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ST-CS-02-398-74

DEFENSE INTELLIGENCE AGENCY

NUCLEAR ENERGY PROGRAMS
JAPAN AND TAIWAN (U)

PREPARED BY
DEFENSE INTELLIGENCE AGENCY
DIRECTORATE FOR SCIENTIFIC
AND TECHNICAL INTELLIGENCE

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NUCLEAR ENERGY PROGRAMS - JAPAN AND TAIWAN

AUTHOR

[redacted] (b)(3)

ST-CS-02-398-74

DIA TASK T74-02-06

DATE OF PUBLICATION
3 September 1974

Information Cut-off Date
1 July 1974

National Security Information

Unauthorized Disclosure Subject to Criminal Sanctions

"This is a Department of Defense Intelligence Document prepared by the Nuclear Energy and Applied Sciences Division of the Directorate for Scientific and Technical Intelligence of the Defense Intelligence Agency."

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ST-CS-02-398-74
3 September 1974

LIST OF EFFECTIVE PAGES

SUBJECT MATTER	PAGE NUMBERS	DATE
Title Page	None	Original
Preface	iii (Reverse Blank)	Original
List of Effective Pages	v (Reverse Blank)	Original
Record of Changes	vii (Reverse Blank)	Original
Table of Contents, List of Illustrations and List of Tables	ix thru xii	Original
Summary	xiii thru xv (Reverse Blank)	Original
Section I	1 thru 30	Original
Section II	31 thru 44	Original
DD Form 1473	45 and 46	Original
Distribution List	47 and 48	Original

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RECORD OF CHANGES

CHANGE NUMBER	DATE OF CHANGE	DATE ENTERED	SIGNATURE, RANK/RATE AND ORGANIZATION OF INDIVIDUAL ENTERING CHANGE

ST-CS-02-398-74
3 September 1974

TABLE OF CONTENTS

UNCLASSIFIED

ST-CS-02-398-74
3 September 1974

TABLE OF CONTENTS (Con't)

UNCLASSIFIED

TABLE OF CONTENTS (Con't)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Con't)

LIST OF TABLES

ST-CS-02-398-74
3 September 1974

SUMMARY

JAPAN

~~(S/NFD)~~ [redacted] (b)(1)

(U) By law, all Japanese nuclear programs are limited to peaceful purposes and are required to be made public. The Japanese are signatories to both the Limited Test Ban Treaty and the nuclear Non-Proliferation Treaty (NPT). While they have not ratified the NPT, it is expected that they will do so within the next year.

(U) The Japanese are conducting extensive research on radioisotopes and radiation, controlled thermonuclear reactions, magnetohydrodynamics, and advanced reactor concepts. Japan has constructed a nuclear powered cargo ship but has been unable to test the vessel because of delays by local residents and fishermen at the home port.

(U) Because of heavy reliance on foreign sources for its energy needs, Japan is rapidly expanding its nuclear power program to solve these energy requirements. Currently 3000 megawatts of electricity are supplied by nuclear reactors, and estimates predict 60,000 megawatts will be generated with nuclear power by 1985. Initially light water reactors were purchased from U.S. companies, however, Japan has now developed the capability to design and construct its own power reactors. Emphasis within the nuclear power program is directed towards solving nuclear facility siting problems, ensuring adequate supplies of nuclear fuel, and providing for the reprocessing of spent fuels and for waste disposal. Japan will generate very large amounts of plutonium in the next decade from its power reactor program. International Atomic Energy Agency safeguards are applied to all of Japan's power reactors.

ST-CS-02-398-74
3 September 1974

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(U) Taiwan has contracted for 3110 MWe to be generated by four nuclear power plants by 1980. Four additional reactors, in the planning stage, will raise the total nuclear generating capacity to 5600 MWe by the late 1980's. The Ministry of National Defense urged adoption of heavy water reactors but Taiwan Power Company adopted light water reactors.

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ST-CS-02-398-74
3 September 1974

SECTION I

JAPAN

A. INTRODUCTION

1. Significance of the Nuclear Program

~~(S/NFD)~~ [redacted] (b)(1)

2. History of Japan's Nuclear Development

a. (U) The Japanese nuclear program began essentially at the time of the First United Nation's International Conference on the Peaceful Uses of Atomic Energy at Geneva, Switzerland, in 1955. The "Basic Law Concerning Atomic Power" (Law 186 of 19 December 1955) provided for a large-scale nuclear research program devoted to peaceful purposes.

b. (U) In 1961 the Japanese Atomic Energy Commission (JAEC) formulated a Long Range Program for the Development and Utilization of Atomic Energy. This program sought to conduct extensive research and to construct the first of Japan's many nuclear reactors.

c. (U) The Japanese Atomic Energy Commission revised its long range program in 1967 promoting the development of power reactors, construction of a nuclear powered ship, development of a complete nuclear fuel cycle and the practical use of radiation. That same year, Japan's first reactor became operational. From 1967 to the early 1970's, Japan intensified and broadened its nuclear research efforts and started construction of several nuclear power stations. A total of twelve research reactors and seven critical assemblies are now operational at government institutes, universities, and industrial sites.

d. (U) In June 1972, the Japanese Atomic Energy Commission prepared a new Long-Range Program of Atomic Energy Development and Utilization. The Program envisaged national projects for the decade which began in 1973. The Program specifically promotes nuclear research and development of reprocessing and enrichment processes and facilities, siting of nuclear facilities, and waste disposal. The designated "national" projects include: advanced thermal reactor, experimental fast reactor, prototype fast reactor, nuclear cargo ship "MUTSU," nuclear fuel reprocessing plant, and uranium enrichment.

B. ADMINISTRATION

1. Law and Tradition

a. (U) The Japanese nuclear program is subjected to more stringent legal restriction than is the program of any other major nuclear power. All nuclear power reactors in operation or under construction in Japan are under International Atomic Energy Agency (IAEA) safeguards. Military nuclear programs are forbidden by Japanese law (Article 2, Section I of the Basic Atomic Energy Law stipulates that "research, development, and utilization of atomic energy are limited to the peaceful uses" and prescribes that its program and results must be made public). Possession of defensive nuclear weapons is, however, considered permissible by the Japanese under their existing laws.

b. (U) The traditional close working relationship between government and private enterprise is characteristic of much of Japan's economic and military development. There is a long standing tradition of government and private enterprise working together toward the attainment of national goals. This partnership, especially true with the nuclear industry, provides sufficient flexibility to allow for the requisite government financing of undertakings that require large initial or continuing investments and do not hold promise of immediate financial return.

2. Organization

a. (U) The basic administrative organization of the Japanese nuclear program has remained largely unchanged since its inception in 1956 when the basic law was adopted and the Japan Atomic Energy Commission (JAEC) was formed. The JAEC, officially headed by the Director, Science and Technology Agency, provides advice on nuclear matters to the Prime Minister. The Basic Atomic Energy Law invests this Commission with the power, not only to plan, but also to participate in the decisions concerning the study, development, and use of atomic energy. The Basic Law stipulates that the Prime Minister must respect the decision of the Commission.

b. (U) Overall administrative responsibility for the nuclear program rests with the Director, Science and Technology Agency; and concern with nuclear matters is concentrated in that Agency's Atomic Energy Bureau. In addition to its own subordinate sections, the bureau is also responsible for the various government-sponsored research institutes operating in the field of nuclear research. These institutes include the Japan Atomic Energy Research Institute (JAERI), the Power Reactor and Nuclear Fuel Development Corporation (PNC), and the Japan Nuclear Ship Development Agency (JNSDA).

c. (U) The Japan Atomic Energy Research Institute (JAERI) is a quasi-governmental research organization established in 1956 to serve as the center for gathering the efforts of governmental, academic and industrial circles with the objective of conducting a broad range of research in the peaceful uses of atomic energy. The institute's research establishments are the Tokai Research Establishment, the Takasaki Research Establishment, the O-arai Research Establishment and the Radiation Center. The Institute is primarily concerned with research and development for systems for nuclear power generation reactor safety and environment, and radiation utilization technology. It is currently engaged in research on thermonuclear fusion core plasma, the high temperature gas cooled reactor, fuels and materials of light water reactors, and studies on conceptual design of fusion reactors. It is also conducting research and development on the utilization of nuclear heat from very high temperature gas cooled reactors to process industries such as iron and steel making.

d. (U) The Power Reactor and Nuclear Fuel Development Corporation (PNC) was established in 1964 to develop advanced power reactors. It is attempting to achieve commercialization of advanced thermal reactors between 1975 and 1984, and of the fast breeder reactors between 1985 and 1994. Beginning in 1970, PNC established its research facilities at the O-arai Engineering Center on the east coast of Japan. PNC is also conducting research on the nuclear fuel cycle. Projects include work on a survey of domestic and foreign uranium resources, development of uranium enrichment technology, development of plutonium fuel and construction of spent fuel reprocessing facilities.

e. (U) As early as 1955 Japan initiated work on proposals and other research projects for the development of a nuclear ship. In 1962 the Government decided to build a ship, and the Japan Nuclear Ship Development Corporation (JNSDA) was established in 1963 to undertake its construction. The Agency was also responsible for the construction of the base port for the ship. The special law establishing JNSDA was for a limited period, and the Agency was scheduled to be dissolved in March 1972. The law was modified in 1971 to extend the life of the Agency for an addition four years.

f. (U) The Japan Atomic Industrial Forum (JAIF), founded in 1956, is an industry-wide organization representing the major Japanese companies (about 600) interested in various aspects of nuclear development. This organization plays a role similar to that of the Atomic Industrial Forum in the United States and wields considerable political influence on development plans for nuclear energy.

