaceful uses.

The foundation of the development of the Korean nuclear power plant infrastructure was created in the 1960's by cooperative efforts of the Korean Government's Office of Atomic Energy, The Korea Electric Company (KECO), and Korean industrial organizations. A Triga Mark II* research reactor began operation March 30, 1962 for training, education, research, and isotope production. The Radiation Research Institute for Agriculture (RRIA) was established in 1966. The Cancer Hospital was established in 1968. Additionally, research centers such as the In Ha Institute - Department of Nuclear Engineering, and the National Chemistry Laboratory - Isotope Laboratory began operations.

Korea's nuclear power plant program and associated infrastructure made major advances in the 1970's. The contract for Korea's first muclear power plant, Kori, - 1 was signed on June 24, 1970 with the Westinghouse Electric Company. This power plant began commercial operation in April 1978, and initiated its first refueling operation in late 1979. Korea's second research reactor, a 2 Mwt Triga Mark III**, began operation May 10, 1972. The Korean Atomic Energy Research Institute (KAERI) was established in February, 1973 incorporating existing institutes doing nuclear-related research.

*This research reactor operates at a maximum steady state thermal power level of 250 KW, producing a maximum thermal neutron flux of 10^{13} neutrons/cm^2-second. Fuel is 20w/o enriched uranium. The reactor is still in use.

**This research reactor can produce a maximum pulse (short duration) of 2,000 Mw and has a maximum thermal neutron flux of 6.5×10^{13} neutrons/cm^2-seconds. It is fueled with 70% enriched uranium, and is currently in use for training, research, and isotope production.

KAERI currently conducts a broad range of important functions in Korea's nuclear power plant program. The Office of Atomic Energy was abolished and the Atomic Energy Bureau was established within Korea's Ministry of Science and Technology (MOST) at the same time. Key milestones in the 70's included contracting for three additional PWR type nuclear power plants (which are now under construction at the Kori Nuclear Station Site), contracting for a 600 MWe CANDU type plant (which is now under construction at Wolsung) and contracting for two PWR type nuclear power plants with site preparation activities now underway at Yeong Gwang. The last four electric generating nuclear power plants committed have been PWR's with a capacity of about 950 MWe.

Additionally, 1) Korean Nuclear Engineering Services, Inc. (KNE) an architech-engineering organization was established in October, 1976; 2) the Korean Nuclear Fuel Development Institute (KNFDI) was established in December 1976; 3) Korean industry has rapidly developed and entered into licencing agreements with several U.S. nuclear manufacturing companies. For example, Korean industry has entered into licencing arrangements with Westinghouse, Combustion Engineering, Babcock and Wilcox and General Electric for construction of Nuclear Steam Supply System (NSSS) equipment, has obtained equipment for manufacture of NSSS components, and has initiated training and qualification activities preparatory to manufacture of nuclear componenets, 4) Korean industry has obtained experience and developed a nuclear power plant construction capability through work on nuclear power plant stations; 5) the Nuclear Regulatory Bureau, under MOST, was established, and is now in full operation with a trained and experience staff; KAERI also provides support to the NRB.

Considerable attention has been given to the planning and implementation of activities necessary to continue expanding Korea's nuclear power program and associated infrastructure development in the 1980s.

This description of Korea's nuclear power plant program is prepared to support the Korean/U.S. Cooperative Energy Assessment with respect to nuclear power plant construction, operation, and associated infrastructure Fuel cycle aspects (such as uranium mining and milling, fuel fabrication, spent fuel reprocessing, and waste management) are dealt with separately in the Electric Power Sector for reasons unique to this particular Country Energy Assessment.

Section 1, Nuclear Power Plant Intrastructure, describes the existing organizations, and institutional resources which support Korea's nuclear power plant program, as well as plans for expansion of Korea's nuclear power plant infrastructure, describing Korea's on-going efforts and plans to develop the necessary manpower, to support nuclear power plant programs and to expand Korea's domestic capability to manufacture nuclear power plant components, and to construct nuclear power plants.

Section 2, Economics, provide information on the economic aspects of Korea's nuclear power program.

Section 3, Observations, provide comments and observations resulting from this assessment of Korea's nuclear power program.

Section 1: Nuclear Power Plant Program Infrastructure

Section 1.1 Infrastructure Overview

Korea's nuclear power plant program involves several Ministries. The Ministry of Science and Technology (MOST) is the responsible government organization for all aspects relevant to nuclear development and regulatory programs, as well as general science and technology promotion programs. The Ministry of Energy and Resources (MER) has the responsibility for the development of long term total energy supply, including the establishing of a long term electric power development program. The Ministry of Commerce and Industry is involved in matters relating to Korea's local industrial infrastructure, and is conducting the enforcement of domestic participation program for the nuclear industry. The Ministry of Science and Technology contains Korea's Atomic Energy Commission (AEC). The AEC acts as the deliberating and policy decision-making body for the nuclear power program. The AEC establishes policies concerning procurement, use, and disposition of nuclear fuel, as well as policies related to safety and safeguards. The AEC consist of nine members: a chairman (who is the Minister of MOST), a vice chairman (who is the Vice Minister of MOST), two standing commissioners and five non-standing commissioners. While the AEC is mainly concerned with long term policies, it also is responsible for arbitration on matters concerning the several administrative agencies in nuclear energy application. The AEC approves licensing nuclear power plants based on review of safety analysis reports the by the NRB, KAERI and recommendation of the Advisory Commission on reactor safeguards. The organization of MOST is shown in Table 1.

There are two Bureau's in MOST directly concerned with nuclear energy. The Atomic Energy Bureau (AEB) is responsible for promotion of nuclear energy.

Details on the AEB are contained in section 1.2 of this annex. The Nuclear Regulatory Bureau (NRB) is responsible for nuclear licencing, regulation and enforcement. Details on the NRB are contained in section 1.3.

In addition, MOST contains the Korean Advisory Committee on Reactor Safeguards (ACRS), which is chaired by the Vice Minister of MOST. The Vice Chairman of the ACRS is the President of KAERI. The ACRS has twenty members. It consists of four separate divisions, i.e. The Quality Assurance, Codes and Standards, and General Management Division; The Site and Environmental Evaluation, Civil Engineering and Architecture Division; The Reactor and Related Facility Division; and the Radiation Safety Control Division. These Divisions are responsible for reviewing safety aspects of applications to construct and operate nuclear reactors, and for conducting inspections and ensuring compliance with approved design specification and safety requirements.

The Korean Atomic Energy Research Institute (KAERI) is a government supported corporate body (responsible to MOST) with a number of diverse and important functions in support of Korea's nuclear power plant program. Section 1.4 describes KAERI's organization and functions.

The Korean Electric Company (KECO) is the sole electric utility in Korea, and is responsible for electric power development including power plant construction and operation and transmission distribution of electric energy. KECO is therefore the agency responsible for planning and carrying out Korea's nuclear power plant program, including both construction and operation. Section 1.5 discusses KECO's organization and functions. KECO is under the responsibility of the Ministry of Energy and Resources (MER).

In addition, the Economic Planning Board excercises economic control over the various phases of the nuclear energy program along with the licencing of the import of capital goods.

Korea has a number of manufacturing and construction firms participating in Korea's nuclear power plant program. Korean industry is rapidly increasing its capability to produce nuclear power plant components and equipment. Korea's industrial infrastructure is discussed is Section 1.6.

Korea has nine nuclear power plants operating, on order or under construction, and is expected to request bids on an additional two nuclear stations in 1981. Korea's nuclear power plant infrastructure is being strengthened and expanded to provide the requisite basis to support a growing nuclear power plant program. Section 1.7 provides additional information on Korea's nuclear power plant infrastructure expansion plans.

Section 1.2 The Atomic Energy Bureau (AEB)

The AEB is the main administrative agency for the nuclear development program. The AEB is responsible for developing the basic policies for nuclear energy development, application and use of atomic energy, and for planning and implementing policies concerning reactor development nuclear fuels and reactors, and for international cooperation.

The AEB Director General is Dr. Park Keoung Shik.(1) The three Division Directors are:

1) International Cooperation - Mr. Chang Sung Tae(1)
2) Research and Development - Mr. Kim Pil Kyu(1)
3) Planning - Mr. Kwak Chong Sun(1)

(1)April 1980

The AEB responsibilities included nuclear regulation and licencing until March 30, 1979, when the Nuclear Regulatory Bureau (NRB) was created by separation of the regulatory and of the development and promotion functions.