C. Nuclear Research

1. Radioisotopes and Radiation

a. (U) Japan has a rather long history of isotope and radiation applications both for scientific research and practical application in various fields. The study of radioisotopes started as early as 1921 using natural radioisotopes. Basic studies were made on small quantities of short-lived radioisotopes beginning in 1938 when a cyclotron was constructed at the Institute of Physical and Chemical Research. These studies, however, were discontinued with the start of World War II. Studies on radioisotopes and tracer applications were resumed in 1950, when a small quantity of radioisotopes was imported from the U.S. and Europe.

b. (U) The establishment of the Joint Atomic Energy Research Institute (JAERI) has accelerated isotope application especially by the production of short-lived radioisotopes and by the activation of samples for tracer studies. In addition, the contributions of the Japan Radioisotope Association, the

Japan Atomic Industrial Forum, the research institutes, and the universities have been significant. JAERI has set up two organizations for the study of radioisotopes and radiation applications: the Takasaki Research Establishment and the Radioisotopes Center, Tokoyo.

c. (U) Strong emphasis has been placed on research and development in the field of radiation chemistry at the Takaski Radiation Chemistry Research Establishment, JAERI. This was probably based on the excellent work done in Japan in the areas of fiber chemistry and chemical engineering.

2. Controlled Thermonuclear Research

a. (U) Because thermonuclear reactions give great promise as an economic source of power, Japanese scientists began research on nuclear fusion devices shortly after work in the U.S., U.S.S.R., and English showed that the production of controlled thermonuclear reactions might be feasible. In the early 1960's many universities and industrial laboratories were studying high temperature plasma machines. The Institute of Plasma Physics (IPP) was set up in 1959 as an administrative component of Nagoya University with its principal aim being the technical realization of controlled nuclear fusion.

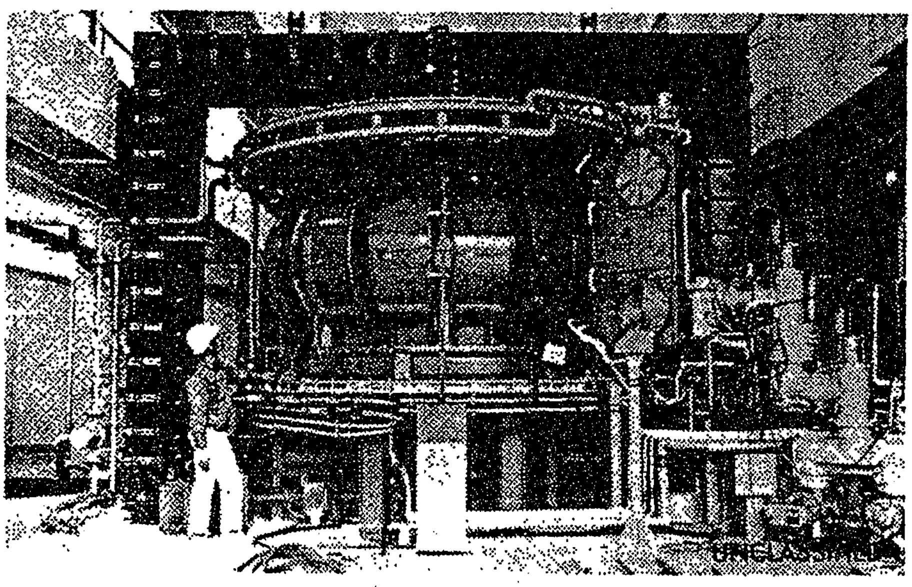

Figure 1. JFT-2 Nuclear Fusion Research Facility (U)

b. (U) In 1969, the JFT-1 (JAERI Fusion Torus No. 1) a toroidal hexapole machine was built at the JAERI Tokai Research Establishment to examine the plasma drift in an electric field. This was the first project of a seven year Special Comprehensive Nuclear Energy Research Program that concludes in 1974. JAERI then constructed, in 1971, the JFT-2, a Tokamak type medium-beta torus machine adopted to confine toroidal plasmas (see Figure 1). It succeeded in forming and confining high temperature plasma at 3 million degrees centrigrade for 0.05-0.1 seconds at a density of 10^{13} electrons per cubic centimeter. While this is far from the international target of 100 million degrees confined for one second, it clearly ranks the Japanese among the world leaders in fusion research. JAERI has ordered a magnetic-field increment power source for JFT-2 which is expected to increase the magnetic field from 10 to 18 kilograms (kg) with confinement times of 0.05 to 0.07 seconds at 10 million degrees centigrade. It has also ordered a JFT-2A, an improved Tokamak device featuring a toroidal tube twisted in a figure eight shape to attain higher stability. Completion date for these projects is mid 1974.

c. (U) Additional fusion research is being pursued by the Institute of Physical and Chemical Research (IPCR) and the National Electro-technical Laboratory (NETL). IPRC conducts studies on plasma measurements, plasma heating, cluster ion sources and ultra high vacuum techniques. The main project at NETL is the confinement of high beta plasma by the toroidal screw pinch device.

3. Magnetohydrodynamics (MHD)

a. (U) MHD is a phenomenon used for the conversion of heat to direct-current electricity by passing an ionized gas through a magnetic field. Research is being conducted world-wide to determine feasibility of using MHD conversion in commercial electric power generation. The process is attractive because these generators, when coupled with conventional of nuclear power plants, can boost the efficiency of the plant by 20% to 25% and because they will considerably reduce thermal pollution.

b. (U) MHD work began in Japan in 1961 and is now being conducted by a number of research groups. The participants include JAERI-Tokai, Electrotechnical Laboratory of MITI, Toshiba Electric Company, Hatachi Electric Company, Tokoyo Institute of Technology and Osaka University.

c. (U) In 1966 the Ministry of International Trade and Industry coordinated the individual activities into a national project scheduled to end in 1972. Due to unresolved technical difficulties the program was extended in 1973 for 3 additional years. In pursuance of their goal, the Japanese have progressed through a series of MHD generators and are presently investigating the ETL Mark VI open cycle generator. The research has resulted in several minutes of power generation with experimental 1000 KW generators and hundreds of hours of generation with smaller generators of several hundred watts.

d. (U) It will be necessary for Japan to construct a test-plant of between 30 and 60 MWe before a pilot plant of about 300 MWe can be built. If Japan continues with her MHD projects, a pilot commercial MHD plant could be in operation by 1985.

4. Advanced Reactors

a. (U) All of the power reactors in Japan are light water reactors (LWR). Because of the limited supply of enriched uranium for LWR's and because LWR's effectively use only a small amount of the uranium-235 in the fuel, Japan is striving to develop advanced reactors to overcome these limitations. The development is the responsibility of the Power Reactor and Nuclear Fuel Development Corporation (PNC). It is attempting to achieve commercial application of the advanced thermal reactors between 1975 and 1984, and of the fast breeder reactors between 1985 and 1994.

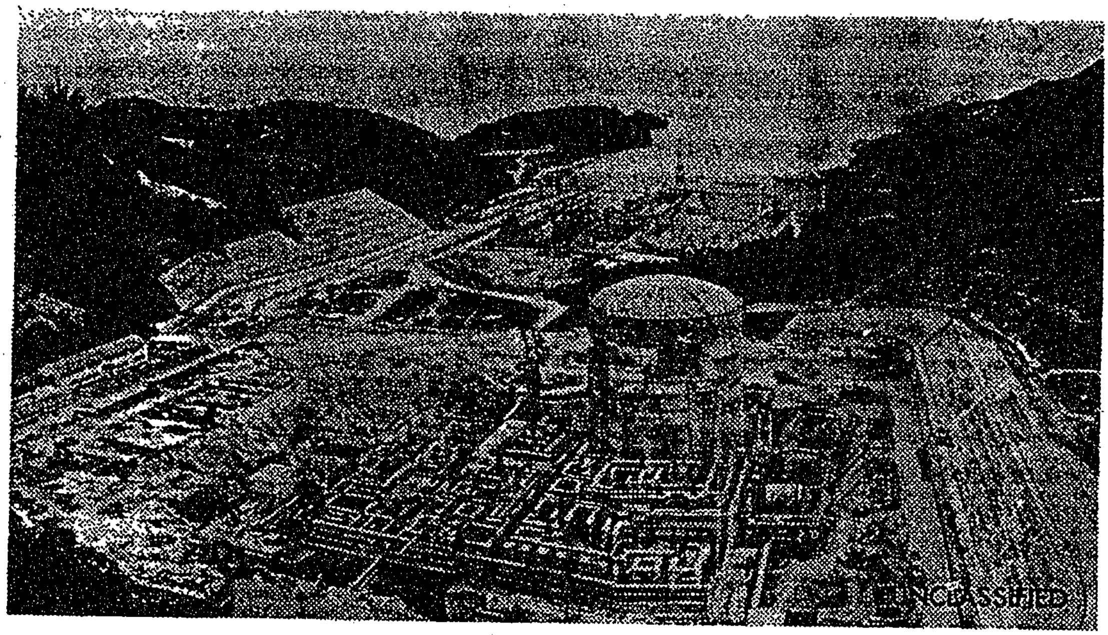

Figure 2. PNC Prototype ATR "FUGEN" (U)

b. (U) PNC started construction of a prototype advanced thermal reactor (ATR) at Tsuruga in November 1970 (see Figure 2). The advanced thermal reactor ("Fugen") is a heavy water moderated, boiling-light water cooled reactor of 165 MWe output, fueled with plutonium and natural uranium. The reactor is expected to reach criticality in 1974. The ATR is a desirable system since it has a higher thermal efficiency than the current light water cooled and moderated system and utilizes a large part of the available LWR technology.