Section 1.3 Nuclear Regulatory Bureau (NRB)

The NRB is the agency responsible for nuclear regulatory activities in Korea. The NRB has a single administrator, the Minister of Science and Technology, who is responsible for actions (as differentiated from the U.S. NRC's five man commission).

The NRB reviews SAR's and associated documentation, in review process analogous to that used by the U.S. NRC, but on a step-by-step basis throughout the design and construction process. The Korean licensing procedure is the same as that used by the U.S. NRC in that the applicant requests siting and construction permits, as well as an operating permit, with a quality assurance plan being required for both construction and operation, and an emergency plan for operational incidents. It is different in that specific construction releases are required to initiate designated nuclear power plant construction activities. There are also safety reviews by Korea's Advisory Committee on Reactor Safeguards (ACRS),analogous to those in the U.S. by a similar committee of the same name.

The NRB's siting approval is based on submittal of a site environmental study report by KECO. Site approval is contingent on satisfactory results from the review of the Preliminary Safety Analysis Report (PSAR) which is the basis of issuance of the Construction Permit. The Korean requirements for the PSAR are the same as in the U.S., which are contained in the U.S. NRC Regulatory Guide 1.70.

Should there be unresolved issues upon completion of the PSAR the NRB/KAERI review and the review by the Korean ACRS, then the NRB would issue a limited work permit. This permit allows construction work on the site to progress to the point of being ready to pour concrete for seismically qualified structures, while the remaining issues are resolved.

Upon satisfactory resolution of all issues, as evidenced by the results of the reviews by the NRB/KAERI and by the ACRS, the AEC then makes the decision allowing issuance of the Construction Permit, which authorizes the site and the project allowing work to proceed. Design reports are submitted as work progresses, which are the basis for the NRB to approve specific construction steps.

An operating permit is issued (based on a decision by the AEC) upon completion of review by the NRB/KAERI and by the ACRS of the Final Safety Analysis Report (FSAR) and resolution of any issues resulting from this review.

The NRB organizes task forces, as necessary, on an ad hoc basis to deal with defined analysis needs and other safety related tasks. These task teams use consultants both from Korean organizations, and from sources outside Korea, e.g., the IAEA. Assistance is also obtained from the USXIRC under an agreement for cooperation on nuclear safety matters.

KAERI has an important relationship to the NRB. Safety questions and analytic undertakings are frequently referred to KAERI. Historically, KAERI was part of MOST until 1973, when it became a seperate organization. Funding is still provided to KAERI by MOST. KAERI's role is discussed in more detail in Section 1.4.

The NRB attempts to deal with safety responsibilities internal to the NRB. Since the NRB staff of about fifty people is not yet large enough to cover the entire field of safety activities, it often calls on KAERI for knowledge and advice. Additionally, the Korean Nuclear Engineering Corp (KNE) is an Architech-Engineer (A/E) organization within KAERI, and also provides specialized support to the NRB on request.

The NRB staff is relatively small numbering about 50 people, particularly in light of existing nuclear plant commitments.

The NRB has done planning on staff increases, but as yet has no definitized approved plans.

The NRB has inspection and enforcement functions to assure nuclear power plants are operated safely, consistent with the conditions of licensing. Careful attention is being given to the results of the reviews which were made following the Three Mile Island-II accident. In fact, the PSAR for KNU 7 and 8 includes review of the lessons learned from TMI II, as applicable to KNU 7 and 8.

To continually evaluate the desirability of procedural and organizational changes, as well as the need for changes in procedures, manuals similar to those used by U.S. utilities are submitted to the NRB for review. (The PSAR must contain a description of the Quality Assurance (QA) program to be used on design, fabrication, construction and testing activities associated with a specific reactor project.) The NRB holds periodic QA audits at sites involved in the nuclear power plant program. There is a continuous program to audit both QA and QC activities in all aspects of the nuclear power program. This

April 1, 1979
KOREAN MINISTRY OF
SCIENCE & TECHNOLOGY

Minister

Choi Jong Wan

Vice Minister

Lee Eung Sun

Atomic Energy Commission

Chairman: Minister

Standing Commissioner:

Lee Byoung Whie
Baek Yeong Hak

Advisory Committee on Reactor Safety

Chairman: Vice Minister

Atomic Energy Bureau

Director-General: Park Keung Shik

- o Atomic Energy Planning Division
  Director: Kwak Chong Sun
- o Atomic Energy R & D Division
  Director:
- o Atomic Energy Int'l Cooperation Division
  Director: Chang Sung-tae

Nuclear Regulatory Bureau

Director-General: Park Shiyohl

- o Safety & Safeguards Division
  Director: Yim Suck Soon
- o Nuclear Reactor Division I
  Director: Hahn Yound Soung
- o Nuclear Reactor Division II
  Director: Kim Byung Do
- o Resident Officer at KORI Nuclear Reactor Site

Section 1.4 Korean Atomic Energy Research Institute (KAERI)

KAERI has a key position in Korean's Nuclear Power Plant Program infrastructure. KAERI has a number of important roles. These include:

1) Providing up-to-date information and support most required in formulating the nation's nuclear energy policy for the Government and industry;

2) Training of nuclear professionals and technicians;

3) Providing assistance in safety review of nuclear power activities;

4) Providing technical consultants and support to nuclear safety inspection and enforcement activities;

5) Providing support to Quality Assurance (QA) activities with respect to tests and evaluations, e.g., radiographic and ultrasonic examinations;

6) Expediting the transfer of nuclear technology to assist Korean industry in selecting, adopting, and using foreign technology, with the objective of increasing the Korean local manufacturing content in nuclear activities;

7) Assisting with in-service inspection activities at operating reactors (e.g., Kori I);

8) Development of indigeneous nuclear power technology, safety research, and development of nuclear manpower.

Table 2 provides an organization chart for KAERI.

KAERI provides a reservoir of technical competence and a research capability that both supports the NRB and conducts reactor safety research.

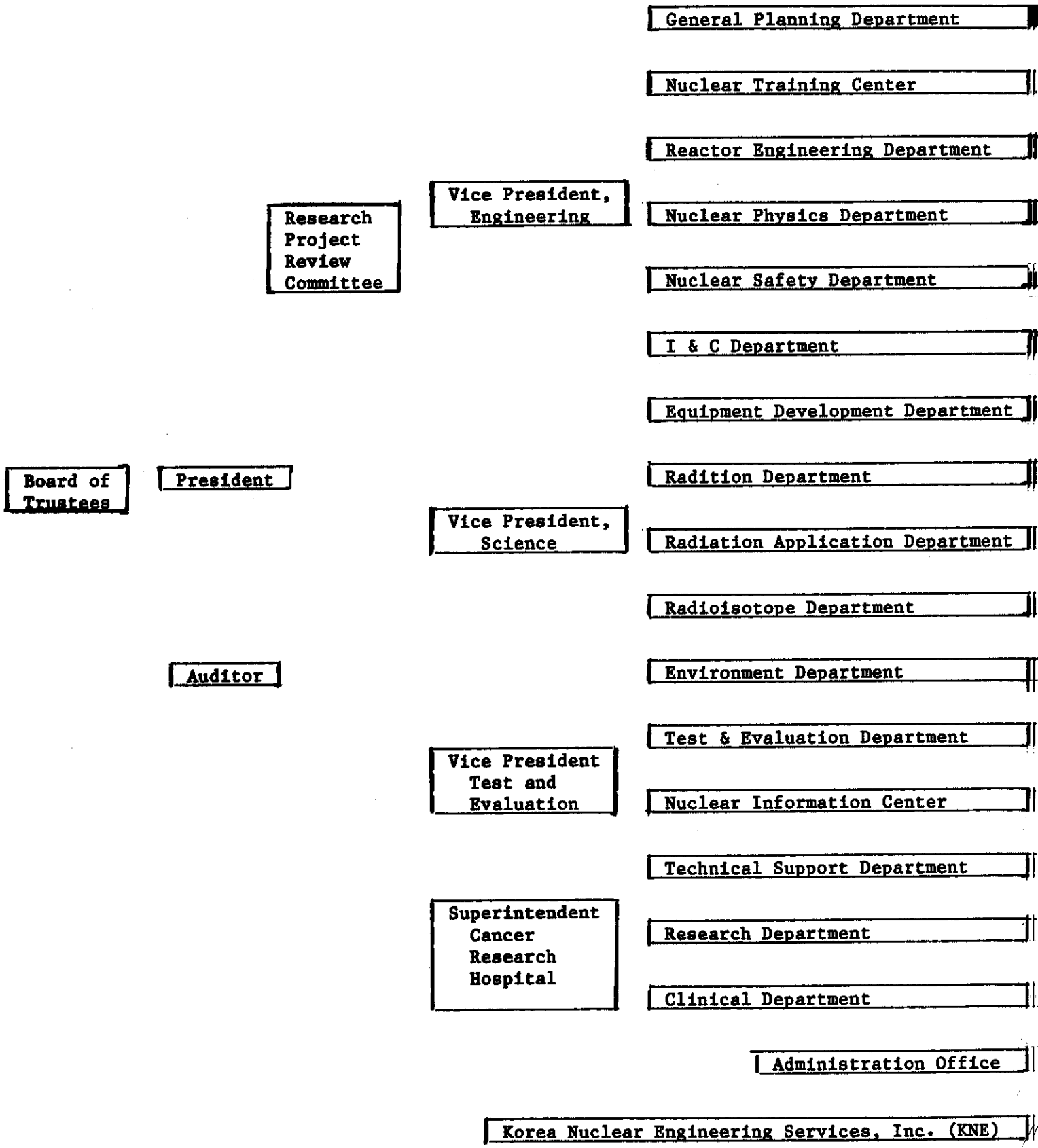
Manpower development and the training of nuclear professionals and technicians are conducted through the Nuclear Training Center. The Center was originally established to provide orientation for new KAERI recruits. More recently the Center has offered training courses for the operators of KECO's nuclear power plants, courses on radio isotope handling, nondestructive testing and quality assurance. In 1979, about 800 people attended various training courses at the center.