c. (U) Like many other countries of the world, Japan is conducting extensive research and development of fast breeder reactors (FBR). The FBR produces more fissionable material then it consumes and therefore can make maximum use of the available uranium. This will greatly reduce the volume of enriched uranium needed by Japan and is designed to be the principal type of reactor built in Japan in the late 1980's. PNC is constructing both an experimental and a prototype fast reactor.

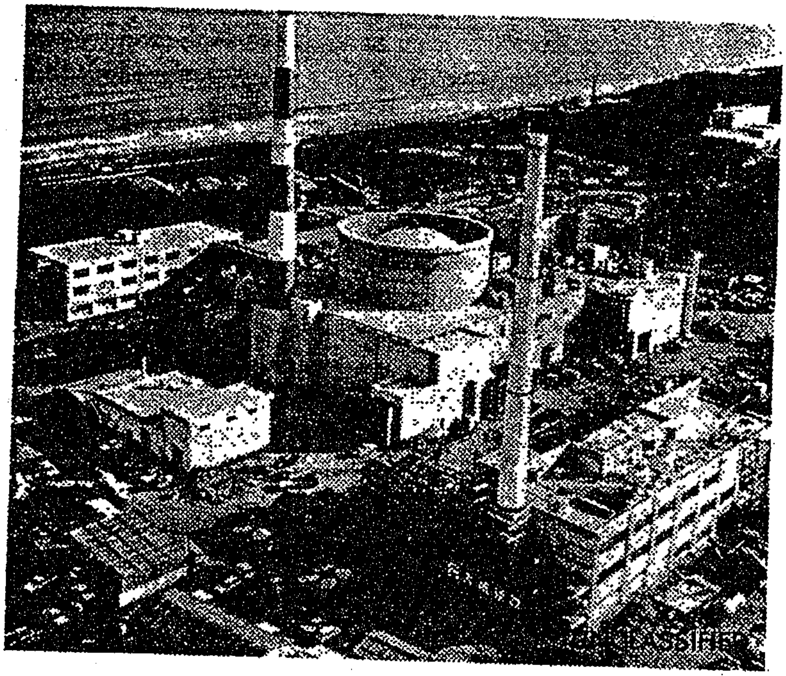

Figure 3. PNC Experimental FBR "JOYO" (U)

d. (U) The Japan Experimental Fast Reactor (JEFR or "Joyo"), is a sodium cooled fast reactor (see Figure 3). The core uses a plutonium-uranium mixed oxide while depleted uranium oxide is used in the blanket. The reactor is designed as a 100 megawatt thermal (MWt) plant, but the initial operating power will be 50 MWt. Construction of the reactor began in 1970 at the O-arai Engineering Center (see Figure 4), completion is scheduled for 1974.

e. (U) The Japan Prototype Fast Reactor (JPFR or "Monju") is also sodium-cooled and is designed for 300 MWe output using uranium and plutonium mixed oxide fuel. Construction will begin in 1974 and it should become critical in 1978.

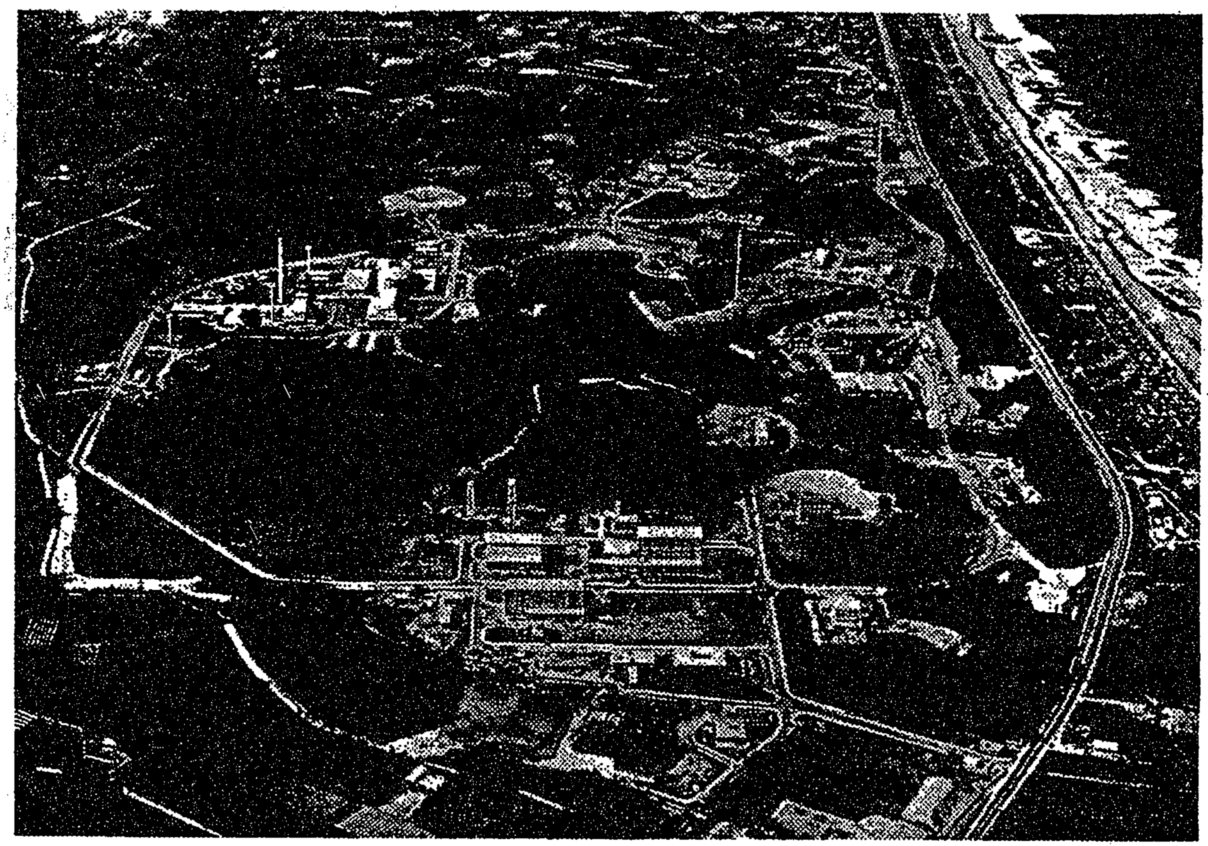

Figure 4. O-arai Engineering Establishment (U)

5. High Temperature Gas Cooled Reactor

a. (U) Electric Power Development Company (EPDC) has ordered Japan's first high temperature gas-cooled reactor (HTGR) from General Atomic International Company (U.S.). The reactor will have a capacity of 770 megawatts. The HTGR provides both higher thermal efficiency and a higher conversion ratio-than the light water reactors currently in operation. A higher thermal efficiency means more of the heat produced goes toward power production and less is discharged as waste heat to the environment; while a higher conversion ratio means more efficient utilization of the uranium-238 in the core. JAERI has also prepared preliminary designs for a 50 MWt HTGR.

b. (U) Associated with the development of an HTGR, Japan's Agency of Industrial Sciences and Technology launched a major project in 1973 to develop a technique for making steel by use of nuclear energy. A high temperature reactor is necessary to obtain the minimum 1000°C temperature level that a steel production plant would require. Heat from the high temperature reactor would be used to produce the reducing gas to obtain sponge iron and also to heat the gas to the temperature required in the reduction furnace. The sponge iron would then be converted to steel ingots by an electric-arc furnace. The Japanese hope to build a steel plant using two to three high temperature gas cooled reactors with a total output capacity of 3000 MWt. A production capacity of 3 to 3.5 million tons of crude steel a year is planned. Phase 1 of this program extends over a period of eleven years and about $21 million has been alloted for development of the pilot plant. Phase 2 calls for the development of an industrial test plant followed by a commercial plant by 1980.

D. Nuclear Power Program

1. Electrical Requirements and Nuclear Reactors

a. (U) The demand for electricity in Japan has increased 280 percent over the last eight years due to the industrial growth and the rising standard of living. To help meet the projected demand, current estimates by the

Atomic Energy Commission of Japan (JAEC) predict that nuclear power plant generating capacity will be 9000 MWe in 1975, 32,000 MWe in 1980 and 60,000 MWe in 1985.

b. (U) Due to the lack of domestic resource, Japan relies heavily on foreign sources for its energy supply. Presently 85 percent of its energy needs are imported; however, such a situation for a major industrial nation is untenable. The absolute need for a stable and low cost energy resources directly under the control of the nation is non-controversial. Therefore, the practical use of nuclear power is expected to have greater requirement and yield greater results in Japan than in most countries.

c. (U) Japan launched its nuclear power program in 1959 when the Japan Atomic Power Company (JAPC) started construction of a British Magnox (gas-cooled, graphite moderated) type reactor. The 166 MWe reactor, built at Tokai-mura, began operation in 1967. Seven power reactors, producing a total of about 3,000 MWe are operational with 15 reactors capable of producing 12,000 MWe under construction (see Table I). The utilities have also planned for an additional 60,500 MWe capacity to be constructed and in operation by 1985 (see Table II).

d. (U) Japan initially relied on foreign technology in developing its commercial nuclear power capability. After obtaining its first reactor from Britain, Japan chose to use only light water cooled and moderated reactors and subsequently purchased BWR's from General Electric and PWR's from Westinghouse. The technical capability has now been developed so that Japanese scientists and engineers can design and build their own light water reactors (see Figure 4). Two of the seven reactors now in operation were designed and built entirely by the Japanese.

2. Siting

a. (U) Siting of nuclear plants is a serious problem in Japan. Siting has to be restricted to coastal areas since few inland rivers provide adequate water for cooling. These coastal areas are also the regions where there are large

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TABLE I

REACTORS OPERATIONAL OR UNDER CONSTRUCTION (U)

Company	Station	Type of Reactor	Capacity Net Mwe	Start of Construction	Fully Operational
Chubu Electric Power Co.	Hamaoka 1	BWR	540	11/70	11/74
	Hamaoka 2	BWR	860	5/79	4/78
Chugoku Electric Power Co.	Shimane	BWR	460	2/70	3/74
Japan Atomic Power Co. Ltd.	Tokai 1	GCR	166	2/60	7/66
	Tokai 2	BWR	1160	/71	10/76
	Tsurga	BWR	357	3/66	3/70
Kansai Electric Power Co.	Mihama 1	PWR	340	12/66	11/70
	Mihama 2	PWR	500	5/68	7/72
	Mihama 2	PWR	826	7/71	7/76
	Takahama 1	PWR	826	12/69	8/74
	Takahama 2	PWR	826	10/70	7/75
	Ohi 1	PWR	1175	2/71	4/77
	Ohi 2	PWR	1175	2/71	10/77
Kyushu Electric Power Co.	Genkai 1	PWR	559	12/70	12/75
Shikoku Electric Power Co.	Ikata 1	PWR	566	4/73	4/77
Tokoyo Electric Power Co.	Fukushima I-1	BWR	460	12/66	3/71
	Fukushima I-2	BWR	784	3/68	7/74
	Fukushima I-3	BWR	784	3/70	12/74
	Fukushima I-4	BWR	784	10/71	6/75
	Fukushima I-5	BWR	784	1/72	12/75
	Fukushima I-6	BWR	1100	3/72	10/76

TABLE II

PLANNED POWER REACTORS (U)

Company	Station	Probable Type	Capacity MWe	Start Construction	Expected Completion
Chubu Electric Power Co.	3	(BWR)	1100	12/76	6/81
	4	(BWR)	1000	1976	1980
	5	(BWR)	1000	1977	1981
	6	(BWR)	1500	1977	1981
	7	(BWR)	1500	1978	1982
Chugoku Electric Power Co.	2	(BWR)	750	7/74	7/74
	3	(BWR)	750	5/78	5/82
Hokkaido Electric Power Co.	Kyowa	(BWR)	550	4/76	7/81
Hokuriku Electric Power Co.	Noto 1	(BWR)	500	9/75	1/80
	2	(BWR)	800	9/76	1/81
Kansai Electric Power Co.	8	(PWR)	1200	3/76	4/82
	9	(PWR)	1200	3/76	4/82
	10	(PWR)	1200	3/77	1/83
	11	(PWR)	1200	3/77	1/83
	12	(PWR)	1000	1/78	6/83
	13	(PWR)	1000	1/78	6/83
	14	(PWR)	1000	1/79	1/84
	15	(PWR)	1000	7/79	7/84
	16	(PWR)	1000	1/80	1/85
Kyushu Electric Power Co.	Genkai 2	(PWR)	559	4/75	2/80
	Sendai 1	(PWR)	890	10/75	10/80
	4	(PWR)	890	10/77	2/82

TABLE II (Cont'd)

Company	Station	Probable Type	Capacity MWe	Start Construction	Expected Completion
Shikoku Electric Power Co.	Ikata 2	(PWR)	566	7/75	12/79
Tohoku Electric Power Co.	Onagawa 1	(BWR)	524	12/74	12/78
	Kodaka 1	(BWR)	784	12/76	6/81
	Kodaka 2	(BWR)	784	12/76	4/82
Tohoku/Tokoyo Electric Power Co.	Shimohita	(BWR)	12,000	12/77	12/81
Tokoyo Electric Power Co.	Kashiwazaki 1	(BWR)	1100	11/75	7/81
	Kashiwazaki 2	(BWR)	1100	1976	1981
	Kashiwazaki 3	(BWR)	1100	1977	1982
	Kashiwazaki 4	(BWR)	1100	1977	1982
	Kashiwazaki	(BWR)	3600	1978	1983
Tokoyo Electric Co.	Fukushima II-1	(BWR)	1100	2/75	10/79
	Fukushima II-2	(BWR)	1100	10/75	6/80
	9	(BWR)	1100	8/76	4/81
	10	(BWR)	1100	2/77	10/81
	11	(BWR)	1100	10/77	1/82
	12	(BWR)	1100	1978	1982
	13	(BWR)	1100	1978	1982
	14	(BWR)	1500	1979	1983
	15	(BWR)	1100	1979	1983
	16	(BWR)	1500	1979	1983
	17	(BWR)	1500	1980	1984
	18	(BWR)	1500	1980	1984
	19	(BWR)	1500	1980	1984

ST-CS-02-398-74
3 September 1974

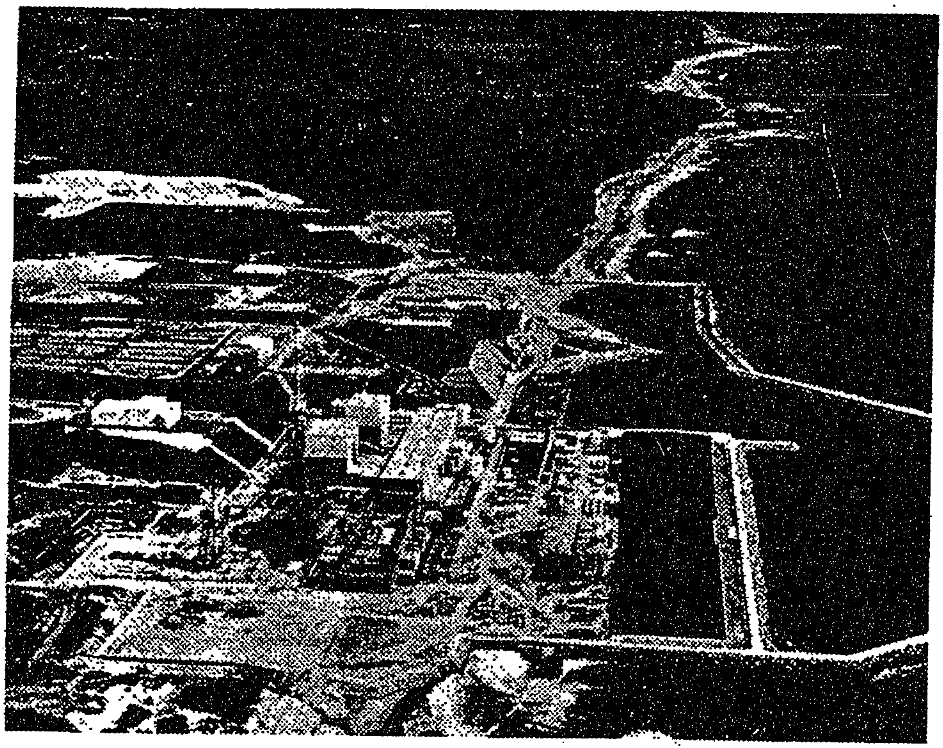

Figure 5. The FUKUSHIMA Nuclear Power Station, showing No. 1, 2, 3, and 4 BWR (U)

concentrations of people. Considerable concern has been shown to the siting of reactors in close proximity to large population centers. In addition, since Japan is one of the most active fishing countries in the world, considerable opposition is encountered from a population very sensitive to the problems of radioactivity in the water.

b. (U) The Government and the Atomic Energy Commission of Japan are working diligently to assure the local inhabitants and fishermen of the safety of nuclear plants because the construction of many nuclear plants have been delayed or halted due to local protests and legal actions.

c. (U) Most of the coastal cities of Japan have soil foundations leading to serious earthquake resistant design problems for nuclear plants, and the final disposal of radioactive wastes creates additional problems that must be solved to ensure the timely completion of scheduled nuclear plants.