Currently courses offered for nuclear professionals include nuclear power plant design, operation, and component manufacture, nuclear fuel technology, use of radioisotopes, nondestructive testing and quality assurance. Specialized courses are also offered in conjunction with international organizations. For instance, the International Atomic Energy Agency, the Government of the Republic of Korea, and the United States Nuclear Regulatory Commission (NRC), recently sponsored a course in Reactor Safety Analysis Review conducted by KAERI in cooperation with Argonne National Laboratory.

Current courses for technicians include reactor operations, basic nuclear science, radioisotope handling and nondestructive testing. Additionally college level courses are offered in Nuclear Engineering and Reactor Technology.

TABLE 2

ORGANIZATIONAL CHART OF KAERI



Korean Nuclear Engineering Service Incorporated (KNE) is a part of KAERI. KNE was established in 1976, with the intention that it will ultimately perform all the architect-engineering services required for nuclear power projects in Korea. KNE initially was developed by incorporating a joint venture (Korea Atomic-Burns and Roe) between KAERI and Burns and Roe (a U.S. Architect Engineer/Constructor) undertaken in 1975. KAERI is in charge of KNE corporate management and operations, and provides KNE technical information and administrative support.

The scope of KNE's activities include:

1) Feasibility studies
2) Planning and Preliminary Engineering
3) Detailed Engineering and Design
4) Construction Management
5) Quality Assurance
6) Procurement
7) Plant Testing and Startup Operation
8) Plant improvements and retrofits
9) Training

KNE* is under President Shiri Kijo (who is also Executive Vice President), and Vice President Park Heejing (Project Operations), Moon In Bo (Engineering) and Kim Jin Hyo (Project Development and Administration).

KNE currently* has about 590 employees, 320 of whom are technical, with the remainder being in management, administrative, and nontechnical positions. KNE has provided limited consulting and design services and technical manpower

*April 1980

plants. KNE is participating in Korean Nuclear Unit (KNU) 5 and 6 through on the job training and participation in architect-engineering (A-E) activities at Bechtel's office in the United States and by providing technical manpower support and consulting services for A-E activities in Korea. The arrangements for KNU 7 and 8 require extensive participation through joint efforts with Bechtel.

KNE's recent training activities*, for example, have included the following training activities:

Number Trained	Subject	Provider of Training
23	QA, welding and fabrication principles	Moody International
20	QA regulations, codes and standards	Nu Tech International
12	Welding Techniques	International Executive Service Corps.

In addition, 12 people were currently* in the United States receiving 12 months of training in in-service inspection techniques.

The following Government Policies have been established with respect to KNE:

1) All A-E services required for nuclear power projects shall be be centralized, developed, and accumulaed by KNE;

*April, 1980

2) Nuclear related industries shall join in fostering KNE, with their manpower and technology so integrated as to be ready to receive advanced technology from foreign countries effectively, while KAERI shall play a major role in operations;

3) KNE shall maintain technical cooperation with foreign engineering firms for acquiring and accumulating A-E capabilities;

4) Until KNE achieves self-sufficiency in its A-E capabilities, KECO may hire foreign companies as prime contractors for A-E services, providing they are to work and share with KNE in all aspects of the work performance.

KNE A-E training activities are currently confined to Bechtel: KNE considered activities with other A-E firms, but since these firms did not have active contracts in Korea the firms were not interested.

KNE has established a system to maintain as-built drawings of nuclear facilities. The as-built drawings for Kori I have been microfilmed and are located at the site (under KECO) and in Seoul.

KAERI is establishing the Nuclear Engineering Test and Evaluating Center (NETEC) to aid in tests and evaluations of Korea's locally produced components and to provide a capability for performing nuclear power plant maintenance, and retrofit operations (the localization Program). The NETEC is scheduled for completion in 1982. The center will perform the following functions:

1) In-service inspection of nuclear power plant components, including development of specialized nondestructive testing capabilities;

2) Qualification Testing of Nuclear grade components such as values and pumps in order to ensure quality and reliability of safety related components;

3) Establishment of a national quality authorization program (such as the American Society for Mechanical Engineers) (ASMEAN) stamp system for locally produced nuclear components.

KAERI's primary localization program goals are to guide local industries so as to provide over half of the nuclear power plants starting construction early in the 1980's, and to complete the domestic supply of most of the major components by the end of the decade.

KAERI produces over 30 kinds of radionuclides for domestic use. Also, A 100,000 curie cobalt 60 accelerator is used for radio sterilization of disposable medical products, and a 300 kilovolt electro accelerator is used for surface coating of plywood, textile processing, and other industrial purposes. In addition KAERI's cancer research hospital continues to play a pioneering role in cancer research and treatment in Korea.

KAERI conducts environmental radiation surveys of nuclear power plants, prepares environmental impact assessment, and assist in the assessment of environmental quality standards and criteria.

KAERI has a long standing "sister laboratory" relationship with the U.S. DOE's Argonne National Laboratory.

Section 1.5 Korean Electric Company (KECO)

KECO is the only electric utility in Korea. It is a relatively large utility with a total generation capacity of over 7,000 MW*. Currently, about 72 percent of this capacity is oil-fired, and 10 percent coal-fired, 10 percent hydro, and 8 percent in nuclear. The increasing cost and supply problems associated with oil, coupled with the high development of Korea's hydroelectric resources have resulted in KECO giving the nuclear power plant program high priority.

The KECO organization for nuclear projects is shown on Table 3.*

KECO's existing program will lead to KECO being among those utilities in the world with the largest dependence on nuclear power plants.

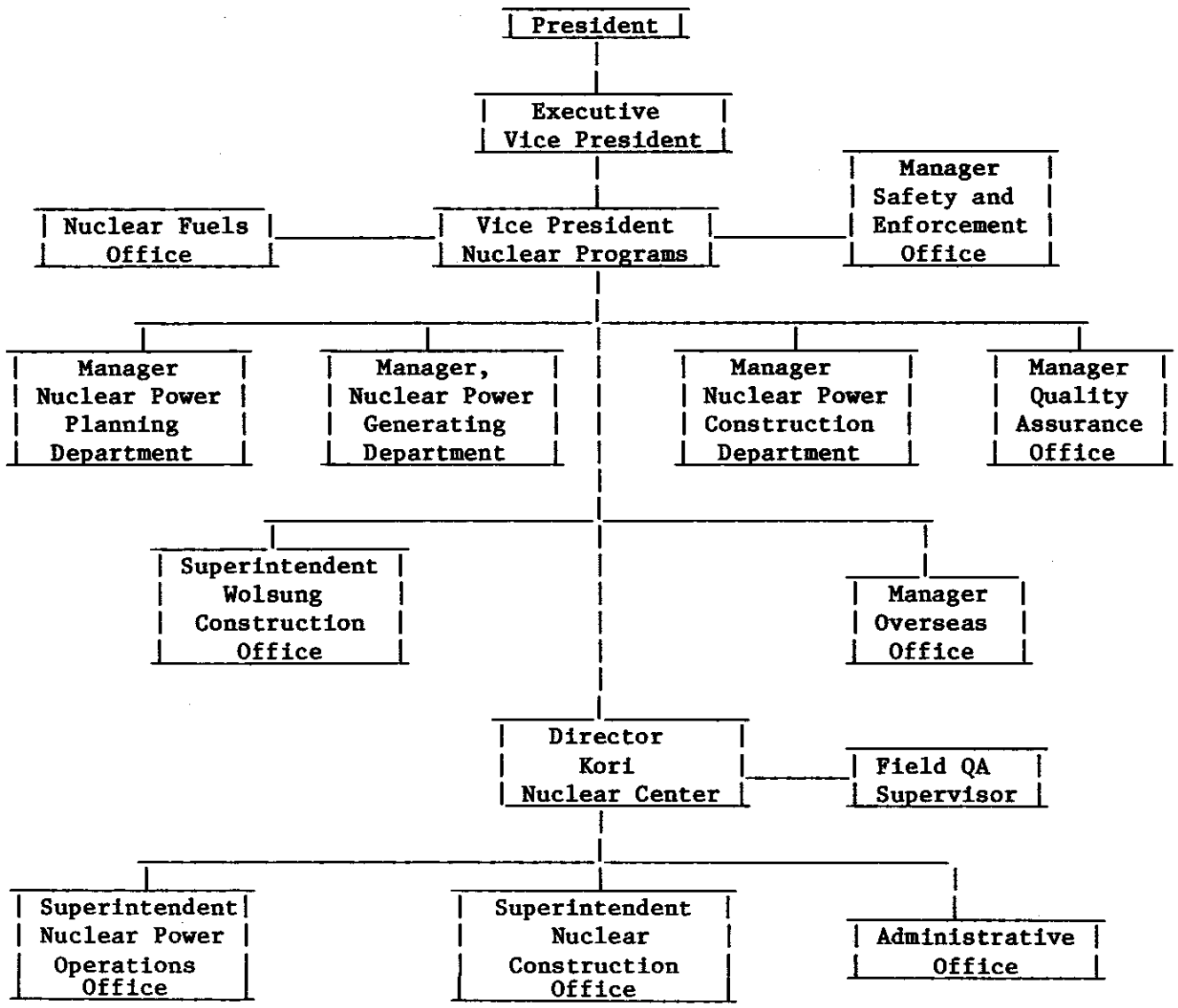
KECO contracted with Westinghouse Electric International Company on June 24, 1970 for Kori I Nuclear Steam Supply System. Kori I is a 595 MW electric (gross) two-loop pressurized water reactor (PWR). KECO currently has four nuclear power plants in various stages of completion. In addition, contracts have been finalized for two additional nuclear power plants, with site preparation activities nearing completion, and is in the process for soliciting bids for additional nuclear power plants.

KECO's current nuclear staff has the benefit of personnel with prior electric utility experience who received nuclear training in the 1960's and have been involved in KECO's expanding nuclear power plant program throughout the 1970's. KECO has also recuited and trained personnel for the nuclear power plant program since the 1960's and on an increasing scale through the 1970's.

*April 1980

TABLE 3

KECO Nuclear Power Plant Program
Organization



The result is that KECO currently has a significant number of well trained and experienced personnel at all levels in their nuclear power plant program. KECO has a total of about 1,500 people working on nuclear projects, including trainees.

KECO's overseas training program in the 1970's provided a total of 260 graduates, 57 in opeations, 62 in plant technical, and 141 in Design and Construction. This training program involved academic training at the MS level, specialty courses (e.g., by IAEA), on-the-job training at A-E and reactor manufacturers offices, and training at component supplier offices for periods of time varying from one month to two years. There were about 100 people in overseas training programs in early 1980. KECO's domestic training program is described in Table 4.

KECO has about 700 employees at Kori, of whom about 250 are trainees.

A KECO nuclear training center is located at the Kori site. The Center has a nuclear power plant training simulator (based on the Surry nuclear power plant). A 29-week course of instruction, using the simulator, included in the almost two-year training program for reactor operators. The center has about 30,000 square feet of floor area divided into space for the simulator and associated computer equipment and classrooms. These classrooms are well equipped with modern audio visual aids, including video equipment, as well as other training aids. Essentially, all instruction is in English. Training manuals and training aids are in English. Major training activities include operator training for Kori II operators, an eight-month course for chemical

specialist, and an eight-month course for instrument repair. The Kori site also has a welder training and qualification facility operated to train construction workers.

KECO has a staff of over 227 at the Wolsung Nuclear Construction site where a CANDU type nuclear power plant is under construction.

After completion of the training program for operators a qualification examination is administered by a separate group from those conducting the training program. This qualification examination must be passed to become a qualified operator. There is no separate qualification program for maintenance people.

Although KECO has training ties with Westinghouse, Atomic Energy Canada, Limited and Bechtel, KECO has no active utility to utility programs with the U.S. utilities. KECO has technical interchange with Taiwan Power and with Kushu in Japan. KECO has attempted to arrange for utility to utility exchanges and cooperative arrangement with U.S. utilities, but as yet the effort has been unsuccessful.

KECO is currently in the process of making arrangement for participation in the Electric Power Research Institute (EPRI).

KECO has recently created an Office of Safety and Enforcement (S&E). This office works closely with the NRB. The NRB issues requests for action directly to the implementing office. S&E follows up to make sure the request are fulfilled. S&E also monitors activities in the field. S&E interfaces with the various QA offices to insure safety related requirements are

promulgated in construction activities and that these requirements are up-to-date. Other activities include checks of as-built drawings and equipment surveys on a monthly basis. (The NRB may join in these surviellance activities as well as conduct independent reviews), and independent surveys of key operational items, such as value operation. It takes about three weeks to a month for the office to obtain documents issued by the U.S. NRC.

Should it be necessary to make changes on an operating nuclear power plant then the time required includes the time to receive the information advising of the need for a change (e.g., from the U.S. NRC), the time for the review, the time required to do the engineering and design work to implement the change, and the ordering time for any required equipment. Where nuclear grade equipment must be imported additional time is required to obtain the necessary approvals, such as approval to convert Korean money to foreign exchange.

KECO's QA office follows the quality standards and practices of the country of origin. Korea has as yet not implemented an overall QA requirement document such as the U.S. IOCFR50, Appendix B.

KECO's QA office has a headquarters staff of 25. Kori I operation has a supervisor, two assistant supervisors and several staff; Kori II construction has a QA supervisor, four assistant supervisors and about staff. There are also nine people assigned to KNU 5 and 6 construction QA, and another nine assigned to Wolsung construction. The Quality Assurance teams at the construction sites report to the construction manager of the site: this is different from U.S. practice which requires QA people to report to an authority other than that directly responsible for the work being done. QA

inspection activities in other countries are conducted by Nuclear Services International Corporation, (NSIC) and at Bechtel's U.S. offices, by Bechtel. NUS (a U.S. concern) provides NDT inspection services at Wolsung while NSIC provides these services at Kori.

KECO's QA office joins with the NRB periodic audits in Korea and with the U.S. NRC for audits at Bechtel and Westinghouse in the United States. However, audit reports are not received, although they could be obtained by special request.

Source inspection in Korea is accomplished by two expatriate inspectors provided by Moody International. Bechtel provides source inspection services in the United States for KNU's 5 and 6. Westinghouse provides these services for Kori II. KECO audits Bechtel's and Westinghouse's activities.

Equipment calibration is provided by the construction contractor and audited by KECO's QA office. Korea's National Standards Office uses the U.S. Air Force for calibration standards, and for calibration of calibration equipment.

Receipt inspection is accomplished by KECO's site organization.

KAERI povides KECO QA in-service inspection services, and is increasing its capability in this area. KNE is also providing site QA services to KECO at Kori II, KNU 5, 6, 7, 8 and Wolsung. KNE is also expected to provide site QA services at KNU 9 and 10.

KECO's Planning Department has formated the actions which are leading to KECO's expanding nuclear infrastructure, facilities and increasing the Korean contract in nuclear facilities (a program called localization).

Kori I is a 587 MWe (gross), 564 MWe (net), pressurized water reactor PWR Westinghouse two-loop design. It began commercial operation in April 1978 and was built on a straight turnkey arrangement. Kori II is also a Westinghouse two-loop PWR of simular design, but with a generating capacity of 635 MWe (gross), 605 MWe (net). It is expected to begin operation in February, 1983 and contains a higher Korean value added content than Kori I. Wolsung I is a standard 600 CANDU type 678 MWe (gross), 629 MWe (net), heavy water reactor being supplied by Atomic Energy of Canada, Limited (AECL) under a turnkey arrangement. This plant is basically the same as the nuclear power plant being constructed at Pt. LeProaum, Canada, and Embalse in Argentina. It is scheduled to begin commercial operation in October 1982.