3. Uranium Mining

a. (U) Domestic. Even with extensive prospecting Japan has discovered only limited reserves of uranium ore. The primary ore desposits are located in the main island of Honshu at the Togo and Ningyo-Togo mines. The exact amount of reserves is unknown; however, it is estimated that Japan has less than 15,000 tons of recoverable uranium ore. In October 1970, the Power Reactor and Nuclear Fuel Development Corporation (PNC) constructed a pilot mill at the Ningyo-Togo Mine with a capacity of 50 tons of ore per day.

b. (U) Foreign. It has been estimated that the Japanese nuclear power program will require from 100,000 to 150,000 total tons of uranium oxide by the mid-1980's. Since virtually all of the required uranium must be imported, Japan has signed extensive long and short term contracts for foreign supply and has joined several joint development programs overseas in order to secure the needed uranium. Overseas explorations have been in the U.S., Australia, Canada, Somalia, Zambia and Niger. Japan hopes to secure one-third of its natural uranium requirements from overseas explorations. The most recent joint venture was in Niger when Japan, Niger and France formed a company, Cie. Miniere d'Akouta (Cominak), which will start full-scale mining and shipment in 1979. Japan reportedly will receive 1000 tons of uranium concentrate annually from the project. Applicability of international safeguards on the material is at this time uncertain.

4. Enrichment

a. (U) Since all the reactors either in operation, under construction or planned, use enriched uranium, Japan will have to purchase enriched fuel or enrichment services from the United States and other foreign countries since they have no indigenous capability. 3000 metric tons separative work units (MTSWU) will be required per year by 1975 and about 8000 MTSWU by 1985.1/ In 1968, Japan signed the US/Japan Atomic Energy Agreement which provided enriched uranium for the reactors in operation or under construction by 1973. This agreement was recently revised to include up to 60,000 MWe of generating capacity which provides for all plants in operation or under construction by the end of 1978. Another bilateral agreement with the U.S. was signed in 1973 for 10,000 additional MTSWU.

b. (U) There has been some concern throughout the Japanese nuclear industry that Japan is too dependent upon the United States for its enrichment requirements. Japan therefore signed an enrichment contract in 1974 with France for about 10,000 MTSWU of enrichment service from the new Eurodif plant. This contract covers a ten-year period beginning in 1980.

c. (U) In order to assure long term supplies, Japan is striving to develop and build an enrichment plant. For several years, Japan has been conducting research into both the gaseous diffusion and centrifuge enrichment processes with the goal of building a full-scale enrichment plant. The gas centrifuge process potentially is superior to the gaseous diffusion process since it requires only about a tenth as much power as does the diffusion process and an economically operable plant can be built on a considerably smaller scale.

1/ An SWU is defined as one kilogram of separative work and is a convenient measure of the capacity of an enrichment plant. This facilitates comparisons of such plants without requiring specific knowledge of their operating parameters. Frequently the expression metric tons SWU (MTSWU) will be used for one thousand kilograms of separative work units.

d. (U) PNC has been tasked to research and develop the centrifuge enrichment method. In 1973, they launched a major program to standardize separators, develop high quality components, and build and operate a cascade. The cascade will consist of 180 separators stacked in 13 stages for the enriching section and a 5 stage stripping (recovery) section. The Japanese goal is to build a pilot plant using the centrifuge enrichment process by 1980.

e. (U) The Japanese have been unhappy with their progress in gaseous diffusion technology and have recently indicated a desire to participate jointly in an international diffusion enrichment project. JAERI continues to develop its gaseous diffusion enrichment technology primarily with the aim of improving Japan's bargaining position in any negatiation on a multinational enrichment venture.

5. Fuel Fabrication

a. (U) The Japan Atomic Fuel Corporation (AFC) together with JAERI was founded in 1956 to set up Japan's first fuel fabrication research laboratory at Tokai. Since then, several industries have utilized the facility for preliminary work in fuel element fabrication. Sumitomo Electric Industries, Ltd. and Furukawa Electric Co., Ltd. also conducted early research and development on nuclear fuel fabrication and supplied fuels for various types of research reactors.

b. (U) There are now three nuclear fuel companies in Japan. The Japan Nuclear Fuel Company, Ltd. (JNF), a jointly owned subsidary of Hitachi, Toshiba and General Electric (U.S.), was formed in 1966. Their plant at Kurihama can produce 560 tons of UO_2 per year for use in boiling water reactors. Pressurized light water reactor fuel is produced at the Mitsubishi Nuclear Fuel Company, Ltd. (MNF) facility at Tokai-mura using enriched uranium purchased from the U.S. This plant, a joint venture by Mitsubishi Metal Corporation, Mitsubishi Heavy Industries and Westinghouse Electric (U.S.), can fabricate 350 tons of UO_2 per year. Sumito Electric Industries, Ltd. and Furukawa Electric Company merged in 1972 to form Nuclear Fuel Industries, Ltd. (NFI) with plans of capturing part of the reload fuel Market. In addition to light water reactor fuels, they will eventually be able to produce fuels for research reactors, ATR's, FBR's, and HTGR's.

c. (U) The Power Reactor and Nuclear Fuel Corporation completed the Plutonium Fuel Fabrication Facility at Tokai-mura in 1972. The facility produces mixed uranium and plutonium oxide fuels for the fast critical assembly, the advanced thermal reactor project and the fast-reactor program.

6. Nuclear Fuel Reprocessing

a. (U) Since all power reactors require the processing of their irradiated fuel in order to separate both the remaining uranium and the plutonium for reuse, Japan has been working for many years towards the development of adequate reprocessing facilities to handle its irradiated fuel needs. It is estimated that the reprocessing requirements will be 80 tons/year in 1975, 600 tons/year in 1980, and 1700 tons/year in 1985. British Nuclear Fuels, Ltd (BNFL) is currently providing Japan its separation service at the Windscale reprocessing plant in England.

b. (U) Japan started building a reprocessing plant in 1971 at Tokai Village after having been delayed almost two years by local residents concerned with safety and use of highways and port facilities in the area for shipment of irradiated fuel. The facility is scheduled to be operational in early 1975 with a reprocessing volume of 0.7 tons per day (210 tons/year). The plant, built under a contract between Japan's Power Reactor and Nuclear Fuel Development Corporation (PNC) and France's St. Gabain Techniques Novelles (SGN), uses the moisture type Purex method of reprocessing.

c. (U) By 1977, Japan's needs will have exceeded the reprocessing capacity of the plant and Japan will again be faced with reprocessing requirements she is unable to meet. Japan is now pursuing several alternatives to determine how best to satisfy its requirements. The Japanese nuclear industry desires that a second reprocessing plant be built in Japan, but problems with siting and the fact that a new facility could not be operational before the early 1980's have prompted inquiries into other possibilities. It will be necessary for the second plant to have a capacity of 5 tons/day in order to satisfy Japan's reprocessing requirement. In the 6 or 7 year period before the second plant could be built, Japan must depend on overseas facilities. An alternative to construction of a second plant would be to commission foreign reprocessors for her needs. Another alternative, which Japan has explored in the US, Korea and Taiwan, is to help finance and build a reprocessing plant in another country. Although Japan will have to use foreign reprocessing in the late 1970's, and early 1980's it is expected that a second plant, privately owned and operated, will be constructed in Japan.

7. Waste Disposal

a. (U) One of Japan's greatest problems in the nuclear industry is the disposal of radioactive wastes. While its nuclear power capacity is growing spectacularly, Japan is faced with limited available space and overpopulation. In addition, its people draw heavily on marine resources for their food needs. These problems have limited the space for storage of radioactive wastes in the ground and have created considerable public dissent for dumping wastes in the ocean.

b. (U) On 26 June 1973, Japan became party to the London Convention that prohibits "ocean dumping" of high-level radioactive wastes. In order to dump other types of wastes, Japan must obtain special permission from the International Atomic Energy Agency (IAEA). She is now pursuing a research and development project on waste disposal. JAERI is conducting radioisotope leaching tests to confirm the safety of ocean dumping of low-level solid wastes. Studies are also being made to develop the methods of solidification of plastics and of volume reduction by compression for plutonium bearing wastes. Japan will evaluate ocean dumping of low-level solid wastes in fiscal 1975 with experimental dumping planned for 1977. Solidification of high-level wastes from the reprocessing plant is scheduled for 1979 after additional research and development has been done on the problem.