KNU 5 and 6, located at the Kori Site are 950 MWe (gross), 900 MWe (net), Westinghouse three-loop PWR's. They are being supplied under a component turnkey arrangement. They are scheduled to begin operation in September 1984 and September 1985. Construction activities are underway* with the reactor building for KNU 5 with containment vessel rebar above grade level and much of the containment vessel liner plate below grade in place. KNU 6 is also proceeding reactor building excavation nearing completion.

Work on the intake and outlet structures for cooling water are fairly advanced. Excavation for the turbine building for KNU 5 and 6 are essentially complete.

KNU 7 and 8, located at a site at Yeong Gwang (Kema-ri), 1000 MWe (gross), 950 MWe (net), Westinghouse three-loop PWR's. They are scheduled for initial operation in March 1986 and March 1987 respectively. They are being

*April 1980

procured on a non-turnkey basis with increased Korean content over that in KNU 5 and 6. Site preparation work is well advanced.

The Westinghouse 950 MWe three-loop PWRs being supplied to Korea are basically the same as the U.S. nuclear power plants listed below:

Name of Plant	Utility	Location	Initial Operation
Beaver Valley 1	Duquesne	Shippinport, Pa.	4/77
Farley 1	Ala. Power Co.	Dothan, Ala.	12/77
Farley 2	Ala. Power Co.	Dothan, Ala.	11/80 (scheduled)
North Anna 1	VEPCO	Mineral, Va.	6/78
North Anna 2	VEPCO	Mineral, Va.	11/80
Surrey 1	VEPCO	Gravel Neck, Va.	12/72
Surrey 2	VEPCO	Gravel Neck, Va.	5/73

The Korean nuclear power plants being supplied by Westinghouse are designed and built to U.S. standards; changes from the above plants are those required to update the design to comply with current requirements, codes and standards.

KECO signed a contract for KNU 9 and 10 to Framatome in late 1980. These nuclear power plants will be 950 MWE (gross), 900 MWe (net), three-loop PWR's. They are scheduled to begin operation in 1987 and 1988, and are to be located at Buku-ri. It is assumed these plants will be designed and built to French safety requirements, codes and standards.

KNU 9 and 10 will be basically the same as the Framatome three-loop 950 MWe power plants which are built under licenses from Westinghouse. Examples

of similar plants now operating for Electricite de France are listed below:

Name of Plant	Location	Initial Operation
Fessenheim 1 & 2	Haut-Rhin	12/77 & 3/78
Bugey 2, 3, 4 & 5	Ain	2/79, 2/79, 7/79, 12/79

There are a total of 32 similar plants in France which are either operating or in the process of design and construction or start-up. Two similar plants are now under construction in South Africa.

KECO is expected to request bids for an additional two unit station early in 1981. The capacity of these units is expected to be 950 MWe (gross).

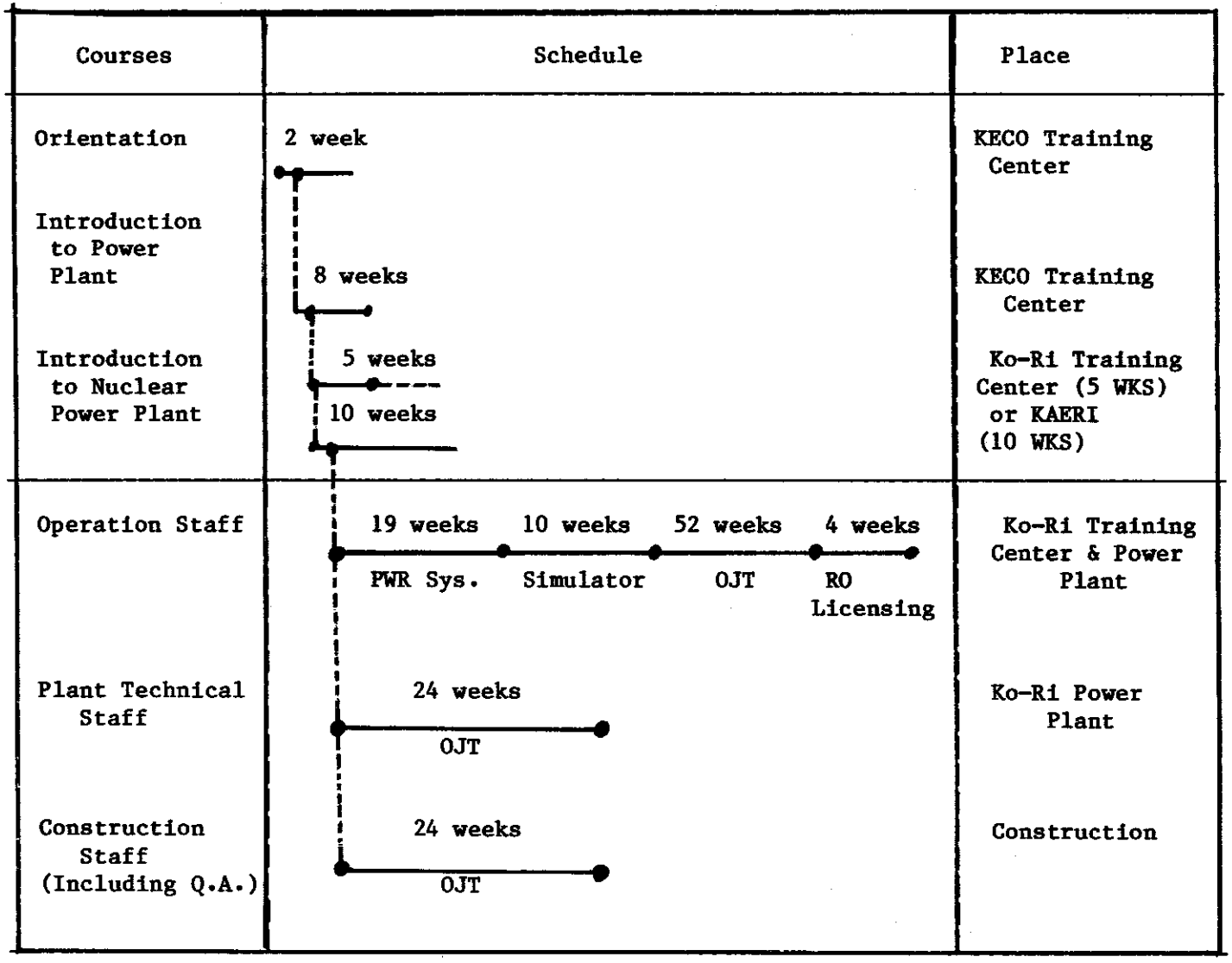
KECO's training programs, and coordination with local industry is based upon these ongoing commitments.

Kori I operated in 1979 through September 1979 with a plant capacity factor of 74.6 percent. Starting in October it was shutdown for about three months for refueling and maintenance. (Oil-fired units in Korea operate at plant capacity factors of about 60 percent.)

KECO officials are carefully studying the details of The Three Mile Island accident as well as the results of the various investigations resulting from this accident. A careful study was made of Kori I in light of the Three Mile Island accident. Some actions have been taken as a direct result of recommendations made to U.S. utilities by the U.S. N.R.C.

TABLE 4

KECO Domestic Training Program



Section 1.6 Korea's Nuclear Power Plant Industrial Infrastructure

Korea's industrial base is currently rapidly increasing its nuclear power plant manufacturing capability. Construction labor is not a limiting factor. Kori I was completed with reliance on Korean labor. There are currently 80,000 Korean construction workers engaged in work on projects outside Korea.

The following is a listing of Korean companies with an interest in nuclear power plant design, manufacture or construction:

Daelim Industrial Company
Daewoo Heavy Industries
Dong-Ah Construction Industrial Company
Korea Heavy Industries and Construction Co. (KHIC)
Han-ell Development Company
Hyosung Heavy Industries
Hyundai Group
Hyundai Construction Company
Kangwon Industrial Company
Korea Heavy Machinery Industrial Company
Pohany Iron and Steel Company
Sambu Construction Company
Samsung Heavy Industries Company
Taihan Electric Wire Company

Korean domestic participation is figured on the basis of value added.

Korea had developed industries for producing high grade specialty steels, alloys, and non-ferrous metals, and heavy construction machinery.

The Korean Government places emphasis on domestic participation in providing nuclear components and materials for nuclear power plants.

The Hyundai Group's Ulsan facility was visited in April 1980. This facility was constructed starting in 1972 and produces a variety of modern ships, including supertankers up to 500,000 DWT, and has the capability to produce up to 18 supertankers per year with a combined capacity of 7,500,000 DWT.

This facility was awarded the right to affix the American Society of Mechanical Enginerrs (ASME) N-stamp as a result of an ASME survey in March 1980. This N-stamp certifies that the design, fabrication, manufacture, and inspection of certain components meet the requirements of Section III (which covers some nuclear power plant components) of the ASME code.

This large facility has a covered floor area of 500,000 square meters and is well equipped with modern high quality machine tools, rigging equipment, welding equipment, and equipment for cutting, shaping, and weld preparation of steel plate. Shop fabrication of the reactor containment building's inner plate modules for KNU 5 and 6 was underway at the time of the visit.

The Ulsan complex includes a modern electric equipment capability producing a wide scope of electrical equipment. The electrical complex has licensing arrangements with Siemens A.G. of The Federal Republic of Germany and others. Electrical items produced include:

1) Control consoles, switchboards and panels, breakers, switchgear.
2) Transformers up to 345 KV.
3) Rotating machinery up to 1,300 MVA.

The facility also produces a variety of large marine diesel engines under license from Sulzer Brothers, Limited, Burmeister and Wain Motors, and Machinen Fabrik Augsburg und Nurnberg Aktiengese Ilschaft (M.A.N.).

A nuclear manufacturing capability is being established at a facility in Changwon. The Changwon facility will employ about 2,000 people for the manufacture of nuclear power plant components and equipment, when in operation.

Korean concerns have licensing arrangements for manufacture of nuclear power plant equipment with Westinghouse, Babcok and Wilcox, General Electric, The General Electric Company (U.K.), and Combustion Engineering.

Korea's large industrial base, licensing agreements, and skilled labor pool provide an excellent basis for increasing the Korean value added to nuclear power plants.

Section 1.7 Infrastructure Expansion Plans

KECO currently has one nuclear power plant (Kori I) in operation and has eight on order or under construction. KECO is expected to request bids on an additional two 950 MWe (gross) stations in 1981.

The nine nuclear power plants now operating or on order have a total gross generating capacity of 7600 MWe (net capacity - 7298 MWe). Section 1.5, Korean Electric Company (KECO) discusses these plants, details of which are summarized below:

Name	Type	Gross Generating Capacity (MN)	Net Generating Capacity (NM)	Location	Expected Commercial Operation
Kori I	PWR	587	564	Kori	Apr. 1978
Kori II	PWR	635	605	Kori	Feb. 1983
Wolsung I	CANDU	678	629	Wolsung	Oct. 1982
KNU-5	PWR	950	900	Kori	Sept. 1984
KNU-6	PWR	950	900	Kori	Sept. 1985
KNU-7	PWR	1000	950	Yeong Gwang	Mar. 1986
KNU-8	PWR	1000	950	Yeong Gwang	Mar. 1987
KNU-9	PWR	950	900	Buku-ri	1987
KNU-10	PWR	950	900	Buku-ri	1988

Korea's expansion plans provide active sites for nuclear power plants until at least near the end of the 1980's. The Kori is to be the site of four nuclear power plants, all of which are now either operating or under construc-

tion. Wolsung is a two unit site, one of which is under construction. Although some civil works, such as the water intake, are under construction for two Candu units, there are no firm plans for a second plant at Wolsung. Yeong Gwang (Kema-ri) is a six unit site, two of which are under construction. Buku-ri is a four unit site, two of which are committed. Hence, Korea has two active nuclear power plant sites which could accommodate another six PWR's (in addition there is the Wolsung site which is allocated to a second Candu unit for which there are currently no firm plans).

KNE's expansion plans were discussed in Section 1.4. These plans would allow KNE to assume an increasing share of the A-E/Construction management work on nuclear power plants. Kori I, Kori II and Wolsung, Korea's first three nuclear power plant projects, are all turnkey projects with the project responsibility assigned to a prime contractor. KECO assumed an increased management role in the KNU 5 and 6 project by using a component approach. Direct contracts were obtained for the nuclear steam supply system, the A-E, and major equipment suppliers. Bechtel (who is also the A-E) will prepare specifications and detailed design drawings and will assist in construction management, including assistance in preparation of construction drawings and site resident activities. Training activities are directed at supporting the development of the required infrastructure for this increasing role.

KNU 7 and 8 will continue the same basic component approach, but with an increased Korean role, both in project management, engineering, and as a supplier of material and equipment.

Essentially all civil construction work and field construction/installation work is currently done with Korean labor. Efforts are in place to allow

Korea to supply all of the concrete and the vast bulk of construction iron and steel.

U.S. NRC's cooperative managements and the examination of the details of their U.S. suppliers project responsibilities to help strengthen Korea's nuclear power plant infrastructure helps demonstrate the complexity, breadth and potential of this effort as well as the roles the various organizations were developing an increasing capability to carry out.

The U.S. NRC has a bilateral agreement for cooperation with Korea's MOST for exchange of reactor operating experience and for exchange of regulatory information. Korea provides the U.S. NRC reports on operating history, and the U.S. NRC provides Korea a full spectrum of information including Licensee Event Reports (LRE's) Regulatory requirement (NUREG's) copies of directives to U.S. Licensees, and results of various reviews of nuclear safety matters. NRB people have been and are being trained by the U.S. NRC both by training courses and on-the-job training assignment to various U.S. NRC Organizations, including regional offices dealing with reactor construction and inspection and inforcement activities. There are, however, no firm long term infrastructure development plans concerning the Nuclear Regulatory Bureau.

Westinghouse has specific commitment to assisting Korean industry develop a capability to manufacture nuclear components in addition to their commitment to train operators. Westinghouse has a License Agreement with Hyundai concerning steam generators, pressurizers, reactor vessels and reactor internals for KNU 5,6,7 and 8. This is supplemented by a Licensing agreement with combustion engineering for the KNU 8 Reactor Vessel. The specific production plans were for the material and required design and engineering information to be

provided by a U.S. supplier with Hyundai performing an increasing amount of work on each unit. This would start with only limited work on the shell courses for the pressure boundary on the steam generator and pressurizer for KNU 5, and increase until a major percentage of the work on these components for KNU 8 was done at Hyundai. The major portion of the welding for the KNU 8 reactor vessel would be done by Hyundai. In addition, Hyundai has the heavy press required for the manfacture of the reactor vessel and other nuclear components. Hyundai would also perform increasing amounts of work on the turbines and generators for KNU's 5 and under agreement with GEC and KNU's 7 and 8 for KNU's 7 and 9 work world mainly be on stationary parts. This progression of increasing work should, if continued in a systematic manner, provide Korea the capability to manufacture reactor vessels and other key nuclear components by the later part of the 1980's.

Bechtel has had responsibilities for providing architectural engineering, procurement, and construction management services on KNU's 1,2,5,6, 7, and 8. Bechtel does the work on design and engineering of safety related systems in Los Angeles. Bechtel assists KNE and KECO in Seoul in designing nonsafety related systems. Bechtel's field engineering services include helping KNE and KECO improve their capability to assume this role.

Infrastructure development in the architect engineering and construction management crew has progressed to the point that KECO is the construction manager on KNU 7 and 8, with Bechtel providing support. Approximately 24% of the value of KNU 5 and 6 will be from Korean sources. The Korean contribution on 7 and 8 is expected to be about 37%.

Bechtel is working with KECO on the cost schedule control system, with periodic initial items reports being issued on (Westinghouse issues similar reports) KECO insures assignments of responsibilities for resolutions of these critical items, and monitors progress.

KECO has established a program of configuration management to control design changes and insure these changes receive appropriate reviews and approvals. KECO requires that anything impacting the License or basic design must receive KECO HQ approval. The KECO resident at Los Angeles can approve other design changes up to 5 million dollars. The KECO site manager can approve field design changes up to $150,000; changes in excess of this require approval of KECO HQ. This configuration management capability will require expansion, consistent with KECO's increasing nuclear commitment.

A complete set of U.S. built drawings are maintained both at the site and at KECO HQ.

A continuation of this systematic and disciplined increase in Korea's nuclear power plant infrastructure should enable Korea to be able to design, build, and operate these plants with only minimal requirement for imports by about 1990. There are some materials, services, and compacts which it may not be economically advantageous for Korea to produce locally, such as nuclear grade forgings and specialized electronic control equipment, unless Korea anticipates a major export trade in such items.