8. <u>Plutonium</u>

a. (U) Plutonium is produced by uranium fueled power reactors as a by-product of operation. The rate of plutonium production depends on the reactor type, core design, fuel composition and burnup. Commercially the plutonium is valuable because it can be used to fuel fast breeder reactors or be recycled (revised in the fuel cycle) in thermal reactors. After reprocessing, the plutonium can be used in the fabrication of new mixed oxide elements replacing some of the necessary U-235. With a very large power program like Japan's recycling plutonium greatly reduces the requirement for enriched uranium.

b. (U) By the mid-1980's, Japan will be generating large amounts of high burnup plutonium (see Table III). Because fast breeder reactors will use this plutonium more economically, the utilities will have to decide whether to try to recycle the plutonium in light water reactors or use it in fast breeder reactors. If it chooses to use plutonium in the fast reactor program, Japan will have to store large amounts of material until fast reactors are commercially available about 1985 or later. Because of the toxicity of plutonium, handling and storage create significant engineering problems.

c. ~~(S/NFD)~~ [redacted] (b)(1)

[redacted] (b)(1)

[redacted] (b)(1)

E. MARINE NUCLEAR PROPULSION

1. First Nuclear Ship

a. (U) Japan started its marine nuclear propulsion program in 1955 when shipping and marine engineers developed designs for several types of ships. The Government decided to build a nuclear powered ship in 1962 and established the Japan Nuclear Ship Development Agency (JNSDA) to oversee the construction project. The original plan was to build an oceanography ship but subsequently the plan changed and a cargo/training vessel was constructed. Construction of the nuclear ship, MUTSU, began in November 1967. The ship is a single-screw vessel powered by a 36 MWt pressurized, light water-moderated and cooled reactor using an indirect steam cycling. It will develop about 10,000 shaft horse power and have a maximum speed of 17 knots (see Figure 5).

b. (U) Installation of the reactor and loading of the fuel was completed in September 1972. Initially, the reactor was scheduled to reach criticality in November 1972. However, continuous delays by local residents of the ship's home port, MUTSU CITY, have prevented achievement of this step. The local residents and fishermen are concerned about the ship's safety and the affect of radiation and radioactive wastes on the local fishing areas. Even more so, they are concerned about the reputation of their products in other areas of the country. JNSDA may have to take the MUTSU out of port under its auxiliary boiler engines into the open seas to conduct the criticality tests.

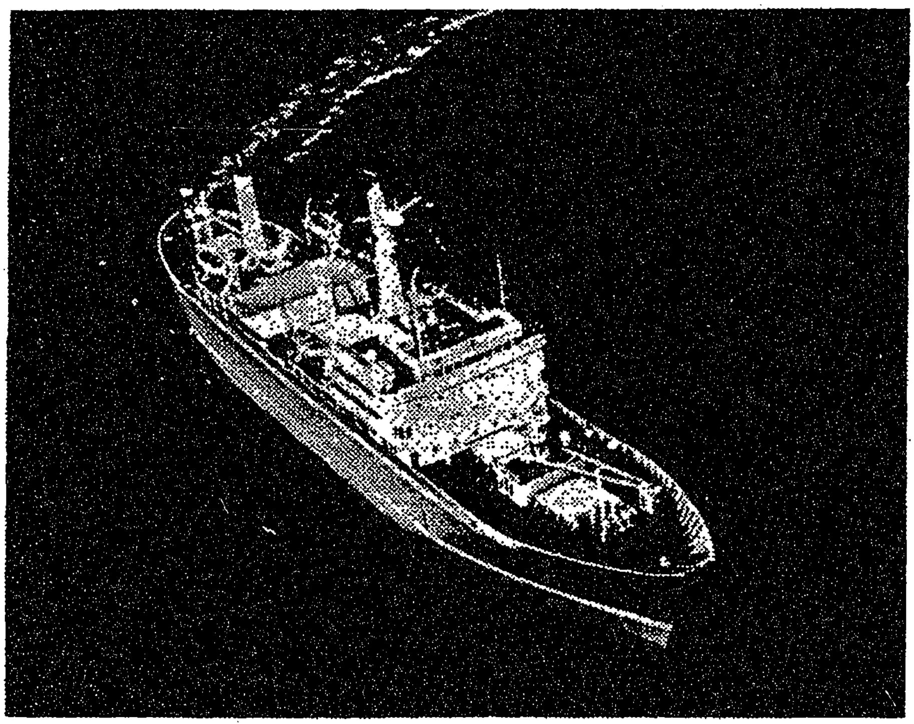

Figure 6. Japan's first nuclear ship, "MUTSU" (U)

2. Future Ships

(U) Although the Japanese have had considerable difficulty with the MUTSU, it is an outstanding technical achievement. It gives Japan the potential to compete in nuclear ship building when there is a demand for nuclear shipping and to build nuclear powered submarines. Japan has conducted an extensive study with Germany on the economics of nuclear powered merchant shipping. Once the problems with the MUTSU have been solved and performance testing completed, Japan will probably construct a second nuclear powered ship. The Transportation Ministry would like to begin construction on a second ship by 1976 and complete it by 1985.

ST-CS-02-398-74
3 September 1974

F. Prospects for Nuclear Weapons Development

1. Political and Military Consideration

a. (U) The Japanese government has repeatedly announced that Japan will adhere to the so-called Three Non-Nuclear Principles of no manufacture, no possession, and no deployment of nuclear weapons. At the same time, the government has stated that possession of nuclear weapons in a defensive role would not be prohibited by the Japanese constitution. Japan continues to rely on the Japanese-U.S. defense agreement and her Self-Defense Force for her defense. Included in the defense agreement, is the "nuclear umbrella" provided by the United States.

b. ~~(S/NFD)~~ [redacted] (b)(1)

c. ~~(S/NFD)~~ [redacted] (b)(1)

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3 September 1974

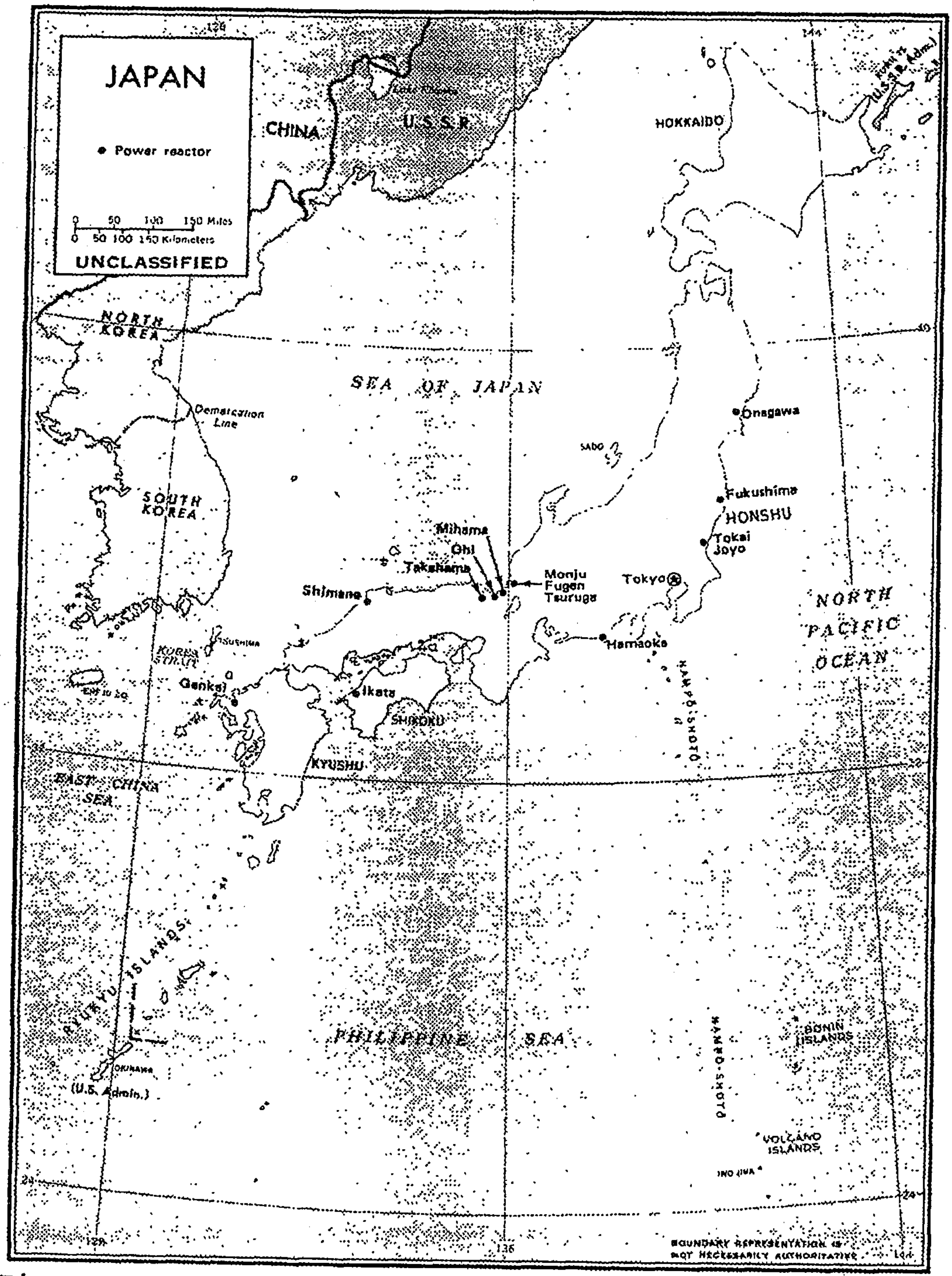

Figure 7. Sites for power reactors in operation or under Construction (U)