The KNU 9 and 10 nuclear steam supply systems are being supplied by Framatome, with the balance of plant expected to be supplied by Korea Heavy Industries and Construction Co. (KHIC). This could represent a shift from the increasing role of KECO in nuclear power plant projects.

There is no information available as to how the KNU's 9 and 10 procurement is integrated into Korea's infrastructure development plans. The exact role of KHIC and its impact on KECO's established role and infrastructure growth is simularly unknown.

Concerning the future, KECO's current development plans are to have 13 nuclear power plants in operation by 1991, with a decision on the number of future plants beyond these 13 to be made in the 1982-1983 time frame. Nine of these plants having been ordered and KECO is expected to order another two units in 1981. No information is available as to plans for the procurement of the remaining two units. Korea's infrastructure development plans are based upon the procurement of these 13 nuclear power plants, with increasing participation.

The ongoing infrastructure development programs by KAERI, KECO, MOST and Korean industry would supply the institutions, manpower, and equipment to enable Korea to supply the major fraction of the labor and equipment for nuclear power plants constructed after the initial 13 units. In fact, these plans, if brought to fruition, could provide Korea surplus capacity which would enable Korea to become an exporter of nuclear power plant equipment and skilled manpower, in the late 1980 should Korea decide to pursue this course of action.

Korean industry has procured equipment to manufacture nuclear power plant major items of equipment such as steam generators, pressurizers, reactor vessels, and reactor vessel internals, as well as a Balance of Plant (EOP) equipment such as the turbine and generator. Actions under way through

component procurements for KNU's 5 through 8 would allow a progressive increase in the contribution of Korean industry to these component such that by the latter part of the 1980's, it should be possible for Korea to produce all of these major equipment items.

The award of the Balance of Plant supply contract for KNU 9 and 10 to Korea Heavy Industries and Construction Co (KHIC) is a major step in the BOP infrastructure development, and will allow much of the BOP equipment including the turbine and generator to be supplied by Korean industry. It is also a departure from the development path which was being followed and thus introduce an uncertainty.

There are other uncertainties which must be considered. The award of KNU 9 and 10 to Framatome is a departure from the course of action on which the infrastructure development planning has been based. This course of action implicity assumed procurement of a PWR from a U.S. supplier, with Westinghouse and Bechtel respectively on all plants (except the CANDU unit at Wolsung) The 950 MWe PWR's to be supplied by Framatome are produced under a license with Westinghouse and are basically the same as the Westinghouse supplied PWR as discussed in Section 1.5. There are, however, differences in the codes, and standards. Design and construction practices, and nuclear regulatory requirements of the United States of America, and those of France. These differences have resulted in their being differences between the current Westinghouse supplied PWR's and those currently supplied by Framatome. In addition, while most manuals, instructions, etc. currently in use in Korea all in English and a large number of Koreans are indluent in English, there are few people in Korea's nuclear power plant infrastructure fluent in French.

In response to these factors, Korea's nuclear regulatory board will have to devote manpower and training resources to accommode a plant designed and constructed based on French nuclear regulatory requirements and procedures. This will require both a diversion of manpower resources currently in use or being developed for Korean NRB activities on U.S. supplied nuclear power plants and additional training and personnel.

Quality assurance training will have to be extended, and actions to deal with the use of a French speaking supplier implemented.

The degree to which this procurement will impact Korea's moves away from turnkey contracting and increasing capability to contribute to the design and supply of Nuclear Steam Supply Systems can not be assessed at this time. Increased training requirements will result, together with a need for increased manpower. An increase in difficulties associated with the nuclear regulatory effort will result. Korea will in turn obtain a broadened base for their nuclear power plant program, as well as the benefit of increased understanding of alternative practices and approaches.

The procurement of the Wolsung CANDU plant is a similar action, which broadens Korea's nuclear power plant program base, and required the attendant development of specialized infrastructure.

The Hyundai group was the key industrial participant in Korea's nuclear power plant program supplying construction services and developed the manufacturing capability required to supply major nuclear power plant components. The Daewoo Industrial group was assigned many of these functions in mid 1980. In turn, Daewoo transfired some functions to the newly created KHIC.

Subsequently, there have been reports of subsequent shifts of responsibility within Korea's industrial structure. It is not apparent when these industrial restructurings will be completed. It is also not apparent what the result of these restructurings will be in terms of closing facilities, relocation of equipment and people between facilities and organizations, or management changes within essentially unaltered facilities.

Section 2 Economics

The Economics of Nuclear Power Plants are basically dependent on the following factors:

1) Capital Cost (Section 2.1)
2) Cost of Money (Section 2.2)
3) Time Required for Construction (Section 2.3)
4) Fuel Cost (Section 2.4)
5) Operating and Maintenance Cost (Section 2.5)
6) Plant Capacity Factor (Section 2.6)

Each of these factors are addressed in this section.

Section 2.1 Capital Cost

The capital cost of three loop Pressurized Water Reactor (PWR) of about 950 MWe capacity, nuclear power plants, such as are now being committed in Korea is in the range of 850 to 900 1980 dollars per kilowatt, assuming one dollar equals 600 whon. This capital cost does not include interest during construction, owners indirect cost, or cost devoted infrastructure development. Interest during construction is discussed in Section 2.2.

The cost of KNU 9 and 10 (purchased from framatome) is reported to be slightly higher than the cost of comparable units from Westinghouse. No exact figures are available.

The comparable cost of a standard CANDU 600 (such as in under construction at Wolsung) would be at least 25% more (1125 $/kw) and possibly 50% more. This increased cost is due to a number of factors including the requirement for about 500 tons of deuterium oxide (heavy water), and the smaller unit size. The large uncertainty range results from none of these type plants currently having been completed, and there have been reports of unanticipated cost increases and schedular delays. The high cost of the CANDU type reactor is off set by the possibilities of higher plant availability resulting from the use of on-line refueling.

Section 2.2 Cost of Money

There is currently a buyers market in nuclear power plants, with considerable competition between suppliers, and with some nations providing favorable loans. Hence, nuclear power plants in Korea are currently being constructed with money obtained on very favorable conditions. It is not possible to predict or speculate as to how far in the future these favorable loan condition will be available, but it is reasonably to expect favorable loans will be available for at least the next 2 or 3 years.

The most recent loan was for KNU 9 and 10. France provided credit to cover 85% of the purchase with terms set at 7.6% over years, the first seven years being a grace period.

Section 2.3 Time Required for Construction

Construction of Keco's first nuclear power plant (Kori 1) started in 1971: Commercial operation began in 1978, a construction time of seven years. Construction began on the second plant (Kori 2) in 1977, and commercial operation is scheduled for 1983.

Keco is currently contracting for two unit stations. Excavation and shared facilities for both units are started together. The first unit is scheduled to start commercial operation six years after start of construction - the second unit after seven years. This approach allows economies in construction cost and efficient use of personal equipment. Actual construction time is scheduled at about 60 months, and provision is made for start-up testing, initial low power operation prior to commercial operation, and for contingencies. Provided 1) key components and hardware are received at the construction site in a timely manner, 2) regulatory approvals are

received when required; and 3) there are no major quality problems, this is reasonable and achievable.

Section 2.4 Fuel Cost

Fuel cost to Keco is essentially the same as the cost of fuel to U.S. utilities. This cost is tied to the U.S. DOE schedule of charges for separative work units, the world market price for uranium, and suppliers cost for fuel manufacture.

Lost of separative work unit are increasing due to the cost of electricity, hence the most current published prices should be used with provision for escalation based on expected increases in electricity lost (eight percent is suggested).

The current cost of fuel is:

Section 2.5 Operation and Maintenance (O&M)

Based on information received from KECO. The following O&M experience (for the operating unit) and estimated (for units under construction) are used for cost estimating.

Unit	Cost - Mill/Kwhr	Cost Per Year Million $
Kori 1	0.63	2.144
Kori 2	0.82	3.042
Wolsung	0.82	3.160
KNU 5 & 6	0.94	5.187
KNU 7 & 8	1.08	5.960
KNU 9 & 10	Not available	

It is suggested that O&M cost for future units be assumed to be 1.1 m.k/Kwhr or about 6 million dollars per year (constant 1980 dollars).

Section 2.6 Plant Capacity Factor

This represents a significant uncertainty in the economics of nuclear power plants since the day cost are the fixed capital cost and financing cost, with the variable fuel cost being relatively minor. Ultimately the plant capacity factor achieved will depend on the plant availability (which is dependent on how well the plants are operated and maintained) and the load management (which depends on the load dispatchers decision to use available nuclear power plant capacity).

Actual experience to date on Kori 1 is that from initial commercial operation (April 1978) through the first shut down for refueling and maintenance (October 1979) the plant capacity factor was 74.8%. Kori 1 was down for about two months, resulting in an annual plant capacity factor of 61.3%

for 1979. The 1980 plant capacity factors (through the end of November) was 67.6%, which in part reflects down time at the first of 1980 required for resolutions of problems identified in the late 1979 refueling/maintaining operation.

Nuclear units now under construction are Westinghouse 900 MW through loop PWR's. As discussed in Section 1.5., there are seven comparable plants in operation in the U.S. The following provides information on the plant capacity factors of these units in the first 11 months of 1980.

Name of Plant	Initial Operation	1980 Plant Capacity Factor
Beaver Valley 1	4/77	0.6 [a]
Farley 1	12/77	70.8
Farley 2	iminent	---
North Anna 1	6/78	73.4
North Anna 2	11/80	10.3 [b]
Surrey 1	12/72	39.6 [c]
Surrey 2	5/73	26.8

Mean 52.6 for 4

(a) Plant was down for modifications

(b) In startup and lowpower testing

(c) Down for repair

A problem with corrosion in the steam generators (denting) resulted in a significant reduction in the availability of some of these units: It is believed that this problem is now resolved. The plant capacity factors of some of these plants were also reduced due to problems associated with resolution of intervenor actions in the nuclear licensing process, and licensing problems. The use of the wrong pipe stress analysis code by the A-E, and

correction of problems identified in the analysis and review resulted in a significant loss of operating availability).

Many of the problems which have reduced the availability of these units are not relevant to the KECO units potential availability. However, the experience gained in the operation of these plants, and the resolution of problems which could potentially have effected the KECO units should contribute to increasing the achievable plant availability.

It should be possible to accomplish refueling and scheduled maintenance of these units in 60 days per year. An allowance of 40 days for unplanned shutdowns and maintenance in reasonable and conservative for plants, such as those being committed in Korea. Assuming the plants will be unavailable 100 days per year results in a unit availability of 72.6%.

Since it is also reasonable to assume the nuclear units will be fully used when available it is recommended that 72.6% be used as the plant capacity factor for nuclear power plants.

The unit availability may be above or below that in a particular period, but it is reasonable to assume KECO should be able to equal or exceed this plant capacity factor, based on their existing plans.

Section 3 Observations

Korea has a large and well planned nuclear power plant program. KECO's current firm nuclear power plant commitment is 7300 MWe net. By way of comparisons in the United States, KECO's commitment is exceeded by the Tennessee Valley Authority which has a firm* nuclear power plant commitment of 14,246 MWe net, Commonwealth Edison with a commitment of about 13,000 MWe net, and Duke Power Company with a commitment of about 9800 MWe. KECO's nuclear power

*Not counting plants which are indefinitely postponed.

plant commitment is about the same as the Washington Public Power Supply System's (WPPS) 6940 MWe net, but WPPS is currently experiencing significant schedular delays and is not expected to make further commitments in the near future, while KECO is expected to continue ordering nuclear power plants. KECO's nuclear commitment is larger than that of Carolina Power and Light (5800 MWe net and Virginia Electric Power Company).

Hence, if ranked with U.S. utilities, KECO would be fourth in its firm nuclear power plant commitment.

All of KECO's nuclear power plants (with the single exception of the Wolsung-1 CANDU) are pressurized water reactors of the same basic reactor type. The U.S. utilities have mixes of plants supplied by different vendors: Babcock and Wilcox, Combustion Engineering, General Electric, and Westinghouse. In some cases, e.g. TVA and Commonwealth Edison the U.S. utilities have both the boiling water reactor and pressurized water reactor type. This high degree of standardization provides numerous benefits.

KECO's training programs are made easier. Problems of personnel staffing are greatly simplified. Considerable opportunity for professional advancement exist for KECO employees at all levels as additional plants are committed and start operation. Maintenance problems and cost are minimized due to the high degree of standardization. The procurement of two PWR's from Fromatome will add some complexities, but these plants are still basically of the same reactor type.

Korea's Nuclear Regulatory effort is considerably simplified by the major commitment to one reactor type over what it would be with less standarization.

Furthermore, due to the paucity of nuclear power plant orders in the past

few years, there is strong competition to sell nuclear power plants. KECO is one of the few utilities in the world which is continuing to commit nuclear power plants every year, and of current trends continue can be expected to rank first in such commitment on a list with U.S. utilities. This gives KECO tremendous leverage as a customer.

KAERI provides valuable technical depth and specialized expertise to support the NRB, KECO, and Korean industry, and also provides a framework for development of additional specialized expertise on demand.

The productivity of Korean workers appears to be relatively high, while labor cost are relatively low. This coupled with the increasing degree of localization is a valuable aid to minimizing capital cost. Additionally, it is reasonable to expect nuclear related exports in the not to distant further, as an adjunct to Korea's internal nuclear power plant development efforts.

The bottom line is that there is a high probability for continuing success and growth in Korea's nuclear power plant and industrial commitment.

There are some areas of concern, and some items which should be considered as having potential to strengthen the nuclear power program:

1) Korea's large nuclear power plant program commitments involve several Korean ministries, institutes, and industrial organziations are involved, in addition to the utility KECO.

Changes which are done hastily without being fully coordinated can be damaging both in increased cost, schedular delays, and the possible lost of qualified and experienced personnel. While reorganizations and functional realignments of responsibilities may be necessary, such changes also inherently cause delays and inefficiencies.

There have been numerous recent changes in organizational responsibilities, and the industrial structure to conduct Korea's nuclear power plant program. The impact of these changes is a source of concern.

2) The pay scale of government and KECO employees is low compared to that in Korean industry and other countries in the world. KAERI is able to pay higher salaries than government ministries and KECO and thus can attract and hod personnel who would otherwise be lost to Korea's nuclear power program. These peoples abilities are available to the Korean ministries and to KECO through KAERI's multiple support roles.

It appears that the discrepancy between the Korean industrial pay levels (including KAERI) and those of the Government and KECO is large enough to be a source of concern. As Korea's nuclear power program expands the competition for the more experience trained people could create unhealthy stresses. Also, it may become increasingly necessary to restructure the assignment of missions from the government and KECO to industry and KAERI, resulting in ways not currently forseen. This could be disruptive, costly and inefficient.

3) While there are a number of government, and industrial organizations involved in Korea's nuclear power plant program, the roles and missions of these organizations, as well as their relationship to each other appears to be well defined and understood. Ad hoc, or limited changes in these roles, mission, and relationships which fragment clear lines of responsibility and authority should be avoided.

4) Although Korean industry has a number of licensing arrangement with respect to nuclear components, there does not appear to be a clear function or

understanding of the obligations for technology transfer and technical assistants which go with these licensing arrangments. Effort could be well spent on more clearly defining the obligation of the grant or of the licenses and in obtaining the requisite agreement to obtain technical assistance which may be required incident to these licensing arrangements.

5) Suppliers of nuclear power plants are required, as part of Korea's localization program to use Korean suppliers for many items. When there are problems of quality or schedule, the supplier is in a weak position to obtain corrective action, with the supplier feeling it is a problem for KECO or the Korean Government. Specific attention should be devoted to this generic problem, ad hoc solutions or costly delays and quality problems.

6) Should a modification be required when the plant is being constructs, expeditous action can be taken since construction funds are available. When the plant is in commercial operation, however, obtaining approval for the expenditure of foreign exchange can be time consuming. It is suggested that attention be directed to assuring the time required to obtain such approvals does not reduce the plant capacity factor.

7) Sattelite communications are available to allow expedition flow of data for design or construction related information. Yet, transmittal of Regulatory and Safety type information be examined.

8) It would be beneficial for Korea to obtain a close working relationship with one or more U.S. electric utilities. Likely candidates for such a relationship would be TVA, Commonwealth Edison, or Duke Power Company. The scope should be to be able to obtain the benefit of these utilities experience and insite in being a customer buying nuclear power plants, responding to safety requirements, maintenance procedures and problems, and operations. Although

the Institute of Nuclear Power Operations (INPO) is an organization for member U.S. utilities, there would be significant advantages to KECO to become affiliates. Efforts should be continued toward this end.

9) Korea should examine the merits of creating an interchange program to allow people in KECO, Government, KAERI, and Korean Industry to work on an exchange basis with each other. For instance, a KAERI employee would exchange jobs with a KECO employee for a one-to-two year period, or people from industrial organizations may be assigned to work in government agencies, etc. The objection would be to achieve cross-training and insight in to the operations of other organizations in the nuclear field.