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3 September 1974

SECTION II

TAIWAN

A. INTRODUCTION

1. Significance of the Nuclear Program

~~(S/NFD)~~ [redacted] (b)(1)

2. History of Taiwan's Nuclear Development

a. (U) Interest in nuclear energy began in Taiwan in 1955 when the government established a Chinese Atomic Energy Council (CAEC) to advise the government and to plan a nuclear energy program. Its concerns are primarily nuclear education and research and nuclear power generation. In 1956, the government established the Institute of Nuclear Science at the National Tsing Hua University to conduct research and carry out the nuclear energy program.

b. ~~(S/NFD)~~ [redacted] (b)(1)

ST-CS-02-398-74
3 September 1974

c. (U) In 1964 the Taiwan Power Company announced the decision to build nuclear power plants that would go on line in the mid-1970's. Taiwan Power now has a total of 8 power reactors in planning or under construction.

d. (U) Taiwan was expelled from the International Atomic Energy Agency in 1971 when the Agency decided that the Peking government was the only one which could rightfully represent China. Taiwan still permits IAEA inspections of its nuclear reactors; although at any time, it could refuse IAEA further access.

B. <u>ADMINISTRATION</u>

1. <u>Organization</u>

~~(S/NFD)~~ [redacted] (b)(1)

2. <u>Finance</u>

~~(C)~~ [redacted] (b)(1)

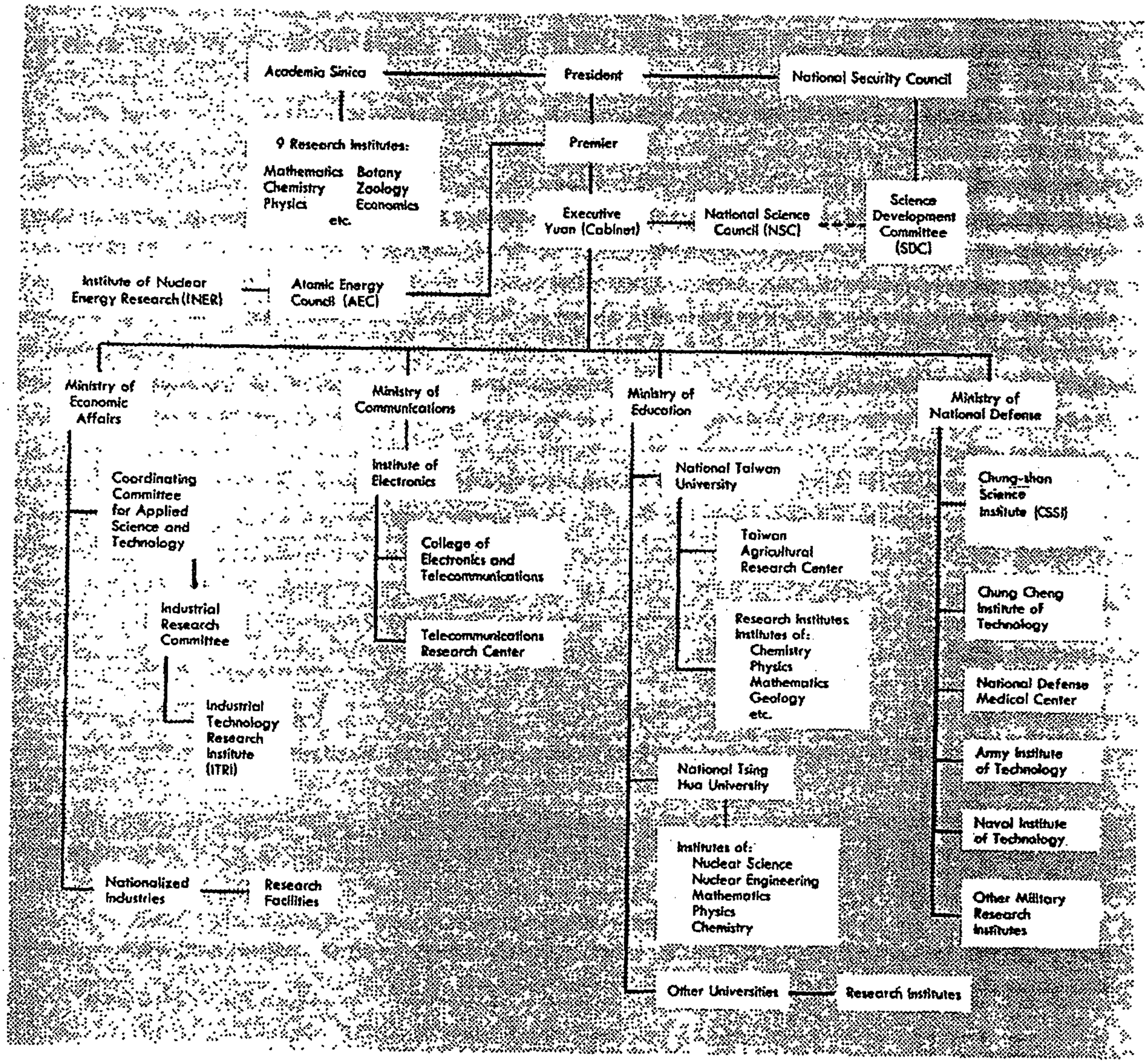

Figure 8. Organization of Scientific and Technical Activities (U)

C. NUCLEAR RESEARCH

1. Basic Research

a. (U) The Chinese government launched a long-range science development program in 1959 in an effort to raise the level of science research and education. Considerable progress has been made since that time. The program was given new impetus following the Sino-American Conference on Science Cooperation held in Taipei in April 1964. Chinese and American scientists established permanent committees in both countries to coordinate research. The committee in the Republic of China is sponsored by the Academic Sinica and its counterpart in the United States by the National Academy of Sciences.

b. (U) The Academic Sinica pioneers and coordinates research on the peaceful uses of nuclear energy and electronics. The Institute of Physics, one of nine institutes at the Academic Sinica, conducts research in nuclear physics in cooperation with the National Tsing Hua University and the National Taiwan University under the Physics Research Center Program. Research done by the Institute of Physics at the Academic Sinica involves work in plasma physics and lasers. The work is plasma physics uses theta pinch and dense plasma focus devices. Laser research consists of work on argon ion lasers, Q-switched lasers, and semi-conductor lasers.

c. (U) The Institute of Nuclear Science was established in 1955 as part of the National Tsing Hua University at Hsinchu. The Institute of Nuclear Science has a two-fold purpose: it offers opportunities for study and research in nuclear science and technology, and also serves as a national laboratory and scientific center to develop and promote the peaceful uses of atomic energy. Major facilities of the Institute include a 3 MeV Van de Graaff accelerator and a 1 MW open-pool type research reactor. This research reactor, known as THOR (Tsing Hua Open-pool Reactor), is a light water reactor that uses uranium fuel enriched to 20% U-235. THOR is used for research and experimental purposes as well as production of radioisotopes which are used in medicine.

In its role as a national laboratory, it provides services which include radiation monitoring and safety, instrument maintenance and calibration, supply and application of radioisotopes, and reactor irradiation of agricultural and industrial samples. The Nuclear Engineering Department of the Institute is designing and building a mobile nuclear reactor. This will be a truck transportable AGN-201 type reactor with an operating power level of 0.1 watt using 20% enriched uranium fuel. The reactor will be shipped to any research institute which has a need for such a facility.

d. (U) Nuclear studies are also pursued at the National Taiwan University in Taipei. Studies on 14 MeV neutron-induced reactions such as (n,d), (n,p), and (n,α) are now in progress. Research into laser applications and plasma physics is also done at the National Chiao Tung University.

2. <u>Chung-Shan Science Institute</u>

a. ~~(S/NFD)~~ [redacted] (b)(1)

b. ~~(S/NFD)~~ [redacted] (b)(1)

ST-CS-02-398-74
3 September 1974

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D. NUCLEAR POWER PROGRAM

1. Electrical Requirements and Nuclear Reactors

a. (U) The present power system in Taiwan has a total installed capacity of 2720 MWe, including 901 MWe of hydro (28 station) and 1819 MWe of thermal power (nine stations). The growth rate has averaged about 14% per year for the past decade and is projected to increase about 12% per year for the next decade. The total system capacity is expected to reach about 8800 MWe in 1980 and 15,000 MWe by 1985. Taiwan Power Company has contracted for 3110 MWe to be generated by nuclear power plants by 1980 (see Table IV). The company is planning to build two additional power stations at sites as yet undetermined. The third station scheduled for completion in 1981 and 1982 is to have dual reactors of about 900 MWe each. The fourth station, scheduled to begin construction in 1986, will also have two units, rated at 1300 MWe each. When these four stations are complete, nuclear power will supply half of Taiwan Power Company's entire generating capacity. Table IV shows original operational dates but construction delays may postpone the operational date for these reactors.

b. (U) All four of the reactors under construction are General Electric Company boiling water reactors. The Ministry of National Defense pushed for the third and fourth reactors to be heavy water reactors. Taiwan Power Company urged construction of light water reactors over those utilizing heavy water because they are less expensive, the construction period is shorter and personnel would not require retraining for new equipment. Each of reactors will operate under IAEA safeguards.

2. <u>Siting</u>

(U) The four commercial nuclear power plants have been located in the northern portion of the island since the southern area is crisscrossed with seismic faults. Becuase of these faults, Taiwan Power is constructing oil-fired units to handle the load growth developing in that area. Taiwan Power, however, is still searching for suitable sites for nuclear power plants in the southern part of the island. It would like to locate the third nuclear station in the south.

3. <u>Nuclear Fuel Cycle</u>

a. ~~(C)~~ [redacted] (b)(1)

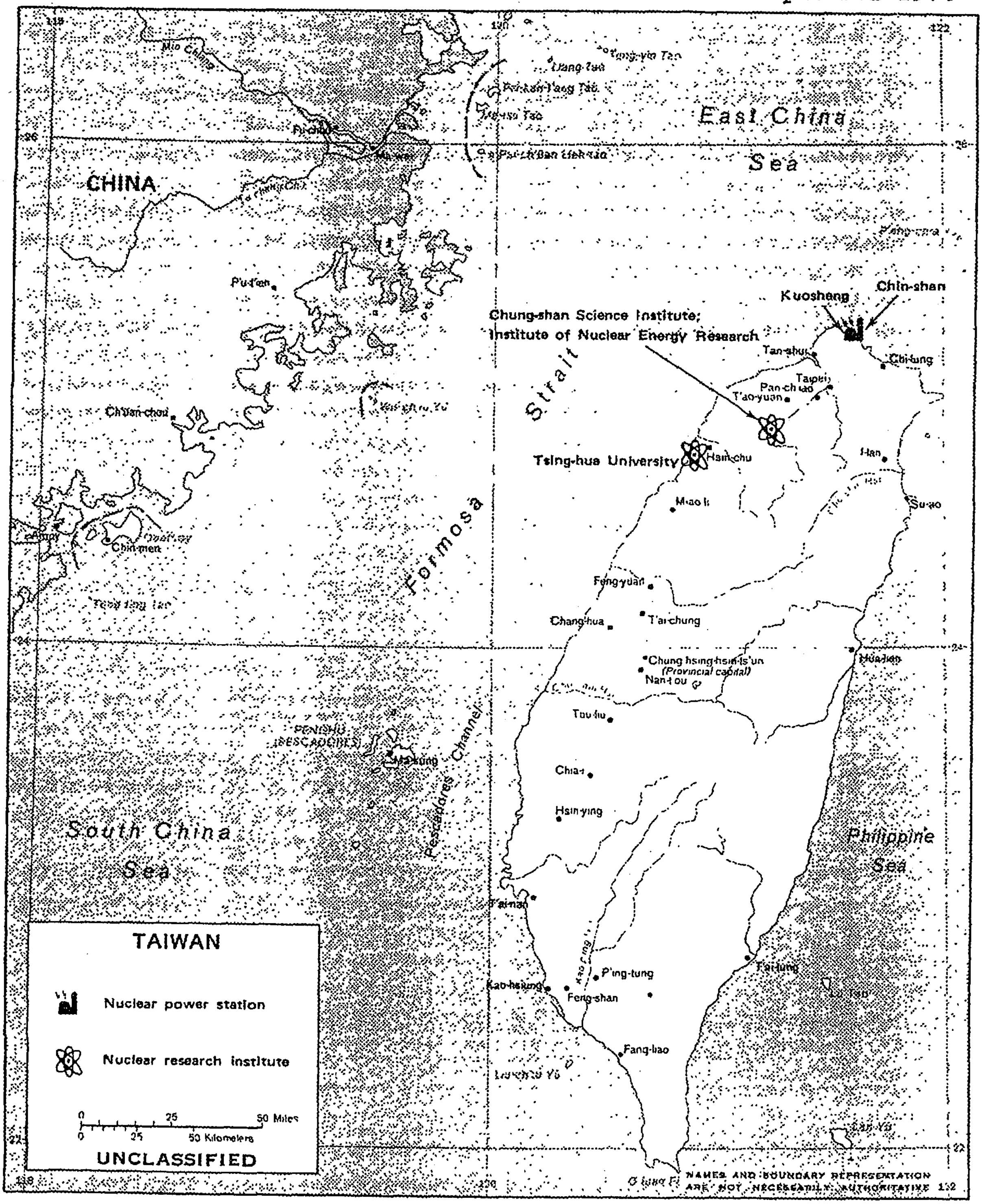

Figure 10. Location of Nuclear Facilities (U)

ST-CS-02-398-74
3 September 1974

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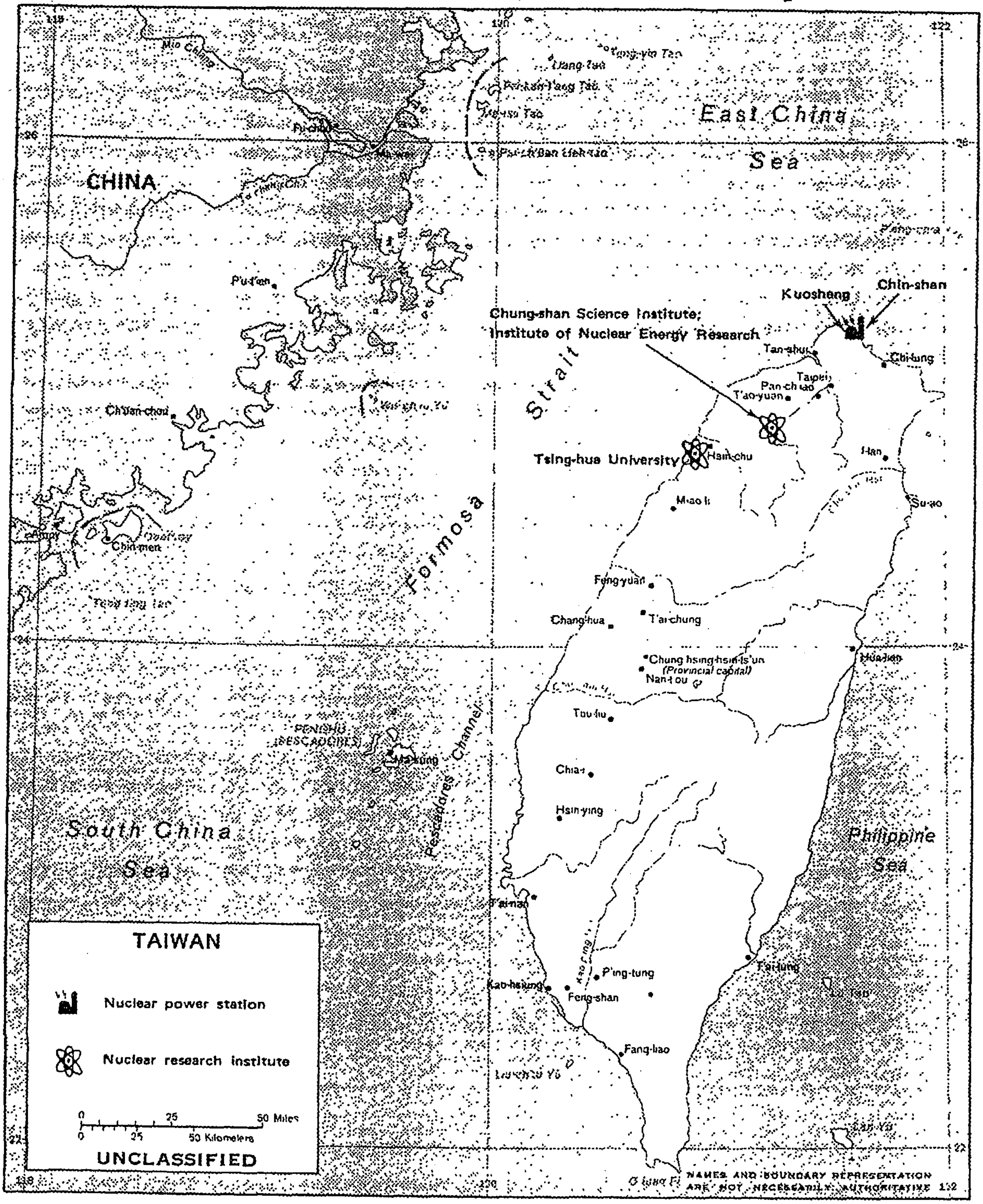

